

2010 Montana State University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Situation: Montana is a rural state with 93 million acres and a population of 975,000. The state has over 29,000 farms and ranches representing over 66% of its land. Montana ranks 2nd in the U.S. in acres devoted to agricultural enterprises with annual crop and livestock cash receipts of over \$3 billion. The state ranks 2nd in the production of edible dry peas, Austrian winter peas, lentils, and safflower, and ranks 3rd in the production of barley and flaxseed. Montana ranks 3rd among states exporting wheat and wheat products. Montana's production of lentils in 2010 was up 130% from 2009 with planted acreage reaching 260,000 acres. Wheat and barley represented about 44% of the 2009 total agricultural receipts. Flax acreage in 2010 increased by 37% and production increased by nearly 60% over 2009. Camelina (*Camelina sativa*) production in Montana increased 35% in 2010 to 255,000 bushels. New contracts with biodiesel producers in 2010 encouraged growers to consider camelina as a viable alternative to other dryland crops. The value of Montana's agricultural exports during fiscal year 2009 totaled \$1 billion, a decrease of \$329 million versus 2008. The state's livestock industry represents over \$1.5 billion in cash receipts annually and is one of the largest industries in the state. Montana ranks 11th in the U.S. in the production of cattle and 7th in the production of sheep and lambs. Cattle and calves represented over 89% of the livestock receipts for the state and 49% of the total agricultural receipts in 2009.

Montana is a headwater's state (tributaries of the Missouri, Yellowstone, and Columbia Rivers) with pristine waters that have scenic value, agricultural and manufacturing applications, and that provide recreational opportunities for Montanans and visiting tourists. A number of diverse ecological systems in Montana provide research opportunities for scientists to study climatic conditions and land use practices. Climate change could challenge agriculture, forestry, and other industries in Montana by the latter half of the 21st century. U.S. programs that address carbon sequestration and reduction of greenhouse gasses are important projects for MSU researchers.

Dedication of the new 40,000 square foot Animal Bioscience Building occurred in fall of 2010 representing several years of construction and extensive fundraising. The complex represents the most important project to affect and benefit Montana's livestock industry in decades and provides advanced research laboratories, support rooms, and classrooms. The new facilities give students access to the latest in research, teaching, and outreach in animal and range sciences. Private funds accounted for over 50% of the financing followed by support from the State of Montana, exemplifying stakeholder support for our research and teaching programs.

Native Americans represent the largest group of potentially underserved citizens in Montana and comprise 6.4% of the population of the state. 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. Cooperative efforts with the Montana Agricultural Experiment Station (MAES) provide resources and training to Native Americans in the areas of livestock testing, certification, childhood obesity, nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification, and social skill building. American Indian students enrolled in the College of Agriculture (COA) comprise about 7% of an increasing

number of Native American students earning degrees at MSU.

The internet has become an increasingly valuable method for disseminating information that provides stakeholders with materials to assist in their decision-making. As technology advances and producers rely increasingly on computer-provided information, electronic dissemination of the results of MSU's research and outreach activities will increase in importance and impact. The COA has made a major effort in 2010 to increase the availability of reports and research documents on our web site.

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

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

Other research areas that receive high priority responses include developing improved management practices in crop production, IPM, livestock production, natural resources, nutrition and health, food safety, global food security, and range management. These results will continue to influence MAES research priority areas in the next decade. 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.

Input Section: Stakeholder input is solicited in the strategic planning process and is continually reaffirmed as programs are developed, implemented, and revised and as dollars are allocated. The COA and MAES have 24 advisory committees and boards with more than 250 members. These include: The Animal and Range Science Advisory Committee, Center for Invasive Plant Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Assistant Dean's Student Advisory Council, Eastern Agricultural Research Center Advisory Committee (MonDak Region), Equine Advisory Committee, Foundation Seed Advisory Committee, MAES State Advisory Council, Beef Advisory Committee, Montana Farmers Union, Montana Pulse Growers Association, Montana Seed Growers Association Board, Montana Wool Growers Advisory Committee, Northern Agricultural Research Center Advisory Committee, Northwestern 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, Variety Release and Recommendation Committee, and Western Triangle Advisory Committee. Members of these committees represent agricultural educators, agricultural organizations, communities, conservation groups, county extension agents, farmers and ranchers, financial organizations, private citizens, reservation groups, scientists, small businesses, and tribal councils. The COA and its MAES faculty respond to input from these stakeholders and state/national/international trends by continually developing new programs. 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, NSF, other states, grants, 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

- Address childhood obesity by enhancing the nutrient content of small grains and developing value-added crops
 - Contribute to commodity and product marketing and economic development
 - Create comprehensive programs that address challenges 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 IPM and other sustainable practices
 - Improve the fundamental understanding of plant and animal biology
 - Improve value-added crops for sustainable energy production

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 information delivery systems
- Improve recruitment and retention of students

Each of the seven agricultural research centers holds annual field days in cooperation with USDA-ARS and allied communities 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

Program #1 Food Safety -- Agronomic and Forage Crops

Situation: Montana's limited water resources and short growing seasons require researchers to be innovative in their approach to managing rangeland and crops. 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 food, feed, and biofuel crops involves close collaboration among faculty in Montana and in neighboring states. Rangelands constitute over 60% of the land mass of Montana and serve as a vital resource to the state's livestock industry.

Priorities: Projects in agronomic and forage research at MSU have objectives that interconnect with program objectives in plant and animal genomics, biobased products, sustainable agriculture, global food supply, and sustainable energy. The establishment of new value-added crops for nutritional enhancement and biofuels, and the development of higher yielding and value-added small grain cultivars are priorities among agronomic researchers. Greater disease and insect resistance in wheat and barley, greater nutritional value of forages, and more efficient use of natural resources (especially water) are key priorities.

MSU researchers work to improve animal and human nutrition, add value to raw products, improve safety of products, and increase product development (biobased chemicals, fuels, lubricants, pharmaceuticals, and nutraceuticals).

Inputs: The Montana Wheat and Barley Committee provides financial support through a competitive grant process. This financial support helps direct research programs to improve the quality of spring/winter wheat and barley, and to adopt improved IPM practices. The Montana Noxious Weed Trust Fund provides funds for cooperative community watershed projects and for competitive education and research funds. Pulse crop checkoff funds provide additional research resources.

Research Activities: Winter and spring peas, canola, corn, lentils, mustard, sunflowers, triticale, and chickpeas are included in long-term rotation studies. Barley cultivars with improved feed and forage quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Because ranching enterprises make major contributions to wildlife habitat, their viability is important to the preservation of wildlife habitat. Research has shown that by manipulating cattle grazing patterns, fisheries and wildlife habitats can be protected and improved. Dryland forage and crop producers need to continually improve yield and quality if they are to remain economically competitive. Yield performance data provides crucial information for producers' cultivar and species selection.

Program # 2 Food Safety -- Animal Health

Situation: 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 horses) has led to advances in genetics, improved performance, and increased reproduction success.

Priorities: Disease management and research programs that increase the quality of meat, milk, and fiber products continue to evolve. Animal losses due to environmental stresses, disease, and death create the need for an improved understanding of factors affecting Montana livestock. A major effort is being directed to identify alternative solutions to reducing the cost of animal ID technology.

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 re-allocated. Valuable input has come from the Animal Biosciences Building Board, Northern Agricultural Research Center Advisory Committee, Montana Beef Advisory Committee, Montana Wool Growers Advisory Committee, USDA-ARS, and other organizations.

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. Over 150,000 "drug-like" candidates have been screened for their activity against agonists in cattle. Infectious diseases caused by coccidian parasites are some of the most important health problems of food animals and humans. In beef and dairy production alone, it has been estimated that over 70 million animals are exposed every year to *Eimeria* spp. parasites. One set of MSU studies is designed to optimize mucosal and systemic antibody responses in heifers to provide passive immunity to newborn calves that are especially susceptible to scours. 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 future vaccines.

Rotavirus is the most important viral agent of neonatal diarrhea and generally affects calves less

than six weeks of age. We are investigating new vaccines that have the potential to develop into effective controls for these agents. 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 control of coccidiosis in livestock.

Mastitis remains one of the costliest diseases of the dairy industry. MSU researchers are developing a better understanding of mammary defense mechanisms to establish effective therapies. Research is continuing in collaboration with researchers at the University of Montana and the NIH Rocky Mountain Lab to study emerging infectious diseases in wildlife and livestock. 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. 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 result 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 they spread within a host.

Brucellosis (*Brucella abortus*) remains a threat to the health and well-being of livestock in Montana, Idaho, and Wyoming. Cohabitation of infected wildlife (especially elk) with cattle has compromised Montana's brucellosis-free status. There are no efficacious brucellosis vaccines for bison, and current vaccines are only partially effective in livestock.

Our targeted grazing effort is a cooperative project between Montana Wool Growers Association and MSU dedicated to developing and implementing non-traditional strategies that increase the competitiveness of Montana's lamb and wool in the world market. Our research shows that improved nutrition is a major factor that reduces lamb mortality and improves profitability. The research has focused on nutritional strategies during late gestation that may impact fetal immune functions. Decreasing input costs and increasing production revenues will help producers achieve higher quality products, generate more income, and maintain Montana's position in the world livestock market. We have developed positive working relationships among stakeholders to improve weed and land management. In addition, sheep grazing protocols and projects have been developed involving private landowners, county weed supervisors, and public agencies.

Program # 3 Global Food Security and Hunger -- 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.

Priorities: Goals are to improve the quality and diversity of agricultural commodities, expand production and pest management strategies with reduced inputs, identify and develop new Montana crops, and develop biofuels and energy alternatives. By increasing productivity in a biobased economy, there is a positive effect on manufacturing, product development, rural development, job opportunities, and farm and ranch incomes. Montana State University COA and MAES take the lead in this project, providing administration and research expertise for product development, enterprise budgeting, and marketing. Research projects strive to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy. A primary emphasis is to add value to existing Montana products and to commercialize new products, while maximizing our limited resources and reducing reliance on commodity agriculture.

Input: Input from focus groups and stakeholder meetings identify strategies for marketing higher-value agricultural commodities, consumer products, and alternative crops.

Research Activities: The primary objective of our research is to develop value-added, agriculturally-based end-use products with a competitive edge in the global market that are suitable for production in rural Montana. We have funded research that is innovative and responsive to the 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 and agribusiness. MSU initiatives in the development of sustainable energy alternatives primarily rely on oilseed crops to provide opportunities for creating renewable biobased products. Initiatives provide new insights into the use of vegetable oils as feedstock for fuel cells, the development of new wheat cultivars for the production of ethanol, non-corrosive biobased de-icers, and the optimization of ethanol production from other feedstocks, such as with barley straw. For the biodiesel industry, the high cost of feedstocks is the major limiting factor affecting biodiesel production in the United States. New oilseed crops and cropping systems are being researched to produce low cost feedstocks for biodiesel production. A dual-purpose forage crop study for bio-ethanol feedstock and for livestock feed has been completed, and a new oilseed-cereal rotation project was initiated to investigate the cropping systems for oilseed biodiesel feedstock production. Four new patents have been filed related to the use of camelina in biolubricants. Biobased processed engineered fuels (typically in pellets, briquettes, or logs) can be manufactured to take advantage of materials that are common to local Montana areas.

Program # 4 Global Food Security and Hunger -- Integrated Pest Management (IPM)

Situation: 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. Weeds, diseases, and insects continually challenge Montana producers who are often already producing crops under less than ideal conditions. Difficult-to-control pests require producers and researchers to evaluate new IPM methodologies in order to maintain a competitive position in U.S. and world markets, while helping to alleviate global hunger. The increase in public concern about food safety, 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 and organic production. Foreign trade partners want decreased pesticide residues in the wheat and barley commodities that they import.

Priorities: IPM programs 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 and of growing organic crops. Understanding 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: 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 research and educational initiatives that align with the multi-agency and citizen-supported Montana Weed Management Plan. The source of funds contributing to the research conducted include: 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 SARE, 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: The wheat stem sawfly (*Cephus cinctus*) is a severe pest of wheat in the northern Great Plains and cannot be managed using conventional tools or agricultural practices. Current management is based primarily on the adoption of solid-stem cultivars that offer partial resistance. MSU is examining the integration of natural enemies, pathogens, and chemicals for management of sawfly and is developing new sources of host plant resistance. Research is ongoing to find additional environmentally friendly solutions for the management of soil-borne plant pathogens. Identifying optimal disease management strategies and establishing biological controls are priorities for producing potatoes, sugar beets, small grains, and other crops in Montana. Our work over the past several years has provided important groundwork through 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 are conducting diversity and behavioral studies. Work in seed alfalfa fields addresses the potential use of alternative management options to control alfalfa pests, while minimizing non-target effects on natural enemies and pollinators. In addition, a better understanding of biological control and its implementation is being achieved by monitoring impacts. Incorporating biopesticides into insect management strategies can conserve natural enemies and pollinators.

A multistate partnership focuses on the management and control of insect pests in stored grain. Insecticidal and non-insecticidal approaches are being tested in laboratory and large-scale field trials. The primary focus of entomological research will be to ensure reduction of grain storage losses at a lower cost than conventional chemical methods with less reliance on chemical intervention.

The emergence of West Nile virus in the western U.S. has drawn considerable attention to the science of mosquito control and the safety of management tactics, especially in areas where insecticides traditionally have not been used. Research is being conducted into the use of ultra-low-volume (ULV) methods to reduce costs and environmental concerns. Projects are in place to demonstrate the effectiveness of the integration of biological control agents into potato disease management systems for soilborne, foliar, and virus diseases. Educational programs are being developed to provide grower education for integrating biological controls with conventional disease management practices. No-till cereal production combined with a conversion from wheat-fallow to annual cropping has led to more intensive plant disease pressure. The use of anti-fungal proteins incorporated into transgenic plants is a promising approach to limiting fungal diseases of cereals.

In discussions about problem weeds, stakeholders mention spotted knapweed, Canada thistle, and kochia as their most severe problems, especially in rangelands and pasture. One project looks at managing spotted knapweed through the targeted grazing by sheep and another looks at the introduction of host specific insects to control weeds. MSU continues to conduct herbicide screening trials to assess the effectiveness of new and existing products for weed control in small grains, sugar beets, potatoes, mint, camelina, dry beans, dry peas, safflower, sunflower, and canola.

Natural enemy efficacy studies against invasive weeds will determine the ecological and physiological basis for insect-host interactions. Characterizing the ecological communities in which natural enemies survive is fundamental to developing and understanding natural enemy densities. Identification and testing of various arthropods continues for the biological control of hoary cress, field bindweed, rush skeletonweed, houndstongue, Russian knapweed, tansy ragwort, and invasive hawkweeds. The combined impacts of seed head insects and root insects are causing the collapse of spotted knapweed populations in many areas of western Montana; the release of two new agents for Russian knapweed was initiated in 2010. Research into the mechanisms of weed resistance helps develop herbicides that target specific

biochemical processes within the plant.

Program # 5 Global Food Security and Hunger -- Plant Breeding, Genetics, and Genomics

Situation: MSU is a recognized international leader in the development of new cultivars of small grains sought by global buyers. 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 insect resistant wheat and barley cultivars. Research results will increase the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and end-use qualities. Based on average planted acreage and prices, development of an improved winter wheat cultivar that produces an additional one bushel per acre either by enhanced yield or reduced yield loss to disease, insects, or environmental stresses adds \$4-\$5 million in revenue per year to the Montana economy. Additional work in the development of alternative crops continues to produce new market opportunities.

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 to remain competitive in the world marketplace. Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality grains. MSU's intensive genomic research will help Montana producers stay competitive and will provide improved cultivars adapted to Montana's 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 and help alleviate world hunger. 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 area larger and higher quality food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat.

Input: 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 cultivar trials and by providing associated inputs. Research proposals are competitively awarded from the Montana Wheat and Barley Committee. Through stakeholder input, we routinely apply for PVP Title V status on all released wheat and barley cultivars, 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. Montana crop producers want improved hard red and hard white winter wheat cultivars adapted to Montana conditions and suitable for both domestic and export markets. We provide 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. Farmers need new and better hard red spring wheat cultivars with excellent qualities to ensure that Montana wheat retains or increases its share of Asian and domestic markets. The goals of selection are high grain protein and gluten strength, high flour extraction and low ash content, good dough mixing and bread baking quality, and superior noodle color and texture.

Bread-making characteristics, especially dough strength and extensibility, are considered when evaluating spring wheat cultivars. The Asian noodle market is an important business market. The quality of noodles made from different wheat samples is evaluated on entries from nurseries. 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.

Barley research will continue to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. The MSU barley improvement program uses quality field research technologies, extensive on-station and on-farm trials, and state-of-the-art genomics tools to develop well-adapted, high yielding barley cultivars for farmers in Montana and the Western U.S. MSU recently released new feed, forage, and malt barley cultivars for Montana's production environments that will provide added value to growers throughout the Northern Plains. Barley cultivars with improved feed quality could provide sustainable feed and grain markets for regional grain producers and marketing advantages to regional beef producers. 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.

Projects are underway to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. Preliminary results have demonstrated that we can modify plant viruses and other protein cage architectures to impart novel functions as nano-templates for nano-materials fabrication with applications in drug delivery, in 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.

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. Scientists are working to identify the genes involved in control of inflorescence development to provide new approaches to breeding practices or transgenic manipulation.

Program # 6 Food Safety -- Sustainable Agriculture

Situation: Basic principles of sustainable agriculture are to investigate current agricultural practices and to find economically feasible and environmentally friendly alternatives to those practices without compromising the ability of future generations to meet their own needs. Farmers and ranchers in Montana historically have practiced sustainable production methods due to the marginal opportunities for success in a semi-arid climate. These include optimizing the use of chemicals for pest control, using alternative tillage systems, and increasing crop diversity. Camelina and safflower for oil and meal production have demonstrated high overall adaptation to dryland conditions.

Priorities: Research conducted in sustainable agricultural projects support our priority to develop competitive, sustainable, and viable plant and animal systems for Montanans. 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 (peas, lentils, chickpeas, and soybeans), herbs, mustard, safflower, sunflower, canola, turf grass, and specialty grains. Increasing crop diversity will improve the economic well-being of dryland agricultural producers in Montana and the Northern Plains. Native Americans represent the largest group of potentially underserved citizens in Montana and comprise 6.4% of the population of the state. 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. Cooperative efforts with MAES provide resources and training to Native Americans in the areas of livestock testing, certification, childhood obesity, nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification, and social skill building. MSU research provides the technology that improves plant and animal production systems while adding value and improving food security for stakeholders. Initiatives will provide new insights into food safety and risk assessment. Consumer demand for omega-3 rich products

is escalating throughout the U.S. Montana camelina oil is currently being used for commercial production of omega-3 rich pet feeds and supplement, omega-3 rich eggs, cosmetics including lotions, massage oils and soaps, and culinary oils. Omega-3 enriched meat products have higher market value than traditional meat products. Direct return to the poultry industry for omega-3 enriched eggs is 50% higher than for traditional eggs.

Input: Surveys at farm conferences in Montana highlight strong producer interest in increasing 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. Partnerships have been created among producers, the agricultural industry, faculty, and other institutions in the region. These partnerships provide outreach activities related to biobased products and food science. Input from focus groups and meetings of stakeholders are used to identify strategies for marketing safe agricultural commodities and consumer products.

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. Winter and spring peas, canola, corn, lentils, mustard, sunflower, triticale, and chickpeas are included in long-term rotation studies. Several new cultivars of *Camelina sativa* have been developed, new uses for camelina oil and meal are being evaluated, two new selections/cultivars of high protein oats have been developed, and new oil products for fuel, food, feed, enzymes and lubricants are being investigated. Oilseed crops continue to represent important new sources of income for farmers and provide opportunities for increasing crop diversity.

Two major initiatives address the needs of Montana livestock producers: targeted grazing (TG) and sustainable beef supply (SBS). The beef industry is evolving towards a more consumer-oriented focus with greater emphasis on documented management practices which result in safe and consistent end products. This requires a team effort to deliver educational programs and to develop a data base for documenting best management practices, such as source- and age-verification of calves for export markets. Beef Quality Assurance (BQA) and bio-security are designed to provide production benchmarks to prevent the introduction and spread of common cattle diseases by documenting health and nutritional management.

Research on feed and supplements fed to lambs is being conducted to produce lambs with higher levels of unsaturated fatty acids in the lean tissue. 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. Studies are established to further define grazing parameters in rangeland that maintain profitable agricultural enterprises while sustaining ecological systems. The SBS was established to return additional revenue to cattle producers and meet consumer needs in Montana.

As the climate changes, the need for new cultivars of Montana crops will increase. Barley, the most durable and adaptable of the cereals, will likely see increased production in a warmer, drier world. The barley cultivars we produce are selected to be more productive and to produce higher quality grain in drier climates. A research project is in place that will contribute crop growth data from a water-constrained climatic situation, thus increasing the accuracy and robustness of crop growth models for spring and winter crops. The models will provide key crop growth data for managing cropping system strategies under "most probable" altered climate scenarios for the northern Great Plains. Understanding the relationships among agriculture-biofuel production, carbon sequestration, and natural resource conservation, as well as traditional commodity production, U.S. agriculture can react effectively and sustainably to climate change, world market dynamics, and world population growth. Because these processes occur over a broad range of time and space, we will study how energy and materials move through agro-ecosystems at multiple scales over the 10-year project period of the research.

Research is providing growth opportunities for rural Montana. 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 Great Northern Grower Cooperative has established an oatmeal processing facility and is distributing high-protein, gluten-free oatmeal. Fenugreek, an annual legume, shows promise as a nutraceutical feed for geriatric and athletic horses. Teff is being developed as a source of gluten-free flour. Canola, chickpeas, fenugreek, camelina, and assorted herbs have been evaluated for their potential in emerging value-added markets. Technology transfer collaborative relationships have been developed. Collaborators have expertise in incubating new and existing products and businesses.

Program #7 Climate Change -- Water Quality and Use

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

In a semi-arid state most crops are dependent upon irrigation from surface water and groundwater. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for their water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 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 our crop breeding programs, water management research, the introduction of new drought tolerant crops, and 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. 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. Low-stress herding and strategic supplement placement can help protect streams' riparian areas and help increase uniformity of grazing by cattle on extensive pastures with rugged terrain. Integrating multiple distribution management practices may be more beneficial than implementing individual practices.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	300.0	0.0
Actual	0.0	0.0	347.3	0.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- 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 COA department heads, includes the principle investigator's (PI) department head, MAES administrator, one department peer reviewer and two additional faculty external to the PI's department. 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 review can be written for a 5-year period. No Agricultural Experiment Station funds are allocated outside of the COA, consequently external expert review occurs with Montana State University-Bozeman faculty external to the COA, as a requirement of the review process. The seminars are announced, 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-NIFA for final approval. We have changed the method for data collection on FTE. This accounts for the large change in FTE between last year and this year.

III. Stakeholder Input

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

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

Brief explanation.

The Montana Agricultural Experiment Station (MAES) and COA obtain stakeholder input on research priorities and programs. Stakeholder committees have been formed that include the College Development Board, sustainable agriculture focus group, MAES State Advisory Council, Ag Coalition and other state and local groups. MAES scientists routinely participate with this group and NRCS to provide training and expertise in GPS, GIS and remote sensing with geospatial applications. The Ag Coalition consists of representation from the Agricultural Business Association, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, Montana Water Users, Montana Wool Growers, Seed Growers, and the Seed Trade. It meets every six months with the Dean and Director to review program priorities, new initiatives, fundraising efforts, and legislative activities. Meetings are advertised via news releases, newsletters, individual letters, and announcements at group meetings. Extension agents are instructed to use county profile information to make sure that the people invited to the sessions would reflect the diversity of the area. The MAES responds to stakeholder inputs by considering their proposals at research planning meetings with scientists, advisory groups, and administrators. 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.

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

1. Method to identify individuals and groups

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

Brief explanation.

Each of the seven agricultural research centers has a local advisory group that meets multiple 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 annually direct and fund research activities that have multiple meetings and communications.

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

1. Methods for collecting Stakeholder Input

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

Brief explanation.

Through our direct participation with agricultural stakeholder groups, broad participation in committees, and directed meetings, MAES listens to and considers defined problems or questions

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

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

Brief explanation.

As a Land Grant Institution, Montana State University has a solid foundation of past and future program activities that allow stakeholder input and strong interactive dialogue. The COA and MAES are leaders in this regard. We are the primary conduit for connection and delivery of education and new knowledge in agriculturally-related activities throughout rural Montana.

Brief Explanation of what you learned from your Stakeholders

Stakeholders approve of current program direction and provide direct input that has been (or will be) implemented through new hires with new program focus.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	2430303	0

2. Totaled Actual dollars from Planned Programs Inputs				
Extension			Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	2145973	0
Actual Matching	0	0	12174318	0
Actual All Other	0	0	20164391	0
Total Actual Expended	0	0	34484682	0

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

V. Planned Program Table of Content

S. No.	PROGRAM NAME
1	Food Safety -- Agronomic and Forage Crops
2	Food Safety -- Animal Health
3	Food Safety -- Biobased Products and Processing
4	Global Food Security and Hunger -- Integrated Pest Management
5	Global Food Security and Hunger -- Plant Breeding, Genetics and Genomics
6	Food Safety -- Sustainable Agriculture
7	Climate Change -- Water Quality and Use

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Food Safety -- Agronomic and Forage Crops

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			25%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			10%	
205	Plant Management Systems			25%	
601	Economics of Agricultural Production and Farm Management			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	20.0	0.0
Actual	0.0	0.0	41.3	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	249225	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1600730	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2166450	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target 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 outreach and commodity group meetings, conferences, and field days.

V(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2000	2500	0	0

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

Patent Applications Submitted

Year: 2010

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	8	22	30

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2010	43

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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 Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The establishment of new value-added crops and the development of higher yielding crop varieties are priorities among agronomic researchers and crop producing stakeholders. Reducing Montana's dependence on small grain monocultures can potentially increase on-farm receipts.

What has been done

Producers are investing in and harvesting more feed crops, including barley hay and forage legumes. The development and establishment of high-value, alternative crops continue to gain momentum in Montana with close involvement among research, extension, and stakeholders. 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. Camelina is an effective rotation crop for small grains with the potential for breaking disease and pest cycles. Camelina production could significantly reduce the cost of biodiesel and provide a source for omega-3 oil. We continue to collaborate with other states in generating data required for product registration on new crops or new pests.

Results

Over 150 germplasm accessions of camelina have been evaluated for adaptability, yield potential, and fatty acid content. An additional 200 accessions of camelina obtained from international gene banks and 50,000 mutant lines are being evaluated for increased omega-3 fats and total oil content. 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. Crop diversity studies continue to show promise for increasing on-farm receipts while reducing a monoculture of small grains. Some examples of new crops and alternative varieties of new crops include winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea which are included in long-term rotation studies and plant

adaptation trials.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #2

1. Outcome Measures

Number of new crops and varieties adopted per year.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers need to continue to evaluate alternative crops due to increasing production costs and price competition in small grains. Reducing dependence on small grain monocultures can potentially increase on-farm receipts.

What has been done

With the MSU focus on new crop development, several new or improved crops have been adopted by Montana producers. Also, value-added characteristics are being researched in small grain varieties that will improve the attractiveness of Montana grains to foreign and domestic markets.

Results

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 (peas, lentils, chickpeas, and soybeans), herbs, mustard, safflower, sunflower, canola, turf, and specialty grains. Organic farming represents a new economic opportunity for farmers in the Northern Great Plains because of growing consumer demand. Studies are providing new information to organic growers on strategies for enhancing soil fertility that will enhance the

sustainability of organic farming systems in this semiarid region.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	5000	9500

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers need to continue to evaluate alternative crops due to increasing production costs, increasing pest populations, and price competition in small grains. Alternative crops allow producers to examine tillage, management of water resources, and markets in order to produce the maximum returns on their investments.

What has been done

With the MSU focus on new crop development, several new or improved crops have been adopted by Montana producers. As a joint effort among the outlying research stations, plant breeders, and research scientists, new small grain cultivars and new alternative crop cultivars have been developed.

Results

Montana continues to capture the attention of foreign buyers due to the high quality wheat that is grown and research that is designed to improve the characteristics of the grains. Flax acreage increased in 2010 by over 37% and production by 60% over 2009. The production of camelina (*Camelina sativa*) in Montana increased 35% in 2010 to nearly 255,000 acres. New contracts with biodiesel producers in 2010 encouraged growers to consider camelina as a viable alternative to

other dryland crops.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
601	Economics of Agricultural Production and Farm Management

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	750	3487

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana State Seed Laboratory provides seed testing services to regional farmers, seed growers, the Montana Seed Growers Association, the Montana Department of Agriculture, and anyone with an interest in having seed tested. With today's narrow profit margins in agriculture, seed testing is an essential part of an overall crop management and production plan.

What has been done

Samples of seed are tested by the Montana State University Seed Lab for purity, germination, noxious weed seeds, restricted weed seeds, total weed seed content, and seed from other crops.

Results

The Montana Department of Agriculture Seed Program assures farmers, gardeners, and homeowners that seeds offered for sale in Montana are truthfully labeled for identity, contamination, and viability. The program encompasses license requirements, label requirements, seed dealer inspections, and seed sampling. These two programs provide a foundational partnership for quality seed production.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems

Outcome #5

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	10	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana livestock producers need operations that are sustainable, that protect land and water, and are profitable. Rangeland grazing represents an important resource for producers who need to reduce costs and maintain livestock production. Livestock grazing practices are receiving increasing attention because of perceived negative impacts on soils, biodiversity, and water quality. Feeding hay in winter represents the greatest percent of variable costs for producers in cold climates. Producers need information on approaches to reducing costs while maintaining the health of cows and unborn calves.

What has been done

Ranches have been certified and have established grazing plans for the watersheds that they utilize. Research has examined cost-effective strategies for using prescribed sheep and goat browsing to suppress conifer encroachment onto foothill rangeland and for using sheep to control invasive weeds.

Results

Grazing plans have been established and distributed to producers across the state. Cattle/wildlife interaction studies have been used to assist producers in determining the best ways to protect their rangeland resources from overgrazing. This is a labor intensive partnership on behalf of MSU personnel and individual landowners or family operations. A total program effort has been implemented to facilitate the incorporation of targeted grazing strategies into weed management programs. Research has shown that by manipulating cattle grazing patterns, fisheries and wildlife habitats can be protected and improved. Because ranching enterprises make major contributions

to wildlife habitat, their viability is important to the preservation of wildlife habitat. The program direction and funding for this effort has been decreased which will further decrease activities.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
121	Management of Range Resources
205	Plant Management Systems
601	Economics of Agricultural Production and Farm Management

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Grazing options are often compromised by drought, lack of access to private or public lands, and by severe weather. While these factors do not affect all producers, they require increased management on the part of the most livestock owners. New wilderness designations and stream access policies are legislative issues that affect grazing rights for ranchers.

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

Evaluation Results

Evaluation studies are in progress.

Key Items of Evaluation

The backlog of ranches requesting assistance has been eliminated. Future funding and program direction will reduce activities in this area.

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Food Safety -- Animal Health

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 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 (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	100.0	0.0
Actual	0.0	0.0	121.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	609603	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2627048	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	10832396	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Create databases that are easily accessible by researchers and producers in order to make research results readily available
- Distribute papers and research results at state nutrition conferences, field days, county meetings and state conventions
- Prepare research articles, fact sheets, and news releases for scientists and state media
- Hold strategic planning meetings with state agricultural groups
- Develop systems that ensure food safety and agricultural security
- Conduct training in cooperation with Montana Beef Quality Assurance standards and the SBS program

2. Brief description of the target audience

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

V(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	850	1300	0	0

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

Patent Applications Submitted

Year: 2010
 Actual: 1

Patents listed

Robert Cramer. ATM1 as a Target for Treating animals and Plant Fungal Infections. Submitted November, 2010. [Provisional patent application]

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	5	85	90

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2010	15

Output #2

Output Measure

- Building built through donations

Year	Actual
2010	1

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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 Measures

Identify critical infection and resistance processes.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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. Animal losses due to disease create the need for an improved understanding of factors affecting Montana livestock.

What has been done

Disease management and research programs that increase the quality of meat, milk, and fiber products continue to be high research priorities. MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef that is raised. Research and educational programs continue to address the animal health, biosecurity, and production efficiencies concerns expressed by producers and consumers. Research is being conducted to define the pathway of prion agents following infection and to improve our understanding of how the agents are transmitted within the host. Infectious disease research at MSU focuses on understanding the biology of each specific group of infectious agents and learning how these specific microbes produce disease when infections are established in people or animals.

Results

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 control of coccidiosis in livestock. Rotavirus is the most important viral agent of neonatal diarrhea and generally affects calves less than six weeks of age. We are investigating new vaccines that have potential to develop into effective controls of these agents. A focus on disease management, reproduction, and carcass traits help ensure that Montana meat products maintain the highest standards. 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. Mastitis remains one of the costliest diseases of the dairy industry. MSU researchers are developing a better understanding of mammary defense mechanisms to establish effective therapies.

4. Associated Knowledge Areas

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

Outcome #2

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	10	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Food safety and security have become important concerns for the beef industry at all production levels. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal. MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef that is raised.

What has been done

MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef that is raised. Research and educational programs will continue to develop to address the animal health, biosecurity, and production efficiencies concerns expressed by producers and consumers. Extension and research efforts have resulted in outreach programs that include beef quality education, feeder calf health certification, and information return and management from the packing plant.

Results

Our targeted grazing (TG) effort is a cooperative project between Montana Wool Growers Association and MSU and is dedicated to developing and implementing non traditional strategies that increase the competitiveness of Montana lamb and wool in the world market. A successful TG program causes significant damage to the invasive weeds with limited damage to the surrounding vegetation. TG efforts are usually integrated with other control methods as part of an overall weed management strategy. The sustainable beef supply (SBS) program was established to return additional revenue and provide current information to cattle producers while meeting consumer needs in Montana and the nation. The SBS uses its resources to undertake research and educational issues that are of immediate concern to Montana beef producers (biosecurity, beef quality assurance, animal verification, feed efficiency). With the SBS program in place, Montana producers can more easily adapt to traceability systems and national animal ID programs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
301	Reproductive Performance of Animals
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #3

1. Outcome Measures

Number of novel vaccines developed per year.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Brucellosis (*Brucella abortus*) remains a threat to the health and well-being of livestock in Montana, Idaho, and Wyoming. Cohabitation of infected wildlife (elk and bison) with cattle has compromised Montana's brucellosis-free status. There are no efficacious brucellosis vaccines for bison, and current vaccines are only partially effective in livestock.

What has been done

MSU researchers are working to develop a better vaccine, but their efforts are complicated by the fact that *Brucella abortus*, the bacteria that causes brucellosis, is closely watched and controlled by the federal government for fear that it could be used in a biological attack. That makes testing vaccines difficult, since researchers cannot run tests on large animals or on a large scale. Studies have produced new subunit and live vaccines that are 75% effectively in bison and about 70% protective in domestic cattle.

Results

Viral pneumonias cause substantial morbidity and mortality in the cattle industry creating a need to develop effective vaccines for these diseases. MSU is testing a mucosal vaccine delivery system to provide the basis for future vaccines.

4. Associated Knowledge Areas

KA Code	Knowledge Area
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Animal losses due to environmental stresses, disease, and death create the need for an improved understanding of factors affecting Montana livestock. Infectious disease causes considerable loss for livestock producers by reducing production of animal units and by reduced sales because of food safety concerns. Disease outbreaks are closely monitored in Montana to ensure quality and disease-free calves are shipped to other states. Investigating the mechanisms by which calves resist lung infections will help us better understand why these calves become susceptible to infection.

What has been done

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 benefit all Montana livestock producers. Immunology and Infectious Disease (IID) at MSU is the only research unit in Montana focused on animal health, particularly the study of infectious diseases of cattle.

Results

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 result in fatal degeneration of the central nervous system. Research is being conducted to define the pathway of prion agents following infection and to improve our understanding of how the agents are transmitted within the host.

4. Associated Knowledge Areas

KA Code	Knowledge Area
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #5

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Food safety and security have become important concerns for the beef industry at all production levels. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal. MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef that is raise.

What has been done

Educational programs on beef quality assurance (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.

Results

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. Traceability of livestock through the production chain can add substantially to the cost of production. Methods are being developed that facilitate traceability of livestock at minimal additional expense to the producer while enhancing the benefits associated with participation in animal identification programs. Tracking will provide both source and process verification for easy trace-back in case there is a disease outbreak. A major effort is being directed to find alternative solutions to reducing the cost of animal identification technology. Decreasing input costs and increasing production revenues will help producers achieve higher quality products, generate more income, and maintain Montana's position in the world livestock market.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

The loss of Montana's "brucellosis free" status has created increasing demand for vaccines that can be administered to livestock or wildlife. Maintaining Montana's presence as a primary source of calves for the feeding and finishing markets is compromised by the change in status. While weather conditions and market strength affect the sustainability of the livestock industry in Montana, efforts at MSU continue to offset these factors with the development of new approaches to disease and livestock management.

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

Evaluation Results

Disease outbreaks have been minimized and quarantines implemented.

Key Items of Evaluation

Cooperation with the State of Montana Livestock Veterinarian has produced programs to control and eradicate animal diseases and prevent the transmission of wildlife diseases to livestock, thereby protecting the livestock industry from significant long-term negative economic impacts.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Food Safety -- Biobased Products and Processing

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			30%	
511	New and Improved Non-Food Products and Processes			30%	
605	Natural Resource and Environmental Economics			10%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			20%	
903	Communication, Education, and Information Delivery			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	8.0	0.0
Actual	0.0	0.0	7.8	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	81402	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	388155	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	277146	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MSU research seeks to:

- 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
 - Develop sustainable fuels from crops grown in Montana

2. Brief description of the target 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(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	800	1150	0	0

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

Patent Applications Submitted

Year: 2010

Actual: 2

Patents listed

Gary Strobel. #7,858,362 Use of Fusarium to Treat Human Wastes. December 28, 2010

Gary Strobel. #7,774,203 Muscador spp. for Use in Human Waste Remediation. July 13, 2010

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	0	10	10

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Actual
2010	1

Output #2

Output Measure

- Number of research citations

Year	Actual
2010	9

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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.
6	Number of biofuels developed from existing crops in Montana
7	Number of new crop options introduced for biofuels in Montana

Outcome #1

1. Outcome Measures

Number of SBIR funding proposals submitted to federal agencies.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Small Business Innovation Research (SBIR) grant proposals are prepared by MSU-COA, university, and non-university personnel. SBIR funds early-stage R&D at small technology companies and is designed to stimulate technological innovation, increase private sector commercialization, increase small business participation in federally funded R&D, and foster participation by minority and disadvantaged firms in technological innovation. Montana companies benefit from this available funding source.

What has been done

Through efforts in the biobased products and processing programs at MSU, several companies have taken new product innovations and created viable businesses, including new value-added products, products from new crops, and other state-of-the-art research.

Results

Montanans and others have benefited from research innovation and discoveries made from new products, new markets, and new dietary products with new Montana crops (e.g. gluten-free flour) and long-established agricultural commodities. Camelina was introduced as a sustainable energy crop. Camelina oil can be used for production of biodiesel or as omega-3 oil and camelina meal can be used for production of omega-3 enriched livestock. The expansion of camelina production across Montana has driven establishment of both small and large oil extraction and biodiesel manufacturing facilities. Omega-3 enriched livestock has higher market value than traditional livestock.

4. Associated Knowledge Areas

KA Code	Knowledge Area
502	New and Improved Food Products

Outcome #2

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana stakeholders are interested in the development of new crops and new uses for crops. MSU researchers investigate new technology, new crops suitable for production in Montana's climate and soil conditions, and mechanisms to add value to existing cropping systems. Programs strive to be innovative and responsive to the developing needs of the State of Montana and the Pacific Northwest/ Northern High Plains. The primary objective of our research is to develop value-added, agriculturally based end-use products with a competitive edge in the global market that are suitable for production in rural Montana.

What has been done

Efforts in the biobased products and processing programs support cutting-edge research and outreach to improve the profitability of Montana agricultural through enhancement of current production and development of new value-added applications and products.

Results

Current value-added products being evaluated include biocontrol agents on plant diseases, biobased highway de-icer, biodiesel, biofuel pellets, cellulosic ethanol, and gluten-free crops. OmegaMontana eggs are commercially available across Montana. Direct return to the producer is 50% higher for these eggs than traditional eggs. Wheat Montana LLC has evaluated camelina oil in bread that will have a higher return per loaf than their existing products. Several new cultivars of camelina have been developed, and new uses for camelina oil and meal are being evaluated. As camelina acreage grows, the need for new varieties becomes apparent in order to meet the need for renewable and clean sources of industrial lubricants. Additional new crops or varieties developed by MSU include high protein oat (PrOatina), gluten-free Teff, high-yielding soybean, fenugreek, and gluten-free timothy. The development of value-added high oleic and high linoleic safflower varieties is a current project that will increase crop sustainability and proved new

products to commercial producers of edible oil, cosmetics, biofuel, birdseed, supplemental fat for livestock rations, and other end-use U.S. and foreign markets.

4. Associated Knowledge Areas

KA Code	Knowledge Area
502	New and Improved Food Products
511	New and Improved Non-Food Products and Processes

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers are attracted to new innovations that can better utilize their farming operations and provide additional profits. Start-up industries in Montana often rely on MSU research to develop ideas for new products that can be marketed from crops grown in the State.

What has been done

Research projects have been funded that strive to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy product development activities.

Results

One project has successfully produced alternatives to solid wood (log and chip) using agricultural crop residue in making biobased pellet fuels for residential stove and commercial boiler burning. Biobased processed engineered fuels can be manufactured to take advantage of materials that are common to Montana agricultural areas. The oilseed crop, camelina, can be added to boost the BTU output. Research conducted at the Western Agricultural Research Center (WARC) is investigating production methods for specialty crops that can be used in value-added biobased products. The production of essential oils, culinary and medicinal herbs, and spice crops provides an opportunity for Montana farmers to diversify their agricultural operations particularly with small

acreage landowners in western Montana. Research is impacting rural Montana. 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 Great Northern Grower Cooperative has established an oatmeal processing facility and is distributing high-protein, gluten-free oatmeal.

4. Associated Knowledge Areas

KA Code	Knowledge Area
502	New and Improved Food Products
511	New and Improved Non-Food Products and Processes

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

A major goal of the projects in biobased products and processing programs at MSU is to develop systems that enhance food safety and agricultural security for U.S. and global consumers. Food safety has also become a concern for the beef industry at all production levels. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent food safety events.

What has been done

Recommendations for food safety are made available to food processors, schools, consumers through different departments at MSU. Using the processes and organizational structure developed by the sustainable beef supply (SBS) program, research and educational programs continue to develop an animal identification and traceability system to address the animal health, biosecurity, and food safety concerns expressed by producers and consumers.

Results

In addition to publications, researchers have developed food products for individuals who may not be able to consume traditional grains. Flour developed from Indian ricegrass (Montina flour) at MSU is now produced and distributed by a Montana cooperative. The development of gluten-free crops, such as high-protein oat and timothy grass, provides food options for those sensitive to gluten. Timothy flour is highly nutritious, gluten-free and can be used to produce a variety of baked products. Research-based information on food safety and other food management principles are made to producers through conferences and producer meetings. Research in organic farming is aimed at promoting economic and environmental sustainability. Research is providing producers with value-added high oleic and high linoleic safflower cultivars for commercial production of edible oils, cosmetics, biofuel, birdseed, and supplemental fat for livestock rations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana and neighboring state industries are seeking innovative markets for new biocontrol tools and new crops, such as camelina, that have been catalyzed by MSU. These industries work directly with the MSU to explore potential licensing for various products.

What has been done

Over 150 available accessions of camelina have been screened for fatty acid profile, total oil content, and total glucosinolate content. Oilseed crops continue to represent important new sources of income for farmers and provide opportunities for increasing crop diversity. The

development of value-added high oleic and high linoleic safflower varieties is a current project that will increase crop sustainability and provide new products to commercial producers of edible oil, cosmetics, biofuel, birdseed, supplemental fat for livestock rations, and other end-use U.S. and foreign markets.

Results

Public policy survey results suggest that producers preferred policies that promised to support agriculture and agriculture's opportunity to grow within a changing environment. Producers' preferences for pursuing new forms of support for specialty crops and creating new risk management tools shows a general preference for policies that focus on addressing emerging issues.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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

Outcome #6

1. Outcome Measures

Number of biofuels developed from existing crops in Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	{No Data Entered}	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The development of bioenergy alternatives will provide opportunities for renewable biobased products and will help to reduce the current dependence on fossil fuels. Consumers are looking for alternatives to fossil fuels in order to reduce our dependence on those fuels and to reduce the potential greenhouse gases associated with them.

What has been done

MSU projects are evaluating various cool and warm season cereal crops for yield potentials in Montana with the intent of maximizing biomass production for the production of ethanol. Crops designated for biodiesel production include canola, camelina, and mustard. A significant potential exists in the Pacific Northwest for the production of canola seed and its use as a biolubricant. 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.

Results

Biobased processed engineered fuels (typically in pellets, briquettes, or logs) can be manufactured to take advantage of materials that are common to local Montana areas.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Number of new crop options introduced for biofuels in Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	{No Data Entered}	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Goals are to improve the quality and diversity of agricultural commodities, expand production and pest management strategies with reduced inputs, identify and develop new Montana crops, and develop biofuels and energy alternatives. By increasing productivity in a biobased economy, there is positive effect on manufacturing, product development, rural development, job opportunities, and farm and ranch incomes.

What has been done

Initiatives provide new insights into the use of vegetable oils as feedstock for fuel cells, the development of new wheat cultivars for the production of ethanol, non-corrosive biobased de-icers, and the optimization of ethanol production from other feedstocks. We have 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.

Results

Research projects 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 is to add value to existing Montana products and to commercialize new products, while maximizing our limited resources and reducing reliance on commodity agriculture.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Normal delays in the development of biocontrol products and the challenges needed to obtain product registrations at the USEPA extend the time needed for innovative research to become commercially viable products. With the granting of emergency uses for biocontrol products, the time to market has been substantially reduced.

- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- 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(I). Planned Program (Evaluation Studies and Data Collection)

Evaluation Results

The success of the biobased products and processing projects has been demonstrated in the substantial and growing interest from agricultural producers and

consumers. The general acceptance of ethanol-based biofuels has increased the interest in the production of camelina and other feedstocks. Growers are adjusting acres of small grains to accommodate this new crop. A major challenge at this juncture is the lack of chemical products labeled for use on alternative crops and the fluctuating prices offered for small grains. Montana is collaborating with other states through the IR-4 program to obtain labels for pesticides used in camelina.

Key Items of Evaluation

Evaluations are on-going through interactions at winter meetings.

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Global Food Security and Hunger -- Integrated Pest Management

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 (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	65.0	0.0
Actual	0.0	0.0	55.5	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	321276	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2340434	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2186897	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Publications will be made available in print and online that provide pest control recommendations
- Regional management guides will be produced
- 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. Brief description of the target audience

- Crop producers, dealers, distributors, and 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(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1200	1500	0	0

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

Patent Applications Submitted

Year: 2010

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	12	88	100

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2010	30

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Actual
2010	56

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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 Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	3	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Transitioning to reduced impact and organic agricultural systems requires that a grower develop a management system that can successfully operate by integrating knowledge of cropping systems, soil and crop nutrition, weed and disease control, and marketing. The development of reduced risk management alternatives for the key pests of forage and seed alfalfa requires the monitoring of pollinators and natural enemies. Reducing dependence on insecticides through the development of cultivars that resist damage from pests is a priority in COA projects. As the organic industry grows domestically and internationally, price premiums will be critical for producers and for all participants in the organic food industry.

What has been done

Educational programs are being developed to provide grower education for integrating biological controls with conventional disease, weed, and insect management practices in potatoes, sugar beets, and other crops. The application of pesticides in specialty crops needs to be understood by growers and applicators, especially since many of the crop protection products are relatively new and are issued under special local need or emergency exemption labels. An emphasis on pest monitoring (using decision-making parameters and determining economic injury levels) will optimize the use of pesticides for controlling pests. Foreign trade partners especially want decreased pesticide residues in the wheat and barley exports.

Results

MSU is examining the integration of natural enemies, pathogens, and chemicals for management of sawfly and is developing new sources of host plant resistance. Research is ongoing to find additional environmentally friendly solutions for the management of soil-borne plant pathogens. The deployment of bio-fungicides could provide an important crop management tool missing in organic wheat production. Implementation of research results reduces risk and increases sustainability of organic farming in the northern Great Plains. Educational programs are providing

grower education for integrating biological controls with conventional disease management practices. Research is being directed toward identifying key mortality factors which contribute to the greatest annual losses of alfalfa leaf-cutting bee pollinators in Montana. Understanding the role of weed diversity and seedbanks in Montana cropping systems will help producers develop more effective weed control programs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

New IPM options discovered and evaluated per year.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana's stakeholders need new and improved methods for controlling insects, weeds, and diseases that challenge producers who produce 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 and organic food production. Stakeholders across the Northern Great Plains identified wheat stem sawfly, Fusarium crown rot, and grassy weeds as major factors threatening the economic and environmental sustainability of small grains primarily due to a lack of effective chemical management options.

What has been done

MSU researchers are examining the integration of natural enemies, pathogens, and chemicals for management of sawfly and are developing new sources of host plant resistance. Research is ongoing to find additional environmentally friendly solutions for the management of soil-borne plant pathogens. Projects evaluate natural enemies, pathogens, and the chemical ecology of wheat stem sawfly and its host plants and seek new sources of host plant resistance as tools for integrated pest management. Several fungal pathogens have been found that cause high levels of mortality in sawfly larvae and are being further developed for potential commercial uses. Research continues in the development of wheat cultivars that are less susceptible to damage from wheat stem sawfly.

Results

Novel sources of host plant resistance and promising agrochemical inducers may be incorporated into wheat stem sawfly IPM and plant breeding programs. For heavy infestations, biological control with parasitoids and pathogens is being developed for integration with the planting of partially-resistant solid-stem varieties. Research is being directed toward identifying key mortality factors which contribute to the greatest annual losses of alfalfa leafcutter bee pollinators in Montana. Additional work investigates colony collapse disorder (CCD) of honeybees, especially determining the role that *Nosema ceranae* infections may have in honeybee colonies.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

Number of broad-ranging stewardship practices implemented.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The increase in public concern about food safety, 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 and organic production. The management of diseases in potatoes and sugar beets is becoming increasingly difficult according to growers who participated in MSU sponsored meetings. Tribal members who are involved in agriculture need an awareness of how to be environmental stewards and preserve natural resources, particularly in irrigated systems.

What has been done

Programs have been established to investigate low impact control options and promote sustainable practices utilizing biological controls. Difficult-to-control pests require producers and researchers to evaluate new IPM methodologies in order to maintain a competitive position while helping to alleviate global hunger. Integrated disease management programs are in place for potatoes and sugar beets that profitably provide growers with management programs using biological, chemical, and host plant resistance options. MSU projects have identified effective and economical biological controls that will help growers manage plant diseases using methods that are safer to humans and the environment. An MSU program provides programming in sustainable agricultural practices combining grazing intensity with preservation of water, native plants, fisheries and wildlife.

Results

Workshops in forest management and stewardship have been completed. Surveys of participants indicated that the majority took home new ideas and tools that helped them better meet their property objectives. Owners had their stewardship plans reviewed and updated through this process. We have demonstrated that mycofumigation using *Muscodor albus*, or synthetic gases that mimic the natural gases, provides excellent control for a wide range of fungal, bacterial, and nematode pathogens, especially in potatoes and sugar beets. The research provides a basis for organic and other growers to control soilborne plant pathogens. The development of a quick and accurate electronic field identification system will aid growers, crop advisors, extension agents, diagnosticians, and others associated with crop production with a multi-entry, multi-media, commodity-based electronic key to aid in the identification and management of pests of small grains, including weeds. To promote good forest stewardship and healthy forests across Montana we have established a program to recruit, train, and maintain forest landowners who will actively manage their forested lands for multiple resource conservation objectives that are sound and scientifically based.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

Passing rate percentage for pesticide application licenses.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	70	90

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

As a minimum requirement for certification, private applicators must show that they possess a practical knowledge of the pest problems and pest control practices associated with their agricultural operations. Also they must be familiar with proper storage, use, handling, and disposal of pesticides and containers use them legally and responsibly.

What has been done

Training programs are available to private and commercial applicators who wish to become certified. A private applicator applicant needs to complete the 50 question open book Montana Private Applicator Certification Exam at their local extension office and pass it with a grade of 70% or better. The Montana Department of Agriculture (MDA) oversees a wide variety of pesticide programs ranging from pesticide education, pesticides, and groundwater to licensing pesticide products and commercial pesticide applicators.

Results

Extension publications, training programs, and application clinics are supported by MSU staff and faculty for private and commercial applicators. To become certified for the first time, private applicators must either attend an approved training program or pass an exam administered by an authorized representative of the MSU Pesticide Education Program, usually the local County Extension Agent. Materials are continually updated to ensure that producers and applicators understand the latest innovations in integrated pest management systems and equipment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

New products registered.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Stakeholders are interested in new and innovative ways to control pests in crops and rangeland. Manufacturers of pesticides and biocontrols must often wait several years before their products can be used on Montana farms. An active monitoring and testing program at MSU ensures that all available control methods are made available to producers in the state via requests for federal, state, or emergency labeling.

What has been done

MSU research and extension personnel cooperate with the Montana Department of Agriculture and manufacturers to support the registration of new products via Section 3, Section 18(c), and Section 24(c) guidelines of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) administered by the USEPA.

Results

Products under development by chemical manufacturers are routinely included in herbicide, insecticide, and fungicide screening trials across the state. Results are used in developing pesticide labels, fine-tuning rate structures, and obtaining emergency labeling as appropriate.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 Measures

Number of potential products/practices evaluated.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	3	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Comparing biological and agricultural risk assessment from biotechnology crops, pesticides, and invasive species allows producers to selectively use a variety of management systems. Risk assessment is an important discipline to provide a better understanding to producers of the ecological and human-health risks associated with pest management options. Incorporating biopesticides into insect management plans can conserve natural enemies and pollinators. Preserving the quality of grain during storage includes the management and control of insect pests. Management of weeds in rangeland includes research in several management areas, including prevention, chemical, mechanical, and biological control, prescribed burning, and revegetation.

What has been done

The purpose of one study is to examine the impact of several reduced-risk biopesticides on alfalfa insect pests, natural enemies, and pollinators, while assessing alfalfa seed damage and seed yield. The research provides growers with information on the efficacy of alternative pesticides to be used in seed alfalfa for control of lygus bugs, aphids, and alfalfa weevils, while minimizing impacts on natural enemies of these insects and on pollinators, both managed and native. Researchers are also determining factors that favor soil-inhabiting forage pests on alfalfa stand longevity. A multistate partnership focuses on insecticidal and non-insecticidal approaches in laboratory and large-scale field trials. The primary focus of entomological research will be to ensure reduction of grain storage losses at a lower cost than conventional chemical methods with less reliance on chemicals.

Results

Educational outreach programs for adoption of reduced-risk insecticides in the seed alfalfa production system are being established. Ecological and human-health risk assessments of emerging infectious diseases and insecticides used to control disease vectors have revealed science-based risks and the uncertainty and variability associated with each risk type.

Lepidopterous insects represent one of the largest insect pest groups of food and fiber crops worldwide. Sex pheromones have been identified from hundreds of moth species and are used in IPM programs as lures to monitor and trap pest species and to disrupt mating.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Demanding government regulations on the approval of new pest control options continue to be a challenge for manufacturers and researchers to obtain registrations for new products. The demands of producers who grow crops organically require innovative pest and fertility solutions often requiring the use of biocontrols and alternative nitrogen sources. Organic farming and the introduction of non-traditional crops create a need for MSU researchers to delve into new non-traditional approaches to managing crop production.

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

Evaluation Results

Evaluation studies are in progress.

Key Items of Evaluation

Evaluation studies are in progress.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Global Food Security and Hunger -- Plant Breeding, Genetics and Genomics

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			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 (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	30.0	0.0
Actual	0.0	0.0	41.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	267774	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1605765	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1871927	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- 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. Brief description of the target 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(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2400	800	0	0

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

Patent Applications Submitted

Year: 2010
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	14	29	43

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Actual
2010	10

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Actual
2010	5

Output #3

Output Measure

- Number of research citations

Year	Actual
2010	16

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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 Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Grain producers in Montana rely on research at MSU for the development of new genetics and cultivars adapted to Montana's climate. New disease and insect resistant wheat and barley cultivars, new cultivars with value-added traits, and new crops weigh heavily in the priorities of Montana stakeholders.

What has been done

We recently released four feed, forage, and malt barley cultivars that fit Montana's production environments and that provide added value to Montana barley growers and to growers throughout the Northern Plains. MSU is developing multiple pest-resistant dryland alfalfa cultivars with good agronomic traits for Montana. In addition to alfalfa projects, efforts have been made to develop new grass cultivars suitable for Montana. Barley research continues to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. Successful genetic research is increasing the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and desirable end-use qualities.

Results

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. 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.

4. Associated Knowledge Areas

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

Outcome #2

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Reliable high quality wheat yield is essential for the long-term marketing of Montana products. The broader impacts of MSU research are a larger and higher quality food supply for the world, and an improved ability of Montana farmers to compete in a global marketplace. The goals of cultivar selection are to ensure that we select for high grain protein and gluten strength, high flour extraction and low ash content, good dough mixing and bread baking quality, and superior noodle color and textural characteristics.

What has been done

MSU researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs. We are examining the degree to which puroindoline proteins control wheat grain hardness and cereal quality and their effect on 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 utilization. Our research provides methods to analyze all lines of wheat to detect novel gene expression related to post-harvest resistance, which could lead to new strategies for post-harvest protection.

Results

Continued productivity of our breeding program will improve our understanding of the genetics of key traits and allow the development of new selection tools and plant varieties. Our research demonstrates that manipulation of puroindoline levels can create defined wheat grain hardness levels. Alterations in puroindoline content can generate desired milling and end product quality. Projects are underway to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. Preliminary results have demonstrated that we can modify plant viruses and other protein cage architectures to impart novel functions with applications in drug delivery and in Magnetic Resonance Imaging (MRI). These discoveries significantly contribute to our long-term goal of producing new therapeutic treatments using plant virus nanoparticles with direct benefits for human and plant health.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	0	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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 marketplace. Researchers evaluate germplasm and identify traits that produce wheat and barley cultivars that meet increasing world demands for quality, while maintaining yields for producers.

What has been done

The development and distribution of high quality, drought tolerant barley cultivars that provide the highest production potential is a priority of barley breeding programs. We have increased our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance. Our multi-state barley research focuses the disciplines of plant breeding, genetics, plant pathology, cereal science, molecular biology, and genomics for barley improvement in Idaho, Montana, and North Dakota.

Results

Based on average planted acreage and prices, development of an improved winter wheat cultivar which produces an additional one bushel per acre either by enhanced yield or reduced yield loss to disease, insects, or environmental stresses, potentially impacts the Montana economy by \$5-\$6 million, annually. Efforts have been made to develop new grass cultivars suitable for Montana. We have consistently maintained a positive annual statewide yield increase of 0.5 bushels per acre for spring wheat and winter wheat over the last 10 years.

4. Associated Knowledge Areas

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

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

MSU is a recognized international leader in the development of new cultivars of small grains sought by global buyers. Global traders want high quality wheat with characteristics that enhance their production of food products. Bread making characteristics, especially dough strength and

extensibility, are considered when evaluating spring wheat cultivars. Montana stakeholders rely on MSU new cultivar development to ensure that they can remain competitive in the global market. Small grains grown for ethanol production influences the cultivar selected by the grower whose goal is higher production and less attention to protein content.

What has been done

MSU has a high throughput of potential lines of winter and spring wheat through our breeding programs. 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. The use of small grains for ethanol production is a potential market providing a new source of sustainable energy fuels. Researchers work to improve animal and human nutrition, add value to raw products, improve safety of products, and increase product development of biobased chemicals, fuels, lubricants, pharmaceuticals, and nutraceuticals.

Results

We have been able to evaluate wheat varieties and conduct quality testing across different Montana environments with new varieties entering the market every four to five years. 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. 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. Cultivar selection for small grain ethanol yield focuses primarily upon grain yield at the expense of protein content. Projects are underway to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. Results have demonstrated that we can modify plant viruses and other protein cage architectures to impart novel functions with applications in drug delivery and in Magnetic Resonance Imaging (MRI). These discoveries significantly contribute to our long-term goal of producing new therapeutic treatments using plant virus nanoparticles with direct benefits for human and plant health.

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

Number of improved variety recommendations by districts across Montana.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	5	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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. Producers want the highest yielding and most pest resistant barley varieties as well. Montana is recognized for production of high quality bread wheat which is essential in maintaining domestic and foreign markets. The export trade in recent years has accounted for about 3/4 of our wheat market.

What has been done

One or two new small grain cultivars are released (or changed through a collaborative process) to growers every other year and the lower yielding or less desirable cultivars may be removed from the recommended lists based upon agronomic and pest responses. This keeps only those cultivars that will be the most beneficial for Montana growers. These decisions are made from a group of MSU faculty, seed growers, seed trade members, and state agencies. Variety recommendations are established each year for wheat (spring, winter, and durum) and barley for the six Montana growing districts and published in the Performance Evaluation and Recommendations guides by MSU-MAES.

Results

As wheat and barley cultivars are developed, information is reviewed by MSU researchers and the larger constituent groups for inclusion in the year's recommendations. These recommendations are made available to growers and seed distributors each year. New small grain varieties developed at MSU and other institutions are annually reviewed by MSU and other industry and state partners before releasing to the public. Additionally, new alternative crops are tested to determine suitability for Montana growing conditions. Several new varieties of Camelina sativa have been developed and two new selections/cultivars of high protein oats have been developed. Sawfly resistant wheat cultivars will prevent crop losses of 15-90% on 379,000 acres, and reduce harvest machine repair costs. Resistant cultivars are the highest producer-generated

priorities.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
205	Plant Management Systems

Outcome #6

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	3	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana crop producers want improved hard red and hard white winter wheat and barley cultivars that are adapted to Montana conditions, resist pests, and generate higher yields. Producers anxiously await new MSU cultivars when released.

What has been done

One or two new cultivars may be introduced each year to Montana growers. As new cultivars are introduced and accepted, the acreage planted of older cultivars (including those developed at MSU) goes down. New varieties are developed on-going at MSU and are annually reviewed by MSU and the Montana Wheat and Barley Committee before being released to the public and allied seed partners.

Results

As wheat and barley varieties are developed, information is reviewed by MSU researchers and recommendations made for the year. The top four varieties of winter wheat planted in 2010 account for nearly 55% of the total winter wheat planted in Montana. The top four varieties of

spring wheat planted in 2010 account for 61% of the total seeded. Three of the four were developed in MSU laboratories. The top four varieties of malting barley represent about 47% of the total planted. Hockett is the third leading malting barley variety seeded and was developed by MSU in 2008. It generates excellent yield and malt quality under dryland conditions. Haxby is the top feed barley variety for the fourth year. It was developed by MSU and performs well in low moisture conditions.

4. Associated Knowledge Areas

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

A variety of weather patterns influence Montana agriculture each year including extreme cold, early frosts, and hail storms. Severe hail across much of southwestern Montana in June caused widespread crop and property damage.

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

Evaluation Results

On-going development in plant genetics ensures that growers will have access to the most adapted and highest yielding varieties of small grains. Growers readily accept new varieties as indicated by purchase and planting records.

Key Items of Evaluation

The rapid adoption and growth of new varieties demonstrate the successful plant breeding programs established at MSU.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Food Safety -- Sustainable Agriculture

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			20%	
204	Plant Product Quality and Utility (Preharvest)			10%	
205	Plant Management Systems			10%	
206	Basic Plant Biology			20%	
213	Weeds Affecting Plants			10%	
215	Biological Control of Pests Affecting Plants			10%	
601	Economics of Agricultural Production and Farm Management			10%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	30.0	0.0
Actual	0.0	0.0	66.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	432777	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2848919	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2342559	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Our long-term strategies are designed to make Montana agricultural products more desirable in U.S. and world markets. 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. The development of high-value food, feed, and biofuel crops involves close collaboration among research and extension faculty in Montana and in neighboring states. We communicate research results through field days, news releases, and presentations at county and state meetings and conventions as well as distribute results of research via the Internet. We hold strategic planning discussions with state agricultural groups. The development of new, highly nutritious crop cultivars with characteristics that improve health and well-being are priorities at MSU. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent perceived food safety events and thus, irreparable harm to beef's market share. MSU researchers work to improve animal and human nutrition, add value to raw products, improve safety of products, and increase product development of biobased chemicals, fuels, lubricants, pharmaceuticals, and nutraceuticals.

2. Brief description of the target audience

- Alternative energy groups and state agricultural advisory committees
- Crop and livestock producers in Montana
- Montana wheat and barley committees, companies, fertilizer advisory committees, conservation tillage equipment companies
 - 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(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	900	1100	0	0

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

Patent Applications Submitted

Year: 2010

Actual: 4

Patents listed

Steven Cash. "Montana" meadow Bromegrass [license]

Steven Cash. "Willow Creek" Forage Winter Wheat [license]

Jerald Bergman. Plant Variety Protection Certificate Application 20080000065 for "Cardinal" Safflower. Patent issued February 10, 2010

Jerald Bergman. Plant Variety Protection Certificate Application 20080000066 for "MonDak" Safflower. Patent issued February 10, 2010

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	0	22	22

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2010	15

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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.
7	Number of programs established to enhance global food biosecurity
8	Number of producers that participate in livestock tracking programs

Outcome #1

1. Outcome Measures

Number of interactive meetings with state groups and agencies.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	10	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

There is a need for continuing meetings with crop and livestock producers, state wheat and barley committees, crop protection companies, fertilizer advisory committee, conservation tillage equipment companies, alternative energy groups, and state agricultural advisory committees to identify research and outreach needs for MSU COA/MAES.

What has been done

Annual meetings are held with producers, commodity groups, advisory boards, and industry to present research results and to plan future research and outreach activities. Surveys are conducted at meetings where producers are present to continue to develop research programs that reflect stakeholder needs. In addition, resolutions are passed in numerous associations and approved by voting members providing direction to MAES.

Results

MSU research continues to provide new small grain varieties and alternative crops that meet the need of Montana producers. Researching new crops and finding new markets for existing crops are potential ways to enhance growth in sustainable agriculture in Montana. 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. As more input is provided to MAES leadership, programs are refined and redirected providing stakeholders realistic time frames for outputs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems

213 Weeds Affecting Plants

Outcome #2

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana is a state with limited crop and livestock diversity due to semi-arid conditions, a short growing season, and the potential for severe winters. Producers recognize that to maintain profitability and sustainability requires considerable effort in ensuring that the right balance of enterprises, innovative marketing, and accurate record keeping occurs.

What has been done

MSU agricultural economists with farm management expertise make over 200 off-campus educational presentations each year. Many of these focus on the economics, management, and budgeting processes required to sustain agricultural enterprises. Presentations include software training, estate planning sessions, succession planning, risk management, and crop sustainability. Cooperation with the MAES research centers and tribal agents have resulted in successful programs involving Native Americans in range, livestock, and crop management.

Results

Extension agents in cooperation with researchers from the College of Agriculture hold commercial and private pesticide applicator workshops, including applicators ranching in reservation lands.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	5	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Surveys at Montana farm conferences indicate a strong interest in diversified crop rotations for increasing on-farm receipts while reducing a monoculture of small grains. Winter and spring peas, canola, corn, lentils, mustard, sunflowers, triticale, and chickpeas are included in long-term rotation studies. MSU research 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.

What has been done

Oilseeds (including *Camelina sativa*, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of 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. Additional initiatives will provide new insights into food safety and risk assessment, including the development of new wheat varieties.

Results

We anticipate several new camelina products will be commercially available in the near term including bread, soil amendments, and omega-3 rich beef and pork. New high-tocopherol lines of safflower will add value to producers in Eastern Montana and Western North Dakota.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems

206 Basic Plant Biology
601 Economics of Agricultural Production and Farm Management

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	20	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Surveys at farm conferences in Montana highlight strong producer interest in improving cropping system diversity. Field days, news releases, and presentations are direct ways for producers to gain insights into alternative enterprises and make site-specific decisions.

What has been done

MSU research and extension personnel attend conferences, state and regional professional meetings, and publish articles, news releases and fact sheets that are applicable for producers interested in enhancing their sustainable agriculture practices.

Results

Montana's growth in alternative crops, such as canola and camelina, demonstrate stakeholder's acceptance of information presented by MSU research and extension personnel.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #5

1. Outcome Measures

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. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers are faced with ever increasing costs of raising crops, including seed, land, and fertilizer and chemical inputs. Maximizing efficiency is paramount for producers to remain in business and address consumer preferences.

What has been done

MSU agronomists make hundreds of off-campus educational presentations each year focusing on the adoption of new crop varieties, new nutrient management concepts, and pest management practices. Some of these presentations are made to Native Americans engaged in crop or livestock production. Activities include demonstrations at field days, class room instruction, providing 24/7 materials on the Internet, distributing CDs, and presentations at state and regional conferences.

Results

Producers maintain high yields with rapid adoption of new varieties and practices. An added incentive to producers is to reduce the amount of inputs due to increasing costs needed to raise a crop. Rate reduction and better utilization of inputs adds significantly to the producer's bottom line profits.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #6

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	5	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers are searching for alternatives to growing monocultures of small grains in Montana. Economists have determined that many small grain producers are marginally sustainable and need other income sources.

What has been done

Growth in the production of specialty crops has been strong from 2004 through 2010. The production of dry peas (including Austrian winter peas, lentils, dry beans), mustard seed, camelina, and flaxseed have increased drastically during the time period.

Results

Montana camelina oil is currently being used for commercial production of omega-3 rich pet feeds and supplement, omega-3 rich eggs, cosmetics including lotions, massage oils and soaps, and culinary oils. Omega-3 enriched meat products have higher market value than traditional meat products. Direct return to the poultry industry for omega-3 enriched eggs is 50% higher than for traditional eggs. Several new cultivars of Camelina sativa have been developed, new uses for camelina oil and meal are being evaluated, two new selections/cultivars of high protein oats have been developed, and new oil products for fuel, food, feed, enzymes and lubricants are being investigated. Oilseed crops continue to represent important new sources of income for farmers and provide opportunities for increasing crop diversity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems

206	Basic Plant Biology
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #7

1. Outcome Measures

Number of programs established to enhance global food biosecurity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	{No Data Entered}	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Food safety and security have become important concerns for the beef industry at all production levels. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal.

What has been done

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.

Results

Utilizing the processes and organizational structure established by the SBS research and educational programs will continue to address the animal health, biosecurity, and production efficiency concerns expressed by producers and consumers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

Outcome #8

1. Outcome Measures

Number of producers that participate in livestock tracking programs

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	{No Data Entered}	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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.

What has been done

Tracking will provide both source and process verification for easy trace-back in case there is a disease outbreak. With the sustainable beef supply (SBS) program in place, it will be relatively easy for Montana producers to adapt to traceability and animal ID.

Results

Traceability of livestock through the production chain is being demanded by the consumer and can add substantially to the cost of production. Methods are being developed that facilitate traceability of livestock at minimal additional expense. A major effort will be directed at identifying alternative solutions to reduce cost of animal ID technology.

4. Associated Knowledge Areas

KA Code	Knowledge Area
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

High grain prices have encouraged growers to stay with traditional crops to take advantage of improved markets.

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

Evaluation Results

Evaluations are in progress. The interest in alternative crops, reduced inputs, and reduced tillage continues to suggest that growers are looking for alternatives to current cropping systems.

Key Items of Evaluation

The increased interest in camelina, winter and spring peas, and dry beans indicates a shift in production goals and enhanced opportunities for Montana farmers.

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Climate Change -- Water Quality and Use

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 (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	20.0	0.0
Actual	0.0	0.0	14.6	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	183916	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	763267	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	487016	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- 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
- Results from research will help to mitigate potential economic losses or disasters from inadequate or excessive water related events

2. Brief description of the target audience

- 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(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	500	750	0	0

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

Patent Applications Submitted

Year: 2010

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Actual	0	26	26

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations.

Year	Actual
2010	18

Output #2

Output Measure

- Successful external grants

Year	Actual
2010	2

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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 Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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, accurately measure quantity (and some quality characteristics), and provide cropping and irrigation recommendations to agricultural and urban stakeholders. Improved ability to monitor soil water and chemical distributions in soils will contribute to better land management opportunities. Target audiences include scientists, graduate students, land managers, federal and state agency personnel, and commercial developers or vendors of sensors and instrumentation.

What has been done

Projects have been developed to improve methods to measure soil water and improve understanding of soil water dynamics. We are investigating critical drivers and relationships that govern catchment water, carbon, and gas behavior and movement. One project focuses on developing, evaluating, and applying innovative approaches to characterize and manage water and chemicals in soils, and on evaluating interrelationships among soils, vegetation, water, and related soil physical properties.

Results

Research fills critical gaps in our knowledge about soil water availability in space and time and the soil processes controlling carbon cycling, global change ecology, and soil gas emissions. New methods to characterize soil water status, solute transport, and related soil properties and processes have been developed.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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- 111 Conservation and Efficient Use of Water
- 112 Watershed Protection and Management

Outcome #2

1. Outcome Measures

Improved management systems for water quality and quantity.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Soil nutrients, crop rotation, and irrigation water need to be carefully managed for optimum economic return in crop production and environmental stewardship. Information is provided to producers, consultants, and agency personnel on soil fertility, crop rotation, and specialty crop production for Montana. Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses, will help protect riparian areas, will improve our State's fisheries and wildlife habitat, and will sustain recreational opportunities for Montana sportsmen and recreationalists. Land management coupled with an increased understanding of watershed processes influences future land management practices.

What has been done

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 our extensive crop breeding programs, water management research, the introduction of new drought tolerant crops, along with other conservation practices. In addition, enhancing our knowledge of water quantity and quality will also influence water-related decisions. The development of critical research information on irrigated cropping systems by the cooperative installation, deployment, and use of precision irrigation systems is providing information on the role these systems play in improving water and soil quality.

Results

Irrigation management and cultural practices that promote water use efficiency, reduce negative effects of soil compaction, and enhance environmental benefits have been developed. The effect of farming practices and the interaction among irrigation methods, crop rotation, and tillage is generating quantitative data on yields, pest problems, and soil water movement. Water quality

and irrigation management bulletins are made available by crop to producers in Montana. The right combination of irrigation and fertilizer management practices can add significantly to yields of Montana crops when compared to dryland cropping.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #3

1. Outcome Measures

Educational programs that address water resource use.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

By maintaining or improving watershed quality, we can protect human health and drinking water, ensure sustainability of irrigated agriculture within the watershed, and protect water quality and quantity. We are currently faced with a need to protect and promote water quality in pristine, agricultural, and impacted watersheds. Target audiences of outreach activities to date have been irrigators, the general public in communities near irrigation projects, and students enrolled in watershed management classes. Improving the quality of watersheds in Montana should be a goal of all rural and urban residents.

What has been done

The protection of riparian areas is one of our primary tools for increasing insight into the impact of human alteration of natural landscapes. MSU research projects include numerous experiments performed, watersheds instrumented, data collected, analysis completed, course taught, and graduate and undergraduate researchers trained.

Results

Research activities have been performed in four geographic areas in Montana and Idaho and have included undergraduates and graduate students in these activities. These activities have

lead to invited university and international meeting presentations. One research program is generating information on riparian zone buffering of upland runoff, stream-catchment connections, groundwater surface water mixing, the exchange of carbon and water between the land and the atmosphere, and the impacts on water of human encroachment in mountain watersheds.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Number of landscape scale datasets created.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Wetland and riparian zones provide a variety of ecological services that contribute to overall water management at local, watershed, and regional scales. Wetlands can effectively minimize sediment loss, control runoff volume, purify surface water, and enhance aquifer recharge. Wetlands and riparian areas are highly diverse ecosystems that have significant variability of physical properties. Excellent wetland management can positively affect agriculturalists as well as municipalities.

What has been done

The shape, size, and distribution of wetland and riparian zones are largely determined by geologic, topographic, and hydrologic conditions. We continue to develop a better understanding of the relationships among watershed factors and mapping the results. The results of our research provide valuable information and tools to Montanans who rely on water resources for agricultural and urban activities.

Results

Combining automated classifications with remote sensing data can quickly and accurately determine the location of small, isolated, and highly variable ecosystems, thus enabling systematic monitoring of watersheds, including riparian areas. Data collection and the utilization of effective sampling protocols for determining landscape variability have been investigated using remote sensing procedures and on-the-ground measurements.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #5

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The winter accumulation of snowpack in the Rocky Mountains is critical to the availability of water for agricultural irrigation during summer months when rainfall is often limited. Sustainable management of water is one of the biggest challenges we face in an era of increasing water demand (through population growth and better living standards) and climatic uncertainty and change. For improved forecasting and water resource management there is a need for quantifying factors affecting watersheds. The uncertainty of potential climatic changing scenarios increases the need for quantifiable results.

What has been done

The development and assessment of watershed models to describe the rainfall-runoff process has been a chief focus of hydrological studies for many decades. Projects at MSU have been established to monitor snowpack and runoff timing in several watersheds to develop relationship models with key universal parameters. Hydrological models allow expansion and management of

water resources, and ensure better interpretation or prediction of physical phenomena.

Results

Work is in progress to develop a model predicting snowpack/runoff into rivers and for in-stream flow. This project will take several years to collect, test, and refine collection methodologies and apply catchment and solute transport models. In mountainous areas across the western United States winter snowpack controls regional water resources partially because of the greater water deposition, accumulation, storage, and reduced evaporation until spring snowmelt. Hydrologic models play an important role in quantifying watershed processes, allowing hypothesis testing about watershed processes with observed data and forecasting of hydrologic variables under future predicted conditions. The project will develop tools for building and manipulating a range of hydrologic models under varying uncertainty.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #6

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Maintaining water quality is a priority of agriculture and industry. All Montanans have a well-defined connection to our water resources, whether it is for consumption, recreation, irrigation, or quality of life. We are faced with a need to protect and promote water quality in pristine, agricultural, and impacted watersheds. Protecting riparian areas is one of the primary tools we are investigating.

What has been done

Since coal bed methane is a potential source of diversified income for many of our Native American tribes and large landowners in sparsely populated eastern Montana, MSU is working with tribes, constituents, and other states to develop models that will establish policies for energy companies and land managers to appropriately reuse the water, protect surface and underground systems, and protect soil and plant resources.

Results

We have developed management guidelines for salinity and sodicity standards applicable to Montana climate, crops, and soil on Tribal lands. We have also established a benchmark research site to examine the impact that mountain resort development has on stream function and water quality. The results of our study will give insight into the impact of human alteration of natural landscapes. We are working on processes important to understanding the fate of organic contaminants in soils and the potential for contamination of surface and ground waters. Our role is to identify mechanisms by which pesticides and other organics interact in soils especially identifying those factors controlling microbial population dynamics and subsequent degradation of specific compounds present in contaminated soils.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
610	Domestic Policy Analysis

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Snowpack in major western watersheds dramatically influences the availability of irrigation water during the summer months. Although current predictions are favorable, growers need to continue to judiciously monitor water resources.

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

Evaluation Results

Water management plans are being used by growers who irrigate small grains, row crops, and alfalfa/hay pastures. The plans are also important to livestock producers who graze livestock near riparian areas. The adoption of these plans is apparent in the reduction of the number of habitat disturbances in sensitive environmental areas.

Key Items of Evaluation

Water management innovations are being adopted by producers and land managers.