

# 2007 Montana State University Research Annual Report

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## I. Report Overview

### 1. Executive Summary

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

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

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

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

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

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

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

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

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

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

Inputs/Funding: The source of funds contributing to the research conducted by MAES faculty include, but are not limited to: BIA, BLM, Canadian Provinces, conservation and wildlife groups, Montana Board of Research and Commercialization Technology, Montana crop and animal agricultural groups, Montana Department of Agriculture, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, Montana Department of Transportation, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, NASA, NIH, NRCS, other states, overhead investments from sponsored programs, private donations, private industry, the State of Montana, USDA, USEPA, and USFS.

#### Outcomes and Impacts:

##### Enhance Economically Viable and Sustainable Agricultural Systems

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

#### Strengthen the Quality of Life for Montana and Its People

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

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

#### Program Areas

##### Agronomic and Forage Crops

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

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

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

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

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

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

#### Animal Health

**Situation:** Domestic and international consumers are demanding more information about the source of the meat products

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

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

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

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

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

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

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

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

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

The Montana Sheep Institute (MSI) is a cooperative project between Montana Wool Growers Association and MSU dedicated to developing and implementing non-traditional strategies that will increase the competitiveness of Montana's lamb and wool in the world market. Our goal is to explore integrated pest management (IPM) opportunities to increase the use of sheep in weed management programs, to improve the profitability and competitiveness of the Montana sheep industry, and to provide marketing opportunities for Montana sheep producers. Research is demonstrating that improved nutrition is a major factor that can reduce lamb mortality and improve profitability. Sheep grazing studies have been initiated in 10 sites involving over 100,000 acres of weed-infested rangeland and over 1000 landowners to determine the feasibility of controlling invasive weeds without the use of chemical controls. MSI is an example of how to develop positive working relationships among stakeholders to improve weed and land management. A new method of analyzing wool samples at the time of shearing has improved the segregation of wool samples by micron size. Researchers met with military personnel to discuss the potential for the use of wool fibers that are 19 microns and finer.

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

#### Biobased Products and Processing

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

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

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

technology and biotechnology that improve plant and animal production systems while adding value and improving food security for our stakeholders.

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

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

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

#### Integrated Pest Management (IPM)

**Situation:** Weeds, diseases, and insects continually challenge Montana producers who are often producing crops under less than ideal conditions. Difficult-to-control pests challenge producers and researchers to evaluate new IPM methodologies in order to maintain a competitive position in U.S. and world markets. The increase in public concern about food quality, cost, natural resource biodiversity, and sustainability of the quality of soil, air, and water is mandating less reliance on traditional pesticides and research into more environmentally friendly systems, including biological controls. Foreign trade partners want decreased pesticide residues in the wheat and barley commodities that are imported into their countries.

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

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

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

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

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

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

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

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

identification and testing of various arthropods for the biological control of hoary cress, field bindweed, rush skeletonweed, Russian knapweed, tansy ragwort, and invasive hawkweeds continued.

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

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

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

#### Plant Breeding, Genetics, and Genomics

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

**Priorities:** MSU seeks to maintain its role as a leading university in small grains genetics research. The agricultural community and allied industries depend on new cultivars of important crops to remain competitive in the world market place. Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality. MSU's intensive genomic research will help Montana producers stay competitive and will provide improved cultivars adapted to Montana climatic conditions and cropping systems. Increased understanding of the molecular biology and biochemistry of cereal grains will lead to the development of products more suited to the requirements of competitive world markets.

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

**Research Activities:** A major effort is underway to characterize and evaluate wheat and barley germplasm and to increase the utilization of world germplasm collections. Based on average planted acreage and prices, development of an improved winter wheat cultivar that produces an additional one bushel per acre either by enhanced yield or reduced yield loss to disease, insects, or environmental stresses adds \$5–\$6 million in revenue per year to the Montana economy. A recently released solid stem winter wheat cultivar, Genou, has improved yield potential, especially in wheat stem sawfly-infested areas of Montana. Sawfly-resistant wheat cultivars can prevent crop-yield losses of from 15 to 90%. Research results are distributed to farmers, colleagues, and stakeholders through technical and non-technical publications, through the release of germplasm, and through new genomics tools and techniques.

The development and distribution of improved barley varieties is a priority of the barley breeding program. MSU recently released four new feed, forage, and malt barley varieties for Montana's production environments that will provide added-value to growers throughout the Northern Plains. The replacement of older barley varieties with new ones (Haxby, Hays, Charles, Craft, and Eslick) should generate a yield improvement of about 15% with a net of about \$45 million per year in added revenue to dryland barley growers; three malting barley varieties (Craft, Geraldine, and Hockett) should result in about \$80 million in added revenue.



Programs use quality field research technologies, extensive on-station and on-farm trials, and state-of-the-art genomics tools to develop well-adapted, high yielding, improved quality barley varieties. Barley research will continue to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. Varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Research trials found few differences in feedlot performance between steers fed finishing diets based on corn or Valier barley; this knowledge translates into increased markets for barley producers and lower average costs of gain for local cattle feeders. Our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance has been developed and extended through genetic diversity experiments.

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

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

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

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

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

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

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

By determining the fate of nitrogen in plants from anthesis to plant death, we expect to improve our understanding of the cellular and molecular details of nitrogen remobilization, thus closing an important knowledge gap in modern plant biology. MSU research is working to identify the genes involved in control of inflorescence development to provide new approaches to breeding practices or transgenic manipulation. Plant research in high CO<sub>2</sub> environments in YNP may offer a window into the future regarding the nature of plant growth and survival in a high-CO<sub>2</sub> world.

### Sustainable Agriculture

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

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

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

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

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

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

By the latter half of the 21st century, climate change could jeopardize agriculture, forestry, crop production, and other industries dependent on the natural environment. Studies under several crop rotation systems continue to address questions on the contribution to global warming of agricultural nitrous oxide (N<sub>2</sub>O). N<sub>2</sub>O is estimated to be over 300 times greater than carbon dioxide in its atmospheric warming potential. Studies are in place to validate or refute methodology for estimating N<sub>2</sub>O emissions in the Northern Great Plains. Scientific interest in the effects of increasing atmospheric CO<sub>2</sub> on plants has motivated us to better understand plant photosynthetic physiology and plant community structure in the high-CO<sub>2</sub> environments of YNP. Several projects have looked at flora growing in or near the hot springs in YNP. Understanding the mechanisms of growth of these native plants in geothermally-modified soils will help researchers gain insight into how climate change may impact agricultural production. Additional projects are investigating the potential for soil carbon sequestration in rangelands; information produced by this research will improve the ability of public decision makers to formulate policies regarding climate change and greenhouse gas mitigation.

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

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

#### Water Quality and Use

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

As a semi-arid state, most crops are dependent on irrigation from streams and groundwater systems. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for the continuing adequacy of water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 8.9 million acre-feet of water annually. Education and research activities have precipitated a general trend toward more efficient irrigation systems and more drought tolerant crops.

Priorities: Research information on water utilization and management in the Northern Rockies is very limited. Finding crops that

require less water per acre and will grow in our short growing season requires innovative solutions. This is being partially accomplished through MSU's extensive crop breeding programs, water management research, the introduction of new drought tolerant crops, and other conservation practices. Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses will help protect riparian areas and improve our state's fisheries and wildlife habitat.

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

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

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

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

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

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

**Total Actual Amount of professional FTEs/SYs for this State**

Year:2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	6.0	0.0	44.8	0.0
<b>Actual</b>	0.0	0.0	306.0	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 College of Agriculture department heads, includes the principle investigator's (PI) department head, MAES administrator, one department peer reviewer and two additional faculty external to the PI's department. Seminars are presented to the review committee and to interested stakeholders, including faculty, staff, students, and constituents. The seminars are announced to the public on the web, so any interested citizen could attend. Reviewers are requested to provide written recommendations on the following items: relevance and importance of the project; relation of the project to previous research; objectives; approach and methods; scientific and technical quality; resources; environmental, economic, and/or social impacts. The responses are presented to the PI during a subsequent meeting with the MAES administrator and department head. Projects that do not meet expectations will not be approved and action upon them will be deferred until all of the key elements listed above have been satisfactorily met. Ultimately, Director approved projects are submitted to USDA CSREES for final approval.

## III. 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 programs)

#### Brief Explanation

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

### 2(A). A brief statement of the process that 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 local advisory groups that meet 2–3 times per year. In addition, a State Advisory Committee meets three times per year to discuss program focus and direction, legislative priorities and productivity/impact. All of these meetings are open to the public. Administrators and faculty in the COA serve on agricultural association committees that direct and fund research activities that have multiple meetings and communications throughout the year.

**2(B). A brief statement of the process that 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)

**Brief Explanation**

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

**3. A statement of how the input was 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 program activities that allow stakeholder input and strong interactive dialogue. The COA and MAES are the leaders in this regard at MSU. We are the primary conduit in connection and delivery of education and new knowledge in agricultural and natural resource activities throughout rural Montana. In particular, the MAES Advisory Council directly interacts with faculty after they become a new faculty member.

**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**

<b>1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)</b>			
<b>Extension</b>		<b>Research</b>	
<b>Smith-Lever 3b &amp; 3c</b>	<b>1890 Extension</b>	<b>Hatch</b>	<b>Evans-Allen</b>
0	0	3829567	0

<b>2. Totaled Actual dollars from Planned Programs Inputs</b>				
	<b>Extension</b>		<b>Research</b>	
	<b>Smith-Lever 3b &amp; 3c</b>	<b>1890 Extension</b>	<b>Hatch</b>	<b>Evans-Allen</b>
<b>Actual Formula</b>	0	0	1987695	0
<b>Actual Matching</b>	0	0	11646925	0
<b>Actual All Other</b>	0	0	26508318	0
<b>Total Actual Expended</b>	0	0	40142938	0

<b>3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous years</b>				
<b>Carryover</b>	0	0	0	0

**V. Planned Program Table of Content**

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



**Program #1**

**V(A). Planned Program (Summary)**

**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%	
	<b>Total</b>			100%	

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	1.0	0.0	3.4	0.0
<b>Actual</b>	0.0	0.0	24.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	91070	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1408826	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2392348	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

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

**2. Brief description of the target audience**

Our target audience includes the 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**

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

	<b>Direct Contacts Adults</b>	<b>Indirect Contacts Adults</b>	<b>Direct Contacts Youth</b>	<b>Indirect Contacts Youth</b>
<b>Year</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>
<b>Plan</b>	250	400	0	0
2007	450	450	0	0

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

**Patent Applications Submitted**

<b>Year</b>	<b>Target</b>
<b>Plan:</b>	0
2007 :	0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	<b>Extension</b>	<b>Research</b>	<b>Total</b>
<b>Plan</b>			
2007	0	8	8

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations.

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	10	15

**Output #2**

**Output Measure**

- Successful external grants

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	1	9

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
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 Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	0	1

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Soil water is a primary limiting factor for plant growth in semiarid and arid regions like Montana. In order to provide sustainability to Montana producers and urban dwellers, several programs are in place to evaluate, monitor, accurately measure quantity (and some quality characteristics), and provide cropping and irrigation recommendations to agricultural and urban stakeholders.

**What has been done**

Projects have been developed to improve methods to measure soil water, and improve understanding of soil water dynamics. A new method to estimate specific surface area of porous media using time domain reflectometry (TDR), based on dielectric properties of bound water, is being refined and evaluated. New faculty hires will also enhance our ability to more readily extrapolate to watershed scale processes.

**Results**

We measured for the first time the permittivity spectrum of materials with high accuracy over a wide frequency range using conventional TDR instruments, facilitating use of time domain spectroscopy in soils applications. Our findings on the effective TDR frequency range allows comparison with other measurement approaches including remote sensing, ground penetrating radar, and capacitance sensors. 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
2007	0	0

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**

Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses, while enhancing our understanding of key resources (water and soil) and inherent geochemical processes, will help protect riparian areas and improve our States fisheries and wildlife habitat.

**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, and other conservation practices. In addition, enhancing our knowledge of water quantity and quality will also influence water-related decisions.

**Results**

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 double or triple alfalfa yields and can add significantly to yields of other crops when compared to dryland cropping in Montana. Higher rates of fertilization combined with improper soil moisture management may become a limiting input influencing yields, returns, and crop quality. Land management (burned or logged lands) coupled with an increased understanding of watershed processes influences future land management practices.

**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
2007	2	5

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**

Target audiences of outreach activities to date have been irrigators and the general public in communities near irrigation projects. Improving the quality of watersheds in Montana should be a goal of all rural and urban residents. 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.

**What has been done**

Montana State University faculty saw a need to expand their current curriculum, as well as the reach of online education, by developing an online water resource field course that combined traditional online learning strategies with field-based science exploration. The course will also serve as a model for development and delivery of field-based, experiential learning on-line course development in other natural resource disciplines.

**Results**

Efforts have been in creating newspaper releases aimed at informing the audience of our project goals and purpose, the importance of agricultural in eastern Montana, and on general topics related to water conservation and watershed protection including water conservation tips and drought.

**4. Associated Knowledge Areas**

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

**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**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2007	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.

**What has been done**

The shape, size, and distribution of wetland and riparian zones are largely determined by geologic, topographic, and hydrologic conditions. Understanding the relationships among watershed factors and mapping the results is a useful and valuable endeavor 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 effective sampling of landscape variability are being investigated using remote sensing procedures and on-the-ground measurements that enable systematic inventories of these ecosystems.

**4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
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 Action Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	0	0

**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.

**What has been done**

Projects have been established to monitor snowpack and runoff timing in several watersheds to develop relationship models with key universal parameters.

**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.

**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
2007	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. Interest in the extraction of coal bed methane has raised questions regarding the reuse of water contaminated during the extraction process.

**What has been done**

Since coal bed methane is a potential source of diversified income for many of our Native American tribes, MSU is working with tribes 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. In addition to researching the waters of the coal bed methane process, a program in water management studies is being developed to help teachers at the secondary school level have access to new teaching materials about the role of water in our environment. The study of water quality is highly multidisciplinary in nature, encompassing areas of biology, ecology, hydrology, chemistry, biochemistry, physics, agronomy, and soil civics. The purpose of this project is to develop, deliver, and evaluate an on-line, experiential course in the science of water quality for secondary science teachers.

#### 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.

##### Key Items of Evaluation

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



**Program #2**

**V(A). Planned Program (Summary)**

**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%	
<b>Total</b>				100%	

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	1.4	0.0	6.1	0.0
<b>Actual</b>	0.0	0.0	71.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	443640	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	4357307	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2507941	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

Research results will be communicated through pesticide workshops and field days held throughout the state. Publications that provide pest control recommendations will be made available in print and online to stakeholders. Results will also be used to update pesticide applicator training materials and to support FIFRA Section 18c products labeling requests. Training materials and regional management guides will be updated for private and commercial applicators of crop protection products.

**2. Brief description of the target audience**

Our target audience includes crop producers, dealers, distributors, technical and registration personnel from crop protection companies, private and commercial pesticide applicators, Montana crop advisory boards, 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**

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

	<b>Direct Contacts Adults</b>	<b>Indirect Contacts Adults</b>	<b>Direct Contacts Youth</b>	<b>Indirect Contacts Youth</b>
<b>Year</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>
<b>Plan</b>	200	150	0	0
2007	1775	1775	0	0

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

**Patent Applications Submitted**

<b>Year</b>	<b>Target</b>
<b>Plan:</b>	0
2007 :	0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	<b>Extension</b>	<b>Research</b>	<b>Total</b>
<b>Plan</b>			
2007	0	15	15

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	10	15

**Output #2**

**Output Measure**

- Multidisciplinary journal articles published

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	0	3

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
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	Amount of financial support from industry per year for ongoing research (\$)
6	New products registered

**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
2007	3	3

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Transitioning to 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.

**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.

**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.

**4. Associated Knowledge Areas**

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

**Outcome #2****1. Outcome Measures**

New IPM options discovered and evaluated per year

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Action Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	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.

**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.

**4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants

**Outcome #3****1. Outcome Measures**

Number of broad-ranging stewardship practices implemented

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Condition Outcome Measure

**3b. Quantitative Outcome**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2007	0	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.

**What has been done**

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. A new potato fungicide management program was developed by MSU research and continues to be used for control of *Rhizoctonia* black scurf in potatoes. This project demonstrates the effectiveness of the integration of proven biological control agents into disease management systems for diseases of potato.

**Results**

Muscodor albus seed treatments show promise as an alternative to chemical pesticides for control of several Rhizoctonia and scab diseases of potatoes. The deployment of bio-fungicides could also provide an important crop management tool missing in organic wheat production. Mycofumigation with volatile organic gases produced by Muscodor albus may provide an alternative to methyl bromide fumigation for control of soil fungi and plant parasitic nematodes.

#### 4. Associated Knowledge Areas

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

#### 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
2007	70	90

##### 3c. Qualitative Outcome or Impact Statement

###### Issue (Who cares and Why)

As a minimum requirement for certification, a private applicator must show that he possesses 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 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
216	Integrated Pest Management Systems
213	Weeds Affecting Plants
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants

#### Outcome #5

**1. Outcome Measures**

Amount of financial support from industry per year for ongoing research (\$)

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Action Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	100000	100000

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Stakeholders rely on information generated from MSU research for maintaining and improving their crop productivity. Funding from multiple sources is needed to ensure that research programs at MSU continue uninterrupted to their conclusion, particularly for new chemicals.

**What has been done**

MSU has secured funding from numerous commercial, private, and governmental organizations, companies, departments, and individuals.

**Results**

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, and the Montana Wheat and Barley Committee.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
213	Weeds Affecting Plants
216	Integrated Pest Management Systems
212	Pathogens and Nematodes Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants

**Outcome #6****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
2007	0	4

**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**

Section 18(c) emergency labeling has been received for control of Fusarium head blight in wheat and barley and for control of Ascochyta blight in lentils. Insecticides to control Varroa mites and small hive beetles in honeybee colonies and new insecticides for control of Russian wheat aphid, cereal leaf beetle, and cutworms in barley have been issued. Additionally a fungicide for control of Cercospora in sugar beets and an insecticide for control of spider mites in seed alfalfa were registered under Section 24(c).

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
212	Pathogens and Nematodes Affecting Plants
213	Weeds Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants
216	Integrated Pest Management Systems
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
- Government Regulations

**Brief Explanation**

Government regulations on the approval of new pest control options continue to be challenging for manufacturers and researchers to obtain registration for new products. The focus of a vocal group of producers on organic production and the use of biocontrols creates a need for MSU researchers to delve into new non-traditional approaches.

**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.



**Program #3**

**V(A). Planned Program (Summary)**

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

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	1.6	0.0	3.6	0.0
<b>Actual</b>	0.0	0.0	36.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	187366	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1283118	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	3241413	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

Activity includes the communication of research results through field days, news releases and presentations at county and state meetings and conventions, holding strategic planning meetings with state agricultural groups, and distributing results of research via the Internet.

**2. Brief description of the target audience**

Our target audience is crop and livestock producers in Montana, Montana wheat and barley committees, crop protection companies, fertilizer advisory committees, conservation tillage equipment companies, alternative energy groups, and state agricultural advisory committees.

**V(E). Planned Program (Outputs)**

**1. Standard output measures**

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

	<b>Direct Contacts Adults</b>	<b>Indirect Contacts Adults</b>	<b>Direct Contacts Youth</b>	<b>Indirect Contacts Youth</b>
<b>Year</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>
<b>Plan</b>	200	100	0	0
2007	1050	1050	0	0

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

**Patent Applications Submitted**

<b>Year</b>	<b>Target</b>
<b>Plan:</b>	0
2007 :	1

**Patents listed**

Bergman, J., Sustainable Systems, LLC license for 'Montola' safflower variety in U.S.

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	<b>Extension</b>	<b>Research</b>	<b>Total</b>
<b>Plan</b>			
2007	0	8	8

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	5	10

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
1	Number of strategic planning meetings with state groups and agencies
2	Number of producers per year implementing new farm management and budgeting practices
3	The amount of additional funding per year from new sources or increased funding from existing sources (\$)
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 strategic planning meetings with state groups and agencies

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	10	14

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

There is a need for meeting 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 the needs of the stakeholders. 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
213	Weeds Affecting Plants
205	Plant Management Systems
121	Management of Range Resources

**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
2007	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 maintaining the right balance of enterprises, innovative marketing, and accurate recordkeeping.

**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.

**Results**

Participation at off-campus educational outreach programs presented by the MSU Department of Agricultural Economics and Economics (general) is high with over 2000 participants per year.

**4. Associated Knowledge Areas**

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

**Outcome #3**

**1. Outcome Measures**

The amount of additional funding per year from new sources or increased funding from existing sources (\$)

**2. Associated Institution Types**

- 1862 Research

**3a. Outcome Type:**

Change in Condition Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	50000	150000

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**

For MSU to be successful in developing and implementing research and outreach programs, adequate external funding is needed. With the necessary funds, researchers are able to develop the information, new varieties, and recommendations that allow producers in Montana to be more productive.

**What has been done**

Annual meetings are held with producers, commodity groups, advisory boards, and industry to present research results, plan future research and outreach activities, and identify funding opportunities for the COA/MAES.

**Results**

The source of funds contributing to sustainable agriculture research conducted by MAES faculty include, but are not limited to: BLM, 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, overhead investments from sponsored programs, private donations, private industry, the State of Montana, and USDA.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
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121	Management of Range Resources
206	Basic Plant Biology

**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
2007	5	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 practicing sustainable agriculture.

**Results**

In Montana, the growth of alternative crops, such as canola and camelina, demonstrates stakeholder acceptance of information presented by MSU research and extension personnel.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
205	Plant Management Systems
121	Management of Range Resources
215	Biological Control of Pests Affecting Plants
213	Weeds 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
2007	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. 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 producers bottom line profits.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems
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
2007	5	20

**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 barely sustainable and need other income sources.

**What has been done**

Growth in the production of specialty crops has been strong from 2004 through 2007. Dry peas (including Austrian winter peas, lentils, dry beans have grown by 30 to 50% per year. Camelina was introduced in 2004 to Montana growers.

**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. Other specialty crops have remained stable during this time, partially due to the astronomically high prices for the traditional wheat and barley crops. Growers continue to investigate crops for biofuels, especially with increasing ethanol production and biodiesel interest.

**4. Associated Knowledge Areas**

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

**V(H). Planned Program (External Factors)****External factors which affected outcomes**

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

**Brief Explanation**

Higher fuel and fertilizer prices have forced producers of small grains to consider alternative cropping systems where feasible.

**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 for Montana farmers.



**Program #4**

**V(A). Planned Program (Summary)**

**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			20%	
605	Natural Resource and Environmental Economics			35%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residu			10%	
<b>Total</b>				100%	

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	0.5	0.0	13.2	0.0
<b>Actual</b>	0.0	0.0	9.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	179447	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	367464	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	476628	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. The Institute has developed additional collaborative relationships with Montana Economic Development Centers, MSU TechRanch and MSU TechLink to facilitate technology transfer from products and practices developed by the Biobased Institute to the private sector. These collaborators have expertise in incubating new businesses and new products, as well as assisting existing enterprises in product expansion.

**2. Brief description of the target audience**

Target audiences include crop and livestock producers in Montana, alternative energy groups, state agricultural advisory committees, economic development groups, State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, other government entities, and participants in extension and commodity group meetings, conventions, and conferences.

**V(E). Planned Program (Outputs)**

**1. Standard output measures**

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

	<b>Direct Contacts Adults</b>	<b>Indirect Contacts Adults</b>	<b>Direct Contacts Youth</b>	<b>Indirect Contacts Youth</b>
<b>Year</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>
<b>Plan</b>	100	50	0	0
2007	750	750	0	0

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

**Patent Applications Submitted**

<b>Year</b>	<b>Target</b>
<b>Plan:</b>	0
2007 :	1

**Patents listed**

Strobel, G.A., Patent No.7,070,985 on the use of Muscodor albus to treat human and animal wastes.

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	<b>Extension</b>	<b>Research</b>	<b>Total</b>
<b>Plan</b>			
2007	0	5	5

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- New business partnerships created

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	1	0

**Output #2**

**Output Measure**

- Number of research citations

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	4	8

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
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
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 to Montana's agricultural products
5	New or expand 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 Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	0	0

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Small Business Innovation Research (SBIR) grant proposals are prepared by MSU-COA, MSU-TechLink, 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 the Bioproducts Institute 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 profits made from new products, new markets, and new dietary products made from new Montana crops (e.g. gluten-free flour) and long-established agricultural commodities.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residu

**Outcome #2****1. Outcome Measures**

Number of opportunities and value-added programs introduced in Montana through continued education, research and partnering

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Action Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	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. MSUs Bioproducts Institute investigates new technology, new crops suitable for production in Montanas climate and soil conditions, and ways to add value to existing cropping systems.

**What has been done**

The MSU Biobased Institute supports 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**

The Institute strives to be innovative and responsive to the developing needs of the State of Montana and the Pacific Northwest/ Northern High Plains regions. 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.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
711	Ensure Food Products Free of Harmful Chemicals, Including Residu
502	New and Improved Food Products

**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 Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	1	3

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**

The Biobased Institute funds research projects that strive to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy product development activities.

**What has been done**

The Biobased Institute funds research projects that strive to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy.

**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.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
502	New and Improved Food Products

**Outcome #4****1. Outcome Measures**

Number of new food safety recommendations developed for consumers, which add value to Montana's agricultural products

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Action Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	2	2

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

A major goal of the Biobased Products Institute at MSU is to develop systems for food safety and agricultural security for US and global consumers.

**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.

**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.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residu

**Outcome #5****1. Outcome Measures**

New or expand 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
2007	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 Biobased Institute to explore potential licensing for various products.

**What has been done**

MSU Researchers have isolated strains of *Bacillus mycoides* discovered by MSU personnel and tested them against numerous diseases of potatoes, sugar beets, cucurbits, and other crops.

**Results**

Two *Bacillus mycoides* disease biocontrol agents (isolate Bmj and isolate Bp16-5) have been developed by MSU and are licensed to Montana Microbials, Inc. (Missoula, MT). Isolate Bmj is currently approved under EPA experimental use permits on 10,000 acres of sugar beets in MT, ND, MN and MI. MSU researchers are working with Wyoming Biodiesel to manufacture composite coal pellets (Bio-Koal™). These pellets are composed of 70% coal residue and 30% camelina oil and generate approximately 10,400 BTU/pound, whereas, the original coal generates 8,400 BTU/pound. The pellets have reduced carbon emissions relative to 100% coal and can be used in any coal-burning generator.

**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 Residu

**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. High fuel costs and the general acceptance of ethanol-based biofuels have increased the interest in the production of camelina. 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.

**Key Items of Evaluation**

Evaluations are on-going through interactions at winter meetings.

**Program #5****V(A). Planned Program (Summary)****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%	
	<b>Total</b>			100%	

**V(C). Planned Program (Inputs)****1. Actual amount of professional FTE/SYs expended this Program**

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	0.0	0.0	4.8	0.0
<b>Actual</b>	0.0	0.0	36.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	436712	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1370851	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2448257	0

**V(D). Planned Program (Activity)****1. Brief description of the Activity**

Activities include the production of technical and non-technical publications, and the release of germplasm, new varieties, and new genomics tools and techniques. In addition, information on plant breeding and genomics advances is communicated through classroom activities, field days, variety trials, news releases, presentations at county and state meetings and conventions, and strategic activities with state agricultural groups.

**2. Brief description of the target audience**

Our target audience is farmers, colleagues, stakeholders, grain associations, Montana Department of Agriculture, Montana Wheat and Barley Committee, grain elevators, state commodity groups, seed companies, and domestic and foreign buyers of quality wheat.



**V(E). Planned Program (Outputs)**

**1. Standard output measures**

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

	<b>Direct Contacts Adults</b>	<b>Indirect Contacts Adults</b>	<b>Direct Contacts Youth</b>	<b>Indirect Contacts Youth</b>
<b>Year</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>	<b>Target</b>
<b>Plan</b>	2000	500	0	0
2007	2600	1000	0	0

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

**Patent Applications Submitted**

<b>Year</b>	<b>Target</b>
<b>Plan:</b>	1
2007 :	2

**Patents listed**

Bruckner, P.L., US Plant Variety Protection Certificate No.200500347, Wheat, common, 'MT1159CL'  
 Bruckner, P.L., US Plant Variety Protection Certificate No.200500334, Wheat, common, 'Genou'

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	<b>Extension</b>	<b>Research</b>	<b>Total</b>
<b>Plan</b>			
2007	0	10	10

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of foreign trade teams in Montana

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	15	26

**Output #2**

**Output Measure**

- Number of foreign trade teams at MSU

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	4	10

**Output #3**

**Output Measure**

- Number of research citations

<b>Year</b>	<b>Target</b>	<b>Actual</b>
2007	10	15

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
1	Documents on new cultivars provided to Montana producers to maintain Montana producers' dominance in specialty 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 (base 2005) of MSU-released small grains in Montana

**Outcome #1****1. Outcome Measures**

Documents on new cultivars provided to Montana producers to maintain Montana producers' dominance in specialty grain markets

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	100	100

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

The development and acceptance of new cultivars of traditional and non-traditional crops is important to producers in Montana and other Great Plains states. 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. A major effort is underway to characterize and evaluate wheat and barley germplasm and to increase the utilization of world germplasm collections.

**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.

**Results**

A solid stem winter wheat cultivar, Genou, released by MSU in 2004, has improved yield potential, especially in wheat stem sawfly-infested areas of Montana. Genou is the top winter wheat variety planted in Montana, jumping from 13th position in 2006 to 1st in 2007. The variety accounts for 16.1 percent of the states acreage total. MSU recently released four new feed, forage, and malt barley varieties for Montanas production environments that will provide added-value to growers throughout the Northern Plains. 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 is also participating in the wheat CAP program.

**4. Associated Knowledge Areas**

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

**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
2007	1	0

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Reliable yield of a high quality is essential for the long-term marketing of Montana wheat. The broader impacts of MSU research are a larger food supply for the world, and an improved ability of Montana farmers to compete in a global marketplace. 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.

**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 quality. Researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs.

**Results**

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.

**4. Associated Knowledge Areas**

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

**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
2007	0	0

**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 market place. 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. A recently released solid stem winter wheat cultivar, Genou, has improved yield potential especially in wheat stem sawfly infested areas of Montana.

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

**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 Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	100	80

**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.

**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.

**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 Cereal Quality Laboratory.

**4. Associated Knowledge Areas**

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

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2007	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.

**What has been done**

About 10 to 15 new varieties are released to growers and the lower yielding or less desirable varieties may be removed from the recommended lists by district based upon agronomic and pest responses. This keeps only those varieties 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.

**Results**

As wheat and barley varieties are developed, information is reviewed by MSU researchers and the Montana Wheat and Barley Committee for inclusion in the years recommendations. These recommendations are made available to growers and seed distributors each year. New varieties are developed on-going at MSU and are annually reviewed by MSU and other industry and State partners before releasing to the public.

**4. Associated Knowledge Areas**

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

**Outcome #6****1. Outcome Measures**

Planted acreage percentage increase per year (base 2005) of 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
2007	10	0

**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 the new MSU cultivars that are released each year.

**What has been done**

One or two new cultivars are commercially 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.

**Results**

As wheat and barley varieties are developed, information is reviewed by MSU researchers and recommendations for the year. Two new wheat cultivars (Genou and Choteau) were planted on 353,000 acres and 594,100 acres respectively in 2007, an increase of collectively over 417,800 acres from 2006. Genou was first planted in 2006 and Choteau was planted on 40,900 acres in 2005. Other MSU varieties (McNeal, Rampart, and Vanguard) were planted on fewer acres in 2006 and 2007 being replaced by Genou and Choteau. Therefore the actual total net percentage increase per year of MSU-released small grains remained about zero.

**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
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources

**V(H). Planned Program (External Factors)****External factors which affected outcomes**

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

**Brief Explanation****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**

Growth in the planting of new varieties demonstrates the success of the breeding programs at MSU.

**Program #6**

**V(A). Planned Program (Summary)**

**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%	
	<b>Total</b>			100%	

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	0.5	0.0	9.3	0.0
<b>Actual</b>	0.0	0.0	105.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	482523	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1949480	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	13723859	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

Activities include the presentation of papers and research results at state nutrition conferences, field days, county meetings and state conventions, and conducting strategic planning meetings with state agricultural groups, including the Montana Stockgrowers Association, the Montana Board of Livestock, and the State Veterinarian.

**2. Brief description of the target audience**



The target audience includes ranchers, seedstock industry, colleagues and related stakeholders, Montana Department of Agriculture, animal health companies, state commodity groups, Montana Stockgrowers Association, and the Montana Board of Livestock.

**V(E). Planned Program (Outputs)**

**1. Standard output measures**

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

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	250	100	0	0
2007	1400	1400	0	0

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

**Patent Applications Submitted**

Year	Target
Plan:	0
2007 :	0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	Extension	Research	Total
Plan			
2007	20	0	20

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations

Year	Target	Actual
2007	15	25

**Output #2**

**Output Measure**

- Building built through donations

Year	Target	Actual
2007	0	0

**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
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	Number of publications or 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 Knowledge Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	1	1

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Infectious diseases of humans and animals are caused by a wide spectrum of microorganisms including single-cell bacteria, multi-cellular parasites, viruses, or infectious proteins. Fatal degeneration of the central nervous system occurs in prion diseases, such as bovine spongiform encephalopathy (BSE) in cattle, and chronic wasting disease (CWD) in deer and elk. Animal losses due to disease creates the need for an improved understanding of these factors affecting Montana livestock.

**What has been done**

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. Research has been conducted to define the pathway of prion agents following infection to improve our understanding of how infection spreads within a host.

**Results**

A focus on disease management, reproduction, and carcass traits will help ensure that Montana meat products maintain the highest standards. The ability of gamma delta T cells to provide some level of disease resistance has been incrementally progressing towards the identification of key process steps whereby intervention may be possible.

**4. Associated Knowledge Areas**

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

**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
2007	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.

**What has been done**

By using a controlled internal drug releasing device (CIDR) as a progestin source and timing artificial insemination of cows, beef production units benefit without the necessity of facilities for feeding pellets containing melengesterol acetate (MGA) and experiencing the inconsistent results associated with feeding MGA.

**Results**

More enterprises are using controlled estrus and developing management plans to improve the economics of raising healthy calves to market.

**4. Associated Knowledge Areas**

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

**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**

<b>Year</b>	<b>Quantitative Target</b>	<b>Actual</b>
2007	0	0

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

A vaccine against brucellosis is needed to ensure that Montana remains a brucellosis free state. Producers expect premiums for their calves raised under these conditions.

**What has been done**

The development of a subunit vaccine for brucellosis combined with live attenuated vaccines will provide effective 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**

Results of the bison and mouse vaccination studies are encouraging because protective efficacy was obtained in both bison and mouse systems. Our results from the bison and mouse vaccination studies are encouraging because protective efficacy was obtained in both animal systems through the identification of a smaller number of effective protein sub-units in the test vaccine.

**4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
307	Animal Management Systems
315	Animal Welfare/Well-Being and Protection
311	Animal Diseases

**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
2007	1	2

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

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. In addition, zoonotic disease outbreaks have caused the quarantine of various regions of Montana to livestock movement.

**What has been done**

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.

**Results**

Because of bluetongue presence in Montana, Canadian trade restrictions prevent shipping feeder cattle from Montana to Canada outside of the non-fly season (March to October). Study results have demonstrated that transmission in Montana is not an issue and cattle shipments should not be subjected to trade restrictions.

**4. Associated Knowledge Areas**

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

**Outcome #5****1. Outcome Measures**

Number of publications or meetings that maintain or enhance Montana's presence in the production of quality meat products

**2. Associated Institution Types**

•1862 Research

**3a. Outcome Type:**

Change in Condition Outcome Measure

**3b. Quantitative Outcome**

Year	Quantitative Target	Actual
2007	1	4

**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.

**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.

**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 resulting in an improvement of animal health.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
902	Administration of Projects and Programs
311	Animal Diseases
303	Genetic Improvement of Animals
302	Nutrient Utilization in Animals
315	Animal Welfare/Well-Being and Protection

**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**

An extended drought created a scenario for increased range and forest fires, which subsequently increased the potential for environmental problems, reduced grazing options, and added stress to livestock that will have landowner impact for years. In these large burn acres, grazing activities become concentrated with livestock and wildlife adding greatly to increases in the potential incidence of disease.

**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.

**Program #7**

**V(A). Planned Program (Summary)**

**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			35%	
<b>Total</b>				100%	

**V(C). Planned Program (Inputs)**

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

Year: 2007	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	1.0	0.0	4.4	0.0
<b>Actual</b>	0.0	0.0	24.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	166937	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	909879	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1717872	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

Activities for this planned program include workshops and meetings with federal and state land management agencies, and the development of research summaries, fact sheets, and Internet materials. Training is conducted in cooperation with the Montana hay Growers Association, Montana Alfalfa Seed Growers Association, and the Montana Seed Growers Association.

**2. Brief description of the target audience**

Our target audience includes farmers and ranchers in Montana, State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities, and participants in extension and commodity group meetings, conferences and field days.

**V(E). Planned Program (Outputs)**

**1. Standard output measures**

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

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	100	200	0	0
2007	2300	2300	0	0

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

**Patent Applications Submitted**

Year	Target
Plan:	0
2007 :	0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

	Extension	Research	Total
Plan			
2007	10	10	20

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations

Year	Target	Actual
2007	6	25



**V(G). State Defined Outcomes****V. State Defined Outcomes Table of Content**

<b>O No.</b>	<b>OUTCOME NAME</b>
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
2007	2	5

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Livestock producers need to obtain more value out of grazing regimes and alfalfa and grass production, especially with the high price of fuel and increasing feed costs. The establishment of new value-added crops and the development of higher yielding crop varieties are priorities among agronomic researchers and crop producing stakeholders.

**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 continues to gain momentum in Montana with close involvement among research, extension, and stakeholders.

**Results**

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
2007	1	0

**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 for Montanans.

**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**

Crop diversity studies continue to show promise for winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea. Montana Agricultural Statistics show that new crops have been adopted based on the increasing acres of chickpeas and lentils. Priorities in developing higher disease and insect resistance in wheat and barley, greater nutritional value for forages, and more efficient use of natural resources (especially water) are being met.

**4. Associated Knowledge Areas**

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
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
2007	5000	5000

**3c. Qualitative Outcome or Impact Statement****Issue (Who cares and Why)**

Producers need to continue to evaluate alternative crops due to increasing production costs, increasing pest populations, and price competition in small grains.

**What has been done**

With the MSU focus on new crop development, several new or improved crops have been adopted by Montana producers.

**Results**

Camelina acreage has dramatically increased and new markets are being created for biodiesel, high-value omega-3 markets, and additional value-added bioproducts.

**4. Associated Knowledge Areas**

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

**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
2007	750	800

**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.

**4. Associated Knowledge Areas**

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

**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
2007	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.

#### **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.

#### **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
112	Watershed Protection and Management
121	Management of Range Resources
205	Plant 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**

An extended drought created a scenario for increased range and forest fires, which subsequently increased the potential for environmental problems and reduced grazing options.

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

##### **1. Evaluation Studies Planned**

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

##### **Evaluation Results**

Evaluation studies are in progress.

##### **Key Items of Evaluation**

There is a backlog of ranches requesting assistance.