2009 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 967,000. The state has over 29,000 farms and ranches representing over 60 million acres, 66% of its land. Nearly nine million acres are cropped and 56 million acres are grazed or used for other agricultural purposes. Montana ranks 2nd in the U.S. in acres devoted to agricultural enterprises with crop and livestock industry annual cash receipts of over $2.3 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 canola, barley, and flaxseed. Wheat and barley represented about 47% of the 2008 total agricultural receipts. Flax acreage increased in 2009 by over 20% and production by 30% over 2008. Harvested acres of safflower dropped by 15% in 2009. The production of camelina (*Camelina sativa*) in Montana increased from 450 acres in 2005 to nearly 50,000 acres in 2007. New contracts with biodiesel producers in 2010 will encourage growers to consider camelina as a viable alternative to other dryland crops. The value of Montana's agricultural exports during fiscal year 2008 totaled $1.2 billion, an increase of $500 million over 2007. Montana ranked 3rd among states exporting wheat and wheat products. The state's livestock industry represents over $1.2 billion in cash receipts annually and is one of the largest industries. Montana ranks 10th in the U.S. in the production of cattle and 7th in the production of sheep and lambs. Cattle and calves represented over 85% of the livestock receipts for the state and 35% of the total agricultural receipts in 2008. Montana beekeepers accounted for 6% of the nation's honey in 2008, placing Montana 6th among states in honey production. Higher prices for beef, wheat, and barley raised farm and ranch incomes; however, escalating input costs challenged Montana enterprises to increase efficiencies and evaluate new markets.

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, crop production, and other industries in Montana by the latter half of the 21st century and U.S. programs that address carbon sequestration and reduction of greenhouse gasses will become important projects for MSU researchers to consider.

Priorities: As a result of stakeholder input meetings, focus groups, and ongoing 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 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 management of livestock diseases, crop production, IPM, livestock production and management, natural resources, nutrition and health, food safety, global food security, and range production and management. These results will continue to influence MAES research priority areas in the next decade.

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, Animal Biosciences Complex Board, Center for Invasive Plant Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Associate Dean's Advisory Council, Associate Dean's Student Advisory Council, Development Board, Eastern Agricultural Research Center Advisory Committee, Equine Advisory Committee, Foundation Seed Advisory Committee, MAES State Advisory Council, Montana 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, Northwest and Western Agricultural Research Centers Advisory Committee, Organic Certification Association of Montana, Potato Certification Board, Southern Agricultural Research Center Advisory Committee, Thermal Biology Institute Scientific Advisory

Board, 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, overhead investments from sponsored programs, private donations, private industry, the State of Montana, USDA, USEPA, and USFS.

Outcomes and Impacts:

Enhance Economically Viable and Sustainable Agricultural Systems
- Contribute to commodity and product marketing and economic development
- Create comprehensive programs that address issues and problems associated with plant and animal systems
- Develop competitive, sustainable, and viable plant and animal systems
- Enhance our understanding of rural, urban, and disturbed landscapes
- Expand stewardship practices
- Foster the development of value-added biobased products
- Improve food safety and quality
- Improve plant and animal health through integrated pest management (IPM) and other sustainable practices
- Improve the fundamental understanding of plant and animal biology
- Improve value-added crops for sustainable energy production
- Address childhood obesity by developing small grains and value-added crops that help reduce the severity of the problem

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

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

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.

Program Areas

Program #1 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 on yield and quality if they are to remain economically competitive. Yield performance data provides crucial information for producers' cultivar and species selection.

Program # 2 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, horses, and wildlife) 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 Complex 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. 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 1,000 private landowners, county weed supervisors, and public agencies.

Calf scours is caused by several infectious agents including viruses, bacteria, and protozoa. Rotavirus is the most important viral agent of neonatal diarrhea and generally affects calves less than six weeks of age. A rotavirus vaccine is commercially available, but is sub-optimal as it fails to protect calves throughout the most susceptible periods. We are investigating new vaccines that have 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 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.

Program # 3 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 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.

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.

Program #4 Global Food Security and Hunger

Situation: 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. 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. 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, it will be relatively easy for Montana producers to adapt to mandatory country-of-origin labeling (COOL) programs.

Priorities: 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: 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: 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. 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 # 5 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 Integrated Pest Management (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 Sustainable Agricultural Program, and USDA. Stakeholder input is collected in county and reservation sponsored input meetings, listening sessions during pesticide applicator education programs, and a Farm Bill Forum. The development of more environmentally-friendly chemical and non-chemical alternatives requires ongoing interaction with chemical and biological pest control product manufacturers, state and federal agencies, and with researchers in other states.

Research Activities: The wheat stem sawfly 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. Alfalfa hay pest management programs use chemical methods, biological controls, and cultural management options. 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 will be 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 will be achieved by monitoring impacts. Incorporating biopesticides into insect management strategies can conserve natural enemies and pollinators. 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 is expected in 2010. Research into the mechanisms of weed resistance helps develop herbicides that target specific biochemical processes within

the plant.

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. Soil-borne plant pathogens cause about 90% of the major diseases of the principal crops in the U. S. with annual revenue losses in excess of $4 billion. MSU projects identify effective and economical biological controls for diseases. Growers can then control plant diseases using these methods with low toxicity to humans and the environment. 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.

Weed management requires rapid and accurate identification of weedy plants. Improper identification can result in misapplication of herbicides or failure to adequately control the weed when it is most vulnerable to IPM practices. 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 small grain pests. 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 controlled 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, hounds tongue, Russian knapweed, tansy ragwort, and invasive hawkweeds.

A diagnostic key for pests of woody ornamentals planted in urban areas is being developed. This project will increase the accurate and appropriate use of pesticides in the home landscape. In addition, this resource will assist in the rapid identification of invasive pests and empower the public to submit samples for proper identification.

Program # 6 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&ndash$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 are a larger and higher quality food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat.

Strengthen the Quality of Life for Montana and Its People

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.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. The replacement of older barley cultivars with new ones (Haxby, Hays, Charles, Craft, and Eslick) should generate a yield improvement of about 15% with a net of about $45 million per year in added revenue to dryland barley growers. 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. 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.

Breadmaking 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.

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

Plant photoreceptors and the light responses they control are critical to growth and development of crop and non-crop species throughout the world. Developing an understanding of how the phytochrome photoreceptors work is a critical part of the search for new and effective ways to sustain and improve crop performance. By determining the fate of nitrogen in plants from anthesis to plant death, we expect to improve our understanding of the cellular and molecular details of nitrogen remobilization, thus closing an important knowledge gap in modern plant biology. Scientists are working to identify the genes involved in control of inflorescence development to provide new approaches to breeding practices or transgenic manipulation.

Program # 7 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. Of the 380 American Indian students at MSU, 26 (7%) are enrolled in the College of Agriculture (COA).

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.

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. While pulse crop production in Montana declined in 2008, 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. 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.

Program # 8 Sustainable Energy

Situation: The development of bio-based fuels is a priority to reduce U.S. dependence on petroleum-based fuels. While current fluctuations in the prices of oils and fuels produced from crops (especially corn, soybeans, and oilseeds) are creating uncertainties in the development of processing plants and in incentives for growers, the long-term opportunities continue to be promising. To help advance biofuel developments, the U.S. Department of Energy and the U.S. Department of Agriculture announced in November, 2009 the availability of $24 million in grants for biofuels, bioenergy, and other bio-based products. The ethanol and biodiesel industry will have a significant impact on the future of the grain industry. Corn grain is the major feedstock for fuel ethanol production in the U.S., yet little corn grain is produced in Montana. MSU initiatives in the development of sustainable energy alternatives primarily rely on oilseed crops to provide opportunities for creating renewable biobased products.

Priorities: Initiatives will 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.

Input: Input from focus groups and meetings of stakeholders is used to identify strategies for marketing higher value agricultural commodities, consumer products, and alternative crops.

Research Activities: Wehavebeen instrumental in identifying potential oilseed crops suitable for production in Montana for use as culinary oils, biolubricants, omega-3 oils, feeds, and production of biodiesel and bioenergy products. Oilseeds (including *Camelina sativa*, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of oils. A significant potential exists in the Pacific Northwest for the production of canola seed and its use as a biolubricant. To be viable, canola cultivars need to be developed that can be direct-seeded, and that are winter hardy and drought tolerant.

Alternative feedstocks are being explored for potential fuel ethanol production. 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 # 9 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 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 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 not only aids 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.

New ways to characterize soil water status, solute transport, and related soil properties and processes are being

developed. Mapping soil water content for site-specific management of farm fields is commonly achieved through grid soil sampling. The results have led to tools with applications that lower costs to producers and rangeland managers with improved monitoring efficiency and enables science-based decisions to be made in the management of irrigation practices in the western U.S.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	300.0	0.0
Actual	0.0	0.0	240.6	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 merit 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 on the internet, 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.

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 Advisory Council, Academic 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, Beef Council, Department of Agriculture, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, 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. 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	2342626	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	2569837	0
Actual Matching	0	0	2637978	0
Actual All Other	0	0	17407954	0
Total Actual Expended	0	0	22615769	0

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

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	20.0	0.0
Actual	0.0	0.0	23.9	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	281463	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	284516	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	1891717	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

The target audience includes 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

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	150	200	0	0
Actual	2000	2500	0	0

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

Year: 2009
Plan: 1
Actual: 0

Patents listed
None

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	5	5	
Actual	9	17	26

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2009	10	21

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	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 90 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. A notice of FDA ?GRAS? status of camelina meal was received in 2009 as a feed ingredient for poultry feed. In 2008 and 2009, five different biodiesel companies began competing for camelina acreage in the state.
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. MSU researchers have presented more information directly to producers and provided publication references and reviews. 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
2009	1	2

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
2009	5000	4500

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
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
2009	750	3767

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 Grower's 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. In 2009, seed samples submitted for analysis representing a significant increase over 2008.

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
2009	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.

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)

1. Evaluation Studies Planned

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

Evaluation Results

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.

Key Items of Evaluation

There is a backlog of ranches requesting assistance, although significant progress has been made to enhance services. As data is retrieved it will be made available to stakeholders.

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	100.0	0.0
Actual	0.0	0.0	81.4	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	621633	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	633284	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	8642637	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Databases that are easily accessible by researchers and producers in order to make research results readily available
Distribution of papers and research results at state nutrition conferences, field days, county meetings and state conventions
Preparation of research articles, fact sheets and news releases for scientists and state media
Strategic planning meetings with state agricultural groups

2. Brief description of the target audience

State agencies, animal health companies, state commodity groups, ranchers, seedstock industry representatives, colleagues, and related stakeholders.

V(E). Planned Program (Outputs)

1. Standard output measures

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	250	100	0	0
Actual	900	1100	0	0

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

Year: 2009
Plan: 1
Actual: 2

Patents listed
Hardy, M.E. Snow Mountain Virus Genome Sequence, Virus-like Particles, and Methods of Use. U.S. Patent # 11/058,030 (2008)
Harmsen, A.G. PCT International Application N.: PCT/US2008/075,373; Converted from Provisional Patent Application Serial Nos.: 60/970,878 and 60/986,985; Entitled: ?Protein Cages and Their Uses.? Counsel Ref.: MONT-095/02WO (2008)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	10	28	38

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual

2009	15	61

Output #2

Output Measure

- Building built through donations

Year	Target	Actual
2009	0	0

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
2009	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 major areas of research. 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. 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. An MSU study seeks to better characterize the action of Yamoa (ground bark of Funtumia elastica tree) in an effort to stimulate the innate immune system for protection against a broad range of pathogens in bovine calves.

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. 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. Research is continuing in collaboration with researchers at the University of Montana and the NIH Rocky Mountain Lab to form a center for studying emerging infectious diseases in wildlife and livestock. Viral pneumonias cause substantial morbidity and mortality in the cattle industry. Research is underway to develop effective vaccines for these diseases. 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
2009	10	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Cow-calf enterprises are critical to the economic stability of the cattle industry in Montana. Reproductive health and estrus synchronization is important to producers in calving and marketing. Sheep production represents a growth opportunity for livestock producers in Montana. Decreasing input cost and increasing production revenues, will help producers achieve higher quality products, generate more income, and maintain Montana's position in the world livestock market.

What has been done
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 products and improve the quality. Research is demonstrating that improved nutrition is a major factor that can reduce lamb mortality and improve profitability. 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 weed with limited damage to the surrounding vegetation. TG efforts are usually integrated with other control methods as part of an overall weed management strategy. Weed projects annually have directly involved over 100,000 acres of weed infested Montana rangeland and about 1000 landowners and 31 sheep producers utilizing 30,000 sheep and goats.

Results
Currently major weed projects are targeted at leafy spurge, spotted knapweed and Dalmatian toadflax. Research is demonstrating that controlled sheep and/or goat grazing is effective in managing established infestations of many of non-native weeds. In 2008 we conducted 15 projects with 22 monitoring sites utilizing 15,000 sheep and goats from 10 sheep producers involving 1000 private landowners, county weed supervisors, and public agencies. More enterprises are using controlled estrus and developing management plans to improve the economics of raising healthy calves to market.

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
2009	1	0

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
The development of a subunit vaccine for brucellosis combined with live attenuated vaccines will provide improved disease prevention for livestock. Once appropriately formulated, we believe that we will be able to develop a cheap and effective brucellosis vaccine for wildlife and cattle.

Results
Studies, in cooperation with Texas A&M, have produced new subunit and live brucellosis vaccines that may effectively protect bison and cattle against brucellosis. Our results from the bison and mouse vaccination studies are encouraging because protective efficacy was obtained in both animal systems. 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. Over 150,000 ?drug-like? candidates have been screened for their activity against agonists in cattle.

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
2009	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
The Veterinary Molecular Biology research unit at MSU is focused on animal health, particularly on the study of infectious diseases of cattle. MSU is testing a mucosal vaccine delivery system to provide the basis for a future generation of ruminant vaccines. Programs that focus on management, nutrition, and health maintenance have been developed that provide cow-calf producers in Montana the tools to produce safe beef and improve the quality of the beef that is raised. Programs are in place to investigate vaccines for rotavirus, which is the major viral cause of diarrhea in cattle and costs the industry $500 million per year. A rotavirus vaccine is commercially available, but is sub-optimal, as it fails to protect calves throughout the most susceptible periods.

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 to improve our understanding of how they spread within a host. A rotavirus vaccine is commercially available, but is sub-optimal as it fails to protect calves throughout the most susceptible periods. We are investigating new vaccines that have 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.

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Consumers critique every bite of meat they consume. Producers know that the diets fed to cattle can affect meat quality. Determining the effect that grain type and variety in the diet have on color, stability, and finishing quality is important to Montana producers. Food safety is a very visible consumer and producer concern and has become a concern for the livestock industry at all production levels. Consumers, both domestic and international, are demanding more information about the beef they purchase, including the age and source of the animal and the health, nutrition, and handling management. Information is being demanded by consumers on labeling the country of origin (COOL) and to ensuring that the products they are buying are safe.

What has been done
Diets using Montana produced grains, including barley, are being tested to determine finishing characteristics of beef. Changes in growth potential could explain some of the variation in tenderness seen in the marketplace. Current information helps give us more information about how growth rate affects tenderness, meat quality and cellular-level response. Research and development strategies and tactics are being investigated that will lead to more economically and biologically efficient beef production. Results will be summarized and disseminated to producers, researchers, rangeland managers, and other interested parties.

Results
Identification of barley varieties that affect color stability could result in designing diets specifically for improved color and increase the use of barley as a finishing grain. A critical and stressful time for feedlot cattle is early in the finishing period. Valier Barley with increased levels of beta-glucan may make it possible to get enough beta-glucan through the rumen in order to stimulate the immune system of ruminants and result in an improvement of animal health. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent food safety events and irreparable harm to the beef industry.

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)

1. Evaluation Studies Planned

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

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

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

V(C). Planned Program (Inputs)

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

Year: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	8.0	0.0
Actual	0.0	0.0	5.9	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	56751	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	58078	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	355289	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Several products are being produced and marketed by private industry, LLC, or grower cooperatives in Montana. Projects in biobased products and processing are ongoing and accomplish the following:

Conduct outreach activities related to biobased products
Develop systems that ensure food safety and agricultural security

Develop value-added, agriculturally based end-use products
Establish biobased product and food science education and research programs
Enhance partnerships among faculty across the Montana university system, producers, agricultural industry, and other educational institutions across the region
Provide mechanisms to enhance agricultural production practices to enhance product quality
Use technology and biotechnology to improve plant and animal production systems

2. 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

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	125	50	0	0
Actual	750	900	0	0

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

Year: 2009
Plan: 0
Actual: 2

Patents listed
Strobel. Munumbicins, wide spectrum antibiotics from Streptomyces. U.S. Patent #7,341,862 (2008)
Strobel, G.A. Endophytic streptomyces from higher plants with biological activity. (provisional patent submitted 10/07). U.S. Patent #7,259,004 (2008)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	0	16	16

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Target	Actual
2009	1	0

Output #2

Output Measure

- Number of research citations

Year	Target	Actual
2009	8	15

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.

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
2009	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, univeristy, 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. 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
511	New and Improved Non-Food Products and Processes

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
2009	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.

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
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. 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. Additional new crops or varieties developed by MSU include high protein oat (PrOatina), gluten-free Teff, high-yielding soybean, Fenugreek, and gluten-free timothy.

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
2009	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
2009	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. Food Safety Works is a food safety education job-training program targeted to Montana high school students. This program has been very successful due to the cooperation among high school students, teachers, MSU Extension, and the food industry. Current and new crops have been evaluated for alternative uses beyond commodity products. 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. The development of flour 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, will provide 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.

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
2009	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
New Montana varieties of camelina were produced in MT, WA, ID, OR, SD, ND, WY, CO, and AK in 2008. Additional new crops or varieties developed include high protein oat (PrOatina), gluten-free Teff, high-yielding soybean, Fenugreek, and gluten-free timothy.

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

- 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.

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

1. Evaluation Studies Planned

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

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

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
205	Plant Management Systems			20%	
502	New and Improved Food Products			20%	
503	Quality Maintenance in Storing and Marketing Food Products			20%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			20%	
903	Communication, Education, and Information Delivery			20%	
	Total			100%	

V(C). Planned Program (Inputs)

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

Year: 2009	Extension		Research	
	1862	1890	1862	1890
Actual	0.0	0.0	14.1	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	89807	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	91850	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	481529	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

Partnerships have been created among producers, the agricultural industry, faculty, and other institutions in the region.

V(E). Planned Program (Outputs)

1. Standard output measures

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
Actual	150	200	0	0

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

Year: 2009
Plan:
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan			
Actual	0	5	5

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2009	{No Data Entered}	10

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of programs established to enhance global food biosecurity
2	Number of new food products created from Montana crops
3	Number of producers that participate in livestock tracking programs

Outcome #1

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
2009	{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
502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Number of new food products created from Montana crops

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	{No Data Entered}	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Growers of commodity and specialty crops look to MSU researchers to develop cultivars that adapt well to Montana?s climatic conditions. Development of new uses for these crops is important to providing global market opportunities for our stakeholders.

What has been done
The development of new, highly nutritious crop cultivars with characteristics that improve health and well-being are priorities at MSU. MSU research provides the technology that improves plant and animal production systems while adding value and improving food security for stakeholders.

Results
Montana camelina oil is currently being used for commercial production of omega-3 rich pet feeds and supplements, omega-3 rich eggs, cosmetics including lotions, massage oils and soaps, and culinary oils. Several products are being produced and marketed by private industry or grower cooperatives, including PrOatina gluten-free oats to the celiac community and beta-glucan barley to the nutraceutical industry. Potential new crops (including fenugreek and Camelina) are being considered in the effort to reduce obesity and in treatment of other health issues.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
502	New and Improved Food Products
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #3

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
2009	{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 mandatory country-of-origin labeling (COOL) programs.

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
502	New and Improved Food Products
503	Quality Maintenance in Storing and Marketing Food Products
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
- Government Regulations

Brief Explanation

Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
Inadequate funding and technical support from partnering institutions and cooperators
Major interruptions in program development

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

1. Evaluation Studies Planned

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

Evaluation Results

Evaluations are in progress.

Key Items of Evaluation

Evaluations are in progress.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	65.0	0.0
Actual	0.0	0.0	36.8	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	434751	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	459293	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	1990716	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

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	300	150	0	0
Actual	1500	1400	0	0

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

Year: 2009
Plan: 0
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	15	37	52

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2009	10	52

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Target	Actual

2009	2	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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	3	3

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. As the organic industry grows domestically and internationally, price premiums will be critical for producers for all participants in the organic food industry. 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.

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.

Results
The deployment of bio-fungicides could provide an important crop management tool missing in organic wheat production. Implementation of research results will reduce risk and increase sustainability of organic farming in the northern Great Plains. Educational programs will be developed to provide 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.

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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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. The wheat stem sawfly is a severe pest of wheat in the northern Great Plains; current management is based primarily on the adoption of solid-stem varieties that offer only partial resistance to the pest.

What has been done
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. 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 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 integrated pest management 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. We expect that the knowledge generated in these research and outreach programs will enhance producers' understanding of multi-trophic level interactions. This knowledge will, in turn, allow producers to develop specific actions to jointly manage cheatgrass, wheat stem sawfly, and Fusarium.

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	1	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Systems integrating biological, cultural, and conventional controls of weeds, diseases, and insects are lacking for potato producers. 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. An MSU program provides programming in sustainable agricultural practices that combine grazing intensity with preservation of surface and ground water, native plants, fisheries and wildlife.

What has been done
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 low in toxicity to humans and the environment. 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.

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. The research provides a basis for organic and other growers to control soilborne plant pathogens.

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
2009	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 his agricultural operations; proper storage, use, handling and disposal of the pesticides and containers; and his related legal responsibility.

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 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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	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 have cooperated 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
A special local need 24(c) label was issued in 2009 for Beleaf insecticide (flonicamid) for control of aphids and lygus bugs in seed alfalfa.

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
2009	3	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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. Comparing biological and agricultural risk assessment from biotechnology crops, pesticides, and invasive species allows producers to selectively use a variety of management systems. Incorporating biopesticides into insect management plans can conserve natural enemies and pollinators. Dryland forage and crop producers need to continually improve on yield and quality if they are to remain economically competitive. Increased diversity in the forage and crop species and appropriate cultural methods must be developed for each forage and crop species if it is to be produced successfully.

What has been done
The purpose of one study is to examine the impact of several reduced-risk biopesticide products on alfalfa insect pests, natural enemies, and pollinators, while assessing alfalfa seed damage and seed yield. The research is aimed at providing 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.

Results
Results indicate that several chemical treatments (including novaluron and neemix) significantly reduced lygus numbers while maintaining favorable numbers of beneficial insect predators, with no discernible impact on pollinators. Other pesticides (bifenthrin) exhibit a greater negative impact on natural enemy numbers. 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.

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 requires 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)

1. Evaluation Studies Planned

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

Evaluation Results

Evaluation studies are in progress.

Key Items of Evaluation

Evaluation studies are in progress.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	30.0	0.0
Actual	0.0	0.0	28.4	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	407223	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	417331	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	1334796	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

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	2000	500	0	0
Actual	2500	900	0	0

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

Year: 2009
Plan: 1
Actual: 2

Patents listed
Bergman, J. Archadia Biosciences license for Centennial safflower variety technologies (2008)
Giroux, M. J., John Sherwood, K. Krishnamurthy, C. Morris. Transgenic Plants expressing Puroindolines and Methods for Producing Such Plants. U.S. patent #7,425,669 (2008)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	19	31	50

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Target	Actual
2009	15	10

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Target	Actual
2009	4	5

Output #3

Output Measure

- Number of research citations

Year	Target	Actual
2009	14	18

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
2009	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
Barley research continues to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. 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.

Results
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. MSU recently released new feed, forage, and malt barley varieties for Montana?s production environments that will provide added-value to growers throughout the Northern Plains. The replacement of older barley varieties with new ones (Haxby, Hays, Charles, Craft, and Eslick) should generate a yield improvement of about 15% with a net of about $45 million per year in added revenue to dryland barley growers. Three malting barley varieties (Craft, Geraldine, and Hockett) should result in about $80 million in added revenue. The top four varieties of winter wheat planted in 2009 account for nearly 53% of the total winter wheat planted in Montana. The top four varieties of malting barley represent about 50% of the total planted.

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	1	0

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. Asian consumers prefer noodles that remain bright in color over time. Grain hardness has a major influence on the end-use properties of wheat. The purpose of one project is to examine the effect of polyphenol oxidase (PPO) and grain protein on Asian noodle color, and to understand the genetic basis for grain hardness and its influence on end use quality in wheat.

What has been done
MSU research is 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. Researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs. Future productivity of the breeding program will be addressed by our efforts to improve our understanding of the genetics of key traits, and to develop new selection tools. A combination of genetic, molecular and biochemical tools will be used to improve our knowledge of cereal N recycling, with the long-term goal of improving N use efficiency. Based on preliminary data on the biochemistry and molecular biology of wheat PPOs, the biological basis for variation in this commercially important trait will be established. Primary emphasis of the winter wheat breeding program is development of improved winter wheat cultivars adapted to Montana climatic conditions and cropping systems. Major objectives are enhanced grain yield, incorporation of resistance to wheat stem sawfly, adequate winter hardiness, and superior end-use quality for bread and Asian noodle markets. A combination of field, laboratory, and greenhouse protocols are used for various objectives. 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. Both winter and spring wheats are selected to have dual-purpose end product quality.

Results
Various wheat research studies were completed including those involved with testing different varieties for usefulness in ethanol production and starch wet milling. A main result of MSU projects is the testing of the thousands of wheat samples that are submitted for the breeding programs and for various research projects. We have found that increased seed starch enzyme levels are associated with increased yield in both wheat and rice. Our research provides methods to analyze all lines of wheat to detect novel gene expression related to postharvest resistance, which could lead to new strategies for postharvest protection. 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.

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
2009	1	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
Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality. Hockett, a high yielding 2-rowed dryland-adapted malting barley cultivar was released in 2007. As a result, Anheuser-Busch contracted 20,000 acres of Hockett in 2008. No new barley or wheat cultivars were released in 2009.

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. Research results are distributed to farmers, colleagues, and stakeholders through technical and non-technical publications, through the release of germplasm, and through new genomics tools and techniques. 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
2009	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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.

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 winterhardiness, 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. Faculty screening of potential lines occurs annually through the MSU Cereal Quality Laboratory. Cultivar selection for small grain ethanol yield focuses primarily upon grain yield at the expense of protein content. Traditional selection for high hard red spring and hard white spring milling and baking quality is not consistent with maximizing ethanol yield per acre.

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	5	5

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. This reputation 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
About 10 to 15 new small grain cultivars are released (or changed through a collaborative process) to growers each year and the lower yielding or less desirable cultivars may be removed from the recommended lists by district 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 Montana Wheat and Barley Committee 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
2009	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. Genou continues to be the top winter wheat variety planted in 2009 in Montana. Farmers planted 598,700 acres of the variety or 24.5% of the total winter wheat acreage. The variety was released by MSU in 2004. Yellowstone is 3rd and accounted for 12.7% of the state?s planted acreage with 311,000 acres seeded. Yellowstone is a hard red winter wheat developed by the MAES and released in 2005. Choteau was the 2nd most common spring wheat variety planted in 2009 with 547,000 acres planted or 22.2% of Montana?s spring wheat acres. Choteau was developed by MAES in 2003. McNeal is ranked third for the third year in a row with 254,400 acres planted or 10.5% of all acres seeded. McNeal was developed by MAES and released in 1995. Haxby is the top barley variety planted for feed purposes in 2009 for the 3rd year in a row. It was seeded on 57,700 acres in 2009 and represents 6.3% of the state total. Haxby is a two-rowed barley developed by MSU. The

new dryland malting barley variety Hockett was commercialized in the spring of 2009. This variety should displace the commonly grown varieties, Metcalfe and Harrington, and should provide regional barley growers with a more reliable malting barley crop.

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. Drought conditions persist in some areas of Montana while spring flooding affected others in 2009.

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

1. Evaluation Studies Planned

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

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 # 7

1. Name of the Planned Program

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			20%	
206	Basic Plant Biology			10%	
213	Weeds Affecting Plants			20%	
215	Biological Control of Pests Affecting Plants			10%	
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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	30.0	0.0
Actual	0.0	0.0	36.4	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	550994	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	565334	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	1949884	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Communicate research results through field days, news releases, and presentations at county and state meetings and conventions

Distribute results of research via the Internet.
Hold strategic planning discussions with state agricultural groups.

2. Brief description of the target audience

State agricultural advisory committees
Crop and livestock producers in Montana
Montana wheat and barley committees, crop protection companies, fertilizer advisory committees, conservation tillage equipment companies
Participants in outreach and commodity group meetings and conferences

V(E). Planned Program (Outputs)

1. Standard output measures

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	400	125	0	0
Actual	800	1050	0	0

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

Year: 2009
Plan: 0
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	0	5	5

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2009	5	31

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.

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
2009	10	0

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 committees, 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, approved by voting members which provide 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, we refine and redirect our programs and stakeholders increase their knowledge of realistic timeframes for outputs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
204	Plant Product Quality and Utility (Preharvest)
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
2009	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 recordkeeping 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. Between 2005 and 2007, we assisted the Tribal Lands Department in writing three Noxious Weed Trust Fund Grants to the State of Montana. These grants were funded on three separate noxious weed control projects covering 347 acres of treatment in 2006, 1090 acres in 2007, and 688 acres for 2008. These projects reduce noxious weeds on wild lands and increase the carrying capacity for wildlife and livestock. In addition to these activities, we provided one-on-one help in sprayer calibration, label interpretation, and pest identification to new applicators.

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
601	Economics of Agricultural Production and Farm Management

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
2009	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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	15	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
2009	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
2009	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 2009. Dry peas (including Austrian winter peas, lentils, dry beans) have grown by 30 to 50% per year. Mustard seed production increased over 2008. Flaxseed production increased 30% in 2009

Results
Over 24,000 acres of camelina were planted in 2007 making the 2007 camelina crop the second largest oilseed crop in Montana behind safflower at 38,000 acres planted. A record barley crop was produced in Montana in 2008 with 71% being sold to malting companies. Specialty crops dipped in acreage planted in 2008 in response to high energy costs and high prices for traditional wheat and barley crops. As prices stabilize, more growers will return to alternative crop rotations.

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

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)

1. Evaluation Studies Planned

- Retrospective (post program)

- During (during program)

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 # 8

1. Name of the Planned Program

Sustainable Energy

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
511	New and Improved Non-Food Products and Processes			30%	
605	Natural Resource and Environmental Economics			30%	
903	Communication, Education, and Information Delivery			40%	
	Total			100%	

V(C). Planned Program (Inputs)

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

Year: 2009	Extension		Research	
	1862	1890	1862	1890
Actual	0.0	0.0	3.5	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	13456	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	13818	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	325487	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct outreach activities related to biobased products
Develop value-added, agriculturally based end-use products
Enhance partnerships among faculty across the Montana university system, producers, the agricultural industry, and other educational institutions across the region
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

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
Actual	200	200	0	0

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

Year: 2009
Plan:
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan			
Actual	5	5	10

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Target	Actual
2009	{No Data Entered}	0

Output #2

Output Measure

- Number of research citations

Year	Target	Actual
2009	{No Data Entered}	5

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of biofuels developed from existing crops in Montana
2	Number of new crop options introduced for biofuels in Montana

Outcome #1

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
2009	{No Data Entered}	0

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 and developing production systems to maximize 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
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.

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 #2

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
2009	{No Data Entered}	0

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.)
- Appropriations changes
- Public Policy changes
- Government Regulations

Brief Explanation

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)

1. Evaluation Studies Planned

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

Evaluation Results

Evaluation results are pending

Key Items of Evaluation

Evaluation results are pending

V(A). Planned Program (Summary)

Program # 9

1. Name of the Planned Program

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: 2009	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	20.0	0.0
Actual	0.0	0.0	10.1	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	113759	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	114474	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	435899	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

A new approach for mapping soil water content for site-specific measure will allow measurements with very small probes

An on-line, experiential course in the science of water quality for secondary science teachers who may be struggling with other time commitments is developed

Better utilization of limited water resources in Montana

Research results will be communicated in meetings with key organizations who impact decisions on water quality and quantity

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

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

V(E). Planned Program (Outputs)

1. Standard output measures

2009	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	350	400	0	0
Actual	400	450	0	0

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

Year: 2009
Plan: 0
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2009	Extension	Research	Total
Plan	0	5	
Actual	0	15	15

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations.

Year	Target	Actual
2009	12	36

Output #2

Output Measure

- Successful external grants

Year	Target	Actual

2009	2	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
2009	0	0

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
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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	0	0

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
2009	2	2

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, analyzes 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 seven invited university and international meeting presentations and 17 unsolicited presentations. One research program contains 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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2009	0	0

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
2009	0	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
2009	2	2

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 are also establishing 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

Snow pack 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)

1. Evaluation Studies Planned

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

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.