

2008 Montana State University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Situation: Montana is a rural state with a land area of 93 million acres and a population of 950,000. Farms and ranches represent over 64% of the land in Montana. Agriculture remained Montana's number one industry in 2007 outpacing other industry sectors by \$418 million. Montana has over 28,000 farms and ranches with 60 million acres dedicated to agriculture. Nearly nine million acres are cropped and 51 million acres are grazed or used for other agricultural purposes. 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 2nd in the production of dry edible peas, flaxseed, lentils, and safflower, and ranks 3rd in the production of canola barley, and wheat. Small grains represented about 68% of the cropped acres with wheat and barley representing about 38% of the total agricultural receipts for the state. Montana's spring wheat acreage during the past five years has ranged from 50–75% of the total wheat acreage planted. Oilseed production dropped in 2008 in response to increased prices for small grains with farmers opting to plant acres to wheat. While flax acreage in Montana more than doubled from 2000–2007, acreage dropped by 50% in 2008, and safflower acreage dropped by 25%. The production of camelina (*Camelinasativa*) in Montana increased from 450 acres in 2005 to nearly 50,000 acres in 2007. It was also affected by wheat prices with planted acres being reduced by over 50% in 2008. Low biodiesel prices may provide a disincentive for farmers to plant camelina in 2009. The value of Montana's agricultural commodities exported during fiscal year 2007 totaled \$723 million with wheat and wheat products representing 73% of the state's agricultural exports. Montana ranked 4th among states exporting wheat and wheat products for fiscal year 2007.

Montana's livestock industry represents over \$1.2 billion in cash receipts annually, and is one of the largest industries in the state. Montana ranks 11th among U.S. states in the production of cattle and 6th in the production of sheep and lambs. Cattle and calves represented over 85% of the livestock receipts for the state and 41% of the total agricultural receipts in 2007. Montana beekeepers accounted for 6% of the nation's honey in 2007, placing Montana 5th among states in U.S. honey production. Higher prices for beef, wheat, and barley raised farm and ranch incomes; however escalating input costs challenged Montana enterprises to increase efficiencies and evaluate new markets.

The College of Agriculture (COA) (six departments and one division) at MSU is headquartered in Bozeman, Montana, 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. 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). Extension efforts are generally reported separately.

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. Cooperative efforts with the MAES provides resources and training to Native Americans in the areas of livestock testing, certification, and nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification, and social skill building.

Construction of the new Animal Bioscience Complex began in the fall of 2008. The complex represents the single most important project to Montana's livestock industry in decades and 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. Private funds account for over 50% of the financing followed by the State of Montana exemplifying stakeholder support for our research and teaching programs.

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. By the latter half of the 21st century, climate change could jeopardize agriculture, forestry, crop production, and other industries in Montana and the

U.S. Programs that address carbon sequestration and reduction of greenhouse gasses will be important projects for MSU researchers to consider.

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 and improved quality varieties
- Expand research on agricultural and natural resource interactions
- Explore alternative and new crops
- Evaluate barley cultivars in feeding studies to demonstrate their effect on feed efficiency and feed costs
- Improve beef production practices and evaluate genetics to improve herds
- Increase research programs on alternative energy sources, including crops for biofuel production

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 and provide better marketing of applied research results.

Input Section: Stakeholder input has been solicited in the strategic planning process and is continually reaffirmed as programs are developed, implemented, and revised and as dollars are allocated. The COA and MAES have 27 advisory committees and boards with more than 250 members. These include: The Animal and Range Science Advisory Committee, Animal Biosciences Complex Board, Center for Invasive Plant Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Eastern Agricultural Research Center Advisory Committee, Equine Advisory Committee, Foundation Seed Advisory Committee, 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 agricultural educators, agricultural organizations, communities, conservation groups, county extension agents, farmers and ranchers, financial organizations, private citizens, reservation groups, scientists, small businesses, and tribal councils. The COA and its MAES faculty respond to input from these stakeholders and state/national/international trends by continually developing new programs. Faculty members also serve on local and state committees.

Inputs/Funding: The source of funds contributing to the research conducted by MAES faculty include, but are not limited to: BIA, BLM, Canadian Provinces, conservation and wildlife groups, Montana Board of Research and Commercialization Technology, Montana crop and animal agricultural groups, Montana Department of Agriculture, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, Montana Department of Transportation, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, NASA, NIH, NRCS, 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 require 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, food, feed, and biofuel crops involves close collaboration among research and extension faculty in Montana and in neighboring states. Rangelands constitute over 60% of the land mass of Montana.

Priorities: Projects in agronomic and forage research at MSU have objectives that interconnect with objectives in plant and animal genomics, biobased products, and sustainable agriculture. The establishment of new value-added crops for nutritional enhancement and biofuels, and the development of higher yielding and value-added small grain varieties are priorities among agronomic researchers and plant breeders. 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. 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. Management of rangeland for grazing livestock and the protection of livestock from disease continue to be priorities among Montana livestock producers. A major environmental challenge in Montana is the creation of better rangeland management in concert with the preservation of riparian habitats, wildlife, and clean water.

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 in 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 pulse crop checkoff provides additional research funds.

Research Activities: Surveys at Montana farm conferences indicate a strong interest in diversified crop rotations for increasing on-farm receipts while reducing a monoculture of small grains. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. 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. Barley varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. A significant potential exists in the Pacific Northwest for the production of canola seed and its use as a biolubricant. To be viable, canola varieties need to be developed that can be direct-seeded, are winter hardy, and drought tolerant. The use of reduced tillage and no-till systems are being evaluated to demonstrate their sustainability in Montana. site-specific management, watershed hydrologic modeling, and the monitoring of carbon sequestration in agricultural lands.

Livestock grazing practices are receiving increasing attention because of perceived negative impacts on soils, biodiversity, and water quality. By determining the grazing behavior by cattle and their subsequent response, decisions can be made on the need for supplemental feed over winter months. Evaluating the effectiveness of livestock distribution practices on grazed watersheds is an ongoing project that includes MSU, University of California (Davis), Oregon State University, and the USDA-ARS. Research has shown that by manipulating cattle grazing patterns, fisheries and wildlife habitats can be protected and improved. Because ranching enterprises make major contributions to wildlife habitat, their viability is important to the preservation of wildlife habitat.

Studies in precision agriculture have led to the development of a process 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 in agricultural lands for use in

Animal Health

Situation: Infectious disease can cause considerable losses for producers by reducing production and by reducing sales due to food safety concerns. A focus on disease management, reproduction, and carcass traits will help ensure that Montana meat products maintain the highest standards. Promoting and maintaining animal health (cattle, sheep, and 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. Food safety is an increasingly important issue in the beef industry. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal. MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef that is raised.

Priorities: Disease management and research programs that increase the quality of meat, milk, and fiber products continue to be major areas of research. Animal losses due to environmental stresses, disease, and death create the need for an improved understanding of factors affecting Montana livestock. A major effort is being directed to identify alternative solutions to reducing the cost of animal 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. Infectious diseases caused by coccidian parasites are some of the most important health problems of food animals and humans. In beef and dairy production alone, it has been estimated that over 70 million animals are exposed every year to *Eimeria* spp. parasites. An MSU study seeks to better characterize the action of Yamo (ground bark of *Funtumia elastica* tree) in an effort to stimulate the innate immune system for protection against a broad range of pathogens in bovine calves. A rotavirus vaccine is commercially available, but is sub-optimal as it fails to protect calves throughout the most susceptible periods. We are investigating new vaccines that have potential to develop into effective control measures to help reduce losses. Research continues in the development of vaccines for *Mycobacterium avium* spp. 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 lifelong, 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 discovery of novel proteins that are essential to cell division will have a significant impact on the identification of new drug and vaccine targets for control of coccidiosis in livestock. More than 260,000 calves and cows have been enrolled in the program through 2007. Studies show that age and source verified calves were worth \$12.83 per head more than non-certified calves. 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. Decreasing input cost and increasing production revenues, will help producers achieve higher quality products, generate more income, and maintain Montana's position in the world livestock market. Reproduction and carcass studies are research focuses. One research project is attempting to understand what genes are segregating in sheep that affect number of lambs born; this information will help sheep producers in their selection decisions.

We have developed positive working relationships among stakeholders to improve weed and land management. In addition, sheep grazing protocols and projects involving 1000 private landowners, county weed supervisors, and public agencies have been developed. The studies continue in 10 sites involving 30,000 sheep in over 100,000 acres of rangeland infested with leafy spurge and spotted knapweed.

One set of MSU studies is designed to optimize mucosal and systemic antibody responses in heifers to provide passive immunity to newborn calves that are especially susceptible to scours. Investigating the mechanisms by which calves resist lung infections will help us better understand why these calves become susceptible to infection. MSU is testing a mucosal vaccine delivery system to provide the basis for 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.

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. 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 feeder calf health certification of is an ongoing project for the Montana Beef Network. M

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.

Honey bees are dying across the United State at an unprecedented rate, a phenomenon termed Colony Collapse Disorder (CCD). Currently, no causal agent has been identified. However, recent data has identified a potentially new pathogen in honey bee colonies across the USA. This pathogen, *Nosemaceranae*, is a fungal-like organism that can cause mortality in honey bee colonies. We will examine the incidence of *Nosema ceranae* infections in honey bee colonies in Montana by using a molecular biology-based technique that allows quick and accurate diagnosis of infection. DNA samples will be extracted from groups of honey bees from specific beekeeping operations and from hives within the individual operations.

Brucellosis (*Brucellaabortus*) remains a threat to the health and well-being of livestock in Montana, Idaho, and Wyoming. Cohabitation of infected wildlife (elk and bison) with cattle has compromised Montana's brucellosis-free status. There are no efficacious brucellosis vaccines for bison, and current vaccines are only partially effective in livestock. 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. Our results from the bison and mouse vaccination studies are encouraging because protective efficacy was obtained in both animal systems.

Our targeted grazing effort is a cooperative project between the Montana Wool Growers Association and MSU dedicated to developing and implementing non-traditional strategies that increase the competitiveness of Montana's lamb and wool in the world market. Our 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. D

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 Products Institute (BPI) 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. BPI's 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.

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. BPI 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: BPI 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; (5) enhancing partnerships across the region; and (6) conducting outreach activities related to biobased products and food science for producer and agribusiness. icers, and the optimization of ethanol production from various feedstocks. Consumer demand for Omega-3 rich products is escalating throughout the US. Montana camelina oil is currently being used for commercial production of omega-3 rich pet feeds and supplement, Omega-3 rich eggs, cosmetics including lotions, massage oils and soaps, and culinary oil. Omega-3 enriched livestock has higher market value than traditional livestock. Direct return to the producer for Omega-3 enriched eggs is 50% higher than for traditional eggs. We anticipate several new camelina products will be commercially available in the near term including bread, soil amendments, and omega-3 rich beef and pork. We anticipate that new high-tocopherol lines of safflower will add value to producers in Eastern Montana and Western North Dakota.

Research from the BPI is impacting rural and agricultural economics in Montana. Several products are being produced and marketed by private industry or grower cooperatives, including PrOatina gluten-free oats to the celiac community and beta-glucan barley to the nutraceutical industry. The Great Northern Grower Cooperative has established an oatmeal processing facility and is distributing high-protein, gluten-free oatmeal. 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 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-

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 require producers and researchers to evaluate new Integrated Pest Management (IPM) methodologies in order to maintain a competitive position in U.S. and world markets. 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 and organic production. Foreign trade partners want decreased pesticide residues in the wheat and barley commodities that they import. IPM projects at MSU tend to be long-term with little change from year to year. IPM programs in Montana seek to optimize grower profitability and natural resource sustainability through the development, selection, and implementation of economically sound and environmentally acceptable pest management strategies.

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 and of growing organic crops. 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. Work in seed alfalfa fields addresses the potential use of alternative management options to control alfalfa pests, while minimizing non-target effects on natural enemies and pollinators. In addition, a better understanding of biological control and its implementation will be achieved by monitoring the impacts associated with these options. -chemical alternatives, several research projects are underway to evaluate innovative control measures. One MSU project looks at managing spotted knapweed through the controlled grazing by sheep and another looks at the introduction of host specific insects to control weeds. These services provide users with vital information on seed quality and help provide the basis for prices to be set on seed in commerce. The service provided by the Laboratory helps maintain high quality in the seed industry throughout the Rocky Mountain region and the Great Plains. The regulatory testing prevents seed with noxious weed seed from being sold in Montana and Wyoming.

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.

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. 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. 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.

Insect collections are critical to entomological research. 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. An on-going project will add specimens to the existing collection and extend our knowledge relative to biodiversity in the state and region.

Soil-borne plant pathogens cause about 90% of the major diseases of the principal 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. 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 led 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.

Herbicide use in Montana's grain production systems represents the single largest use of pesticides in the state. Improving wheat competitiveness and developing herbicide tolerance through bioengineering are priorities among researchers. In discussions about problem weeds in Montana, stakeholders 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 grain producers. In order to continue to serve the stakeholders with improved recommendations and non

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. 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 continues.

MSU continues to conduct herbicide screening trials to assess the effectiveness of new and existing products for weed control in small grains, sugar beets, potatoes, and developing crops, including mint, camelina, dry beans, dry peas, safflower, sunflower, and canola.

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.

Stakeholders across the region have identified wheat viruses and grassy weeds as having major impacts on yield and grain quality. One project's goal is to provide joint weed control and virus management recommendations for small grain growers throughout the Great Plains and Pacific Northwest.

Weed management requires rapid and accurate identification of weedy plants. Improper identification can result in misapplication of herbicides or failure to adequately control the weed at the time that it is most vulnerable to IPM practices. The development of a quick and accurate electronic field identification system will aid growers, crop advisors, extension agents, diagnosticians, and others associated with crop production with a multi-entry, multi-media, commodity-based electronic key to aid in the identification and management of pests of small grains, including weeds.

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.

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. Research results will increase the competitiveness of Montana wheat producers through improved winter wheat varieties with enhanced yield potential, pest resistance, and end-use qualities.

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 marketplace. Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality grains. MSU's intensive genomic research will help Montana producers stay competitive and will provide improved cultivars adapted to Montana 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. 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.

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 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. 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. 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. New wheat varieties introduced in 2007 include one hard red winter wheat variety (Yellowstone) and three imidazolinone resistant varieties (Bynum, Norris, and Hyalite). The MSU barley improvement program uses quality field research technologies, extensive on-station and on-farm trials, and state-of-the-art genomics tools to develop well-adapted, high yielding barley varieties for farmers in Montana and the Western United States. Hockett, a high yielding 2-rowed dryland-adapted malting barley variety was released in 2007. As a result, Anheuser-Busch contracted 20,000 acres of Hockett in 2008. MSU recently released new feed, forage, and malt barley varieties for Montana's production environments that will provide added-value to growers throughout the Northern Plains. The replacement of older barley varieties with new ones (Haxby, Hays, Charles, Craft, and Eslick) should generate a yield improvement of about 15% with a net of about \$45 million per year in added revenue to dryland barley growers. Three malting barley varieties (Craft, Geraldine, and Hockett) should result in about \$80 million in added revenue. Varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance has been developed and extended through genetic diversity experiments.

Bread making characteristics, especially dough strength and extensibility, are considered when evaluating spring wheat cultivars. 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. MSU research is examining the degree to which puroindoline proteins control wheat grain hardness and cereal quality and what alterations can be made to generate desired milling and end-product quality. Further research will address the effects that modifying the starch biosynthetic pathway has upon grain hardness, milling quality, yield, and end-product quality. In addition to improved cultivar characteristics, researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs.

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

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

As timberlines rise as a result of climate change, baseline data on declining alpine systems will be valuable. We now have a list of over 200 species for the alpine areas of the Rocky Mountains, including the Beartooth Plateau in Montana and Wyoming. Our research examines the diversity and distribution of the beneficial mycorrhizal fungi that support woody plants and trees in Montana and biologically related regions. We are focusing primarily on the fungi crucial to white bark pine. White bark pine forests are an important part of the Montana landscape, since pine nuts serve as a critical food for grizzly bears and their presence benefits watershed dynamics as a tree-line species. Whitebark pine forests are in serious decline due to blister rust and mountain pine beetles. Mycorrhizal fungi are crucial to the sustainability of these forests; yet we know nothing of the fungi associated with this tree species. The objective of this research is to develop systems to inoculate nursery grown stock with appropriate native fungi that will prevent further decline and begin to reestablish forested areas.

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

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

By determining the fate of nitrogen in plants from anthesis to plant death, we expect to improve our understanding of the cellular and molecular details of nitrogen remobilization, thus closing an important knowledge gap in modern plant biology. MSU

research is working to identify the genes involved in control of inflorescence development to provide new approaches to breeding practices or transgenic manipulation. Plant research in high CO₂ environments in YNP may offer a window into the future regarding the nature of plant growth and survival in a high CO₂ world.

Sustainable Agriculture

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

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

Input:

Research Activities: In Montana and throughout the U.S., maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policy. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. Several new varieties of *Camelina sativa* have been developed, new uses for camelina oil and meal are being evaluated, two new selections/cultivars of high protein oats have been developed, and new oil products for fuel, food, feed, enzymes and lubricants and being investigated. Organic farming represents a new economic opportunity for farmers in the Northern Great Plains because of growing consumer demand for agricultural products that are produced without synthetic fertilizers and pesticides. Maintaining soil fertility without the use of synthetic fertilizers represents a challenge to organic growers in the area which is dominated by high pH and calcareous soils that limit the availability of phosphorus. learn more about seasonal patterns and accumulative N₂O emissions from agricultural soils in the Northern Great Plains under different cropping systems, water regimes, crop residue levels, and nitrogen fertility rates. Scientific interest in the effects of increasing atmospheric CO₂ on plants has motivated us to better understand plant photosynthetic physiology and plant community structure in the high-CO₂ environments of Yellowstone National Park (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.

While pulse crop production in Montana declined in 2008, the oilseed crops continue to represent important new sources of income for Montana farmers and provide 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. Over 220 fenugreek germplasm accessions have been evaluated for their production potential in Montana and their use for equine and human nutrition.

By the latter half of the 21st century, climate change could jeopardize agriculture, forestry, crop production, and other industries dependent on the natural environment. Studies under several crop rotation systems continue to address questions on the contribution to global warming of agricultural nitrous oxide (N₂O). N₂O is estimated to be over 300 times greater than carbon dioxide in its atmospheric warming potential. Studies are in place to

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 primary objective of the MSI is to develop and implement nontraditional strategies that will increase the competitiveness of Montana lamb and wool in world markets. 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. MSU 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.

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. The Montana Beef Network was established to return additional revenue and provide current information to cattle producers while meeting consumer needs in Montana and the nation. 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 program 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 (tributaries of the Missouri, 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. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for their water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 8.9 million acre-feet of water annually. Education and research activities have precipitated a general trend toward more efficient irrigation systems and more drought tolerant crops.

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

Input: Input comes from meetings with conservation and wildlife groups, Bureau of Indian Affairs (BIA), Bureau of Land

Management (BLM), Montana Department of Agriculture, Montana Fish, Wildlife and Parks, NASA, NRCS, State of Montana, USFS, USGS, and other organizations interested in water quantity and quality issues. Extensive water monitoring across Montana has helped researchers develop predictive models that help direct future research.

Research Activities: Soil water is a primary limiting factor for plant growth in semiarid and arid regions 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 facilitates measurements with very small probes. The results have led to tools with applications that lower costs to producers and rangeland managers with improved monitoring efficiency and enables science-based decisions to be made in the management of irrigation practices in the Western U.S. Stream Side Science is a permanent, tuition-supported component of the Master of Science in Science Education (MSSE) program. Twenty-three secondary teachers will be enrolled in the first two years, and assuming each teacher passes skills and knowledge gained in the course on to 50 secondary students, 1150 students could potentially be reached during the grant period. The course will be offered annually and likely be included in future water quality units. 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. The development of the course in the science of water quality provides a way to introduce children to the basics of natural resource management. This program will help our youth (our future community leaders) in their understanding of agricultural water requirements and the role of water in landscapes.

Total Actual Amount of professional FTEs/SYs for this State

Year:2008	Extension		Research	
	1862	1890	1862	1890
Plan	6.0	0.0	44.8	0.0
Actual	0.0	0.0	279.0	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. Reviewers provide written recommendations on the following items: approach and methods; economic, environmental, and/or social impacts; objectives; relation of the project to previous research; relevance and importance of the project; resources; and scientific and technical quality. The responses are presented to the PI during a follow-up meeting with the MAES administrator and department head. Projects that do not meet expectations will not be approved and action 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 outreach programs)

Brief Explanation

The Montana Agricultural Experiment Station (MAES) and College of Agriculture (COA) obtain stakeholder input on research priorities and programs. Stakeholder committees have been formed that include the Ag Coalition, College Development Board, MAES Advisory Council, Precision Ag Research Association (PARA), sustainable agriculture focus group, 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, Montana Beef Council, Montana Department of Agriculture, Montana Farm Bureau Federation, Montana Farmers Union, Montana Seed Growers Association, Montana Seed Trade Association, Montana Stockgrowers Association, Montana Wool Growers Association, and the Water Users Association. It meets every six months with the Dean and Director to review fundraising efforts, new initiatives, legislative activities, and program priorities. Meetings are advertised via announcements at group meetings, individual letters, newsletters, and news releases. Extension agents are instructed to use county profile information to make sure that the people invited to the sessions reflect the diversity of the area. MAES responds to stakeholder inputs by considering their proposals at research planning meetings that include administrators, advisory groups, and scientists. 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 are based on 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 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, and 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)
- Survey specifically with non-traditional groups

Brief Explanation

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

3. A statement of how the input 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 for the connection and delivery of education and new knowledge in agricultural and natural resources throughout rural Montana. In particular, the MAES Advisory Council directly interacts with faculty after they become a new faculty member as a component of their mentoring program.

Brief Explanation of what you learned from your Stakeholders

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

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	2195157	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	3507011	0
Actual Matching	0	0	3598622	0
Actual All Other	0	0	20693227	0
Total Actual Expended	0	0	27798860	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous years				
Carryover	0	0	2150837	0

V. Planned Program Table of Content

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

Program #1

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

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	1.0	0.0	4.4	0.0
Actual	0.0	0.0	25.2	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	353198	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	363975	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1740762	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

- Crop and livestock producers in Montana
- State agricultural advisory committees
- State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities
- Participants in 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	125	200	0	0
2008	2300	2300	0	0

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

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	5	5	
2008	10	10	20

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2008	8	25

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

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

Outcome #1**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	2	2

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

The establishment of new value-added crops and the development of higher yielding crop varieties are priorities among agronomic researchers and crop producing stakeholders.

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. Oilseeds (including Camelina sativa, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of culinary oils, biolubricants, omega 3 oils, feeds, and biodiesel. Camelina is an effective rotation crop for small grains with the potential for breaking disease and pest cycles. Camelina production could significantly reduce the cost of biodiesel and provide a source for omega 3 oil. We continue to collaborate with other states in generating data required for product registration on new crops or new pests.

Results

Over 90 germplasm accessions of camelina have been evaluated for adaptability, yield potential, and fatty acid content. Additional initiatives will provide new insights into food safety and risk assessment, including the use of vegetable oils as feedstock for fuel cells, the development of new wheat varieties, non-corrosive biobased de icers, and the optimization of ethanol production from various feedstocks. MSU researchers have presented more information directly to producers and provided publication references and reviews. Crop diversity studies continue to show promise for increasing on-farm receipts while reducing a monoculture of small grains. Some examples of new crops and alternative varieties of new crops include winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea which are included in long-term rotation studies and plant adaptation trials.

4. Associated Knowledge Areas

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

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
2008	1	2

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

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

What has been done

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

Results

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
2008	5000	4500

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

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

What has been done

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

Results

The production of camelina (*Camelina sativa*) in Montana increased from 450 acres in 2005 to nearly 50,000 acres in 2007. However, high wheat prices reduced camelina plantings by over 50% in 2008. The value of Montana's agricultural commodities exported during fiscal year 2007 totaled \$723 million with wheat and wheat products representing 73% of the state's agricultural crop exports. Montana continues to capture the attention of foreign buyers due the high quality wheat that is grown and research that is designed to improve the characteristics of the grains.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	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. In 2008, seed sample numbers submitted for analysis were significantly reduced due to the uncertainty in markets, decreased reseeding needs (e.g. fire restoration), and the economic downturn.

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. Tests determine percentages of pure seed, other crop seed, weed seed, inert matter, and germination in seeds used for planting.

4. Associated Knowledge Areas

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

Outcome #5**1. Outcome Measures**

New grazing plans established for livestock and wildlife in rangeland environments

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	10	5

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

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

What has been done

Ranches have been certified and have established grazing plans for the watersheds that they utilize. Research has examined cost-effective strategies for using prescribed sheep and goat browsing to suppress conifer encroachment onto foothill rangeland and for using sheep to control invasive weeds. Beavers have been proposed as habitat restoration agents for aspen and willow communities in areas of heavy elk and deer grazing. This study will attempt to determine if this premise is correct for areas that have reintroduced beaver in the past 15 years.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

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

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

Brief Explanation

Grazing options are often compromised by drought, lack of access to private or public lands, and by severe weather. While these factors do not affect all producers, they require increased management on the part of the most livestock owners.

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. As data is retrieved it will be made available to stakeholders.

Program #2

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%	
311	Animal Diseases			50%	
315	Animal Welfare/Well-Being and Protection			5%	
902	Administration of Projects and Programs			5%	
	Total			100%	

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.5	0.0	9.3	0.0
Actual	0.0	0.0	74.6	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	1205790	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1238362	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	9925483	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

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

V(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
2008	1000	1000	0	0

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

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	5

Patents listed

Young, M. Protein Caged Nanoparticles for Inducing iBALT Formation U.S. Patent (provisional application)
 Hardy, M.E. Snow Mountain Virus Genome Sequence, Virus-like Particles and Methods of Use. U.S. Patent # 11/058,030 (2008)
 Harmsen, A.G. Protein Cages and Their Uses. PCT International Application No.:PCT/US2008/075.373 (2008)
 Harmsen, A. Provisional patent 60/970,878, HSP Cage-induced Resistance to Influenza Infection. (2007)
 Quinn, M.T. Provisional Patent 60/929,334, Inhibitors of Neutrophil Elastase and Methods of Their Use. (2007)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	20	5	25

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2008	15	25

Output #2

Output Measure

- Building built through donations

Year	Target	Actual
2008	0	0

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

O No.	OUTCOME NAME
1	Identify critical infection and resistance processes
2	Number of ranches per year adopting enterprise management of animal health issues
3	Number of novel vaccines developed per year
4	Number of activities per year that prevent disease outbreaks or manage diseases of Montana livestock
5	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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	1

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

Infectious disease can cause considerable losses for producers by reducing production and by reducing sales due to food safety concerns. A focus on disease management, reproduction, and carcass traits will help ensure that Montana meat products maintain the highest standards. Animal losses due to disease create the need for an improved understanding of factors affecting Montana livestock.

What has been done

Disease management and research programs that increase the quality of meat, milk, and fiber products continue to be major areas of research. One set of MSU studies is designed to optimize mucosal and systemic antibody responses in heifers to provide passive immunity to newborn calves that are especially susceptible to scours. Infectious disease research at MSU focuses on understanding the biology of each specific group of infectious agents and learning how these specific microbes produce disease when infections are established in people or animals. An MSU study seeks to better characterize the action of Yamao (ground bark of *Funtumia elastica* tree) in an effort to stimulate the innate immune system for protection against a broad range of pathogens in bovine calves.

Results

The discovery of novel proteins that are essential to cell division will have a significant impact on the identification of new drug and vaccine targets for control of coccidiosis in livestock. A focus on disease management, reproduction, and carcass traits will help ensure that Montana meat products maintain the highest standards. Research in targeted mutagenesis of cells in cattle will make milk and beef production more efficient, increase the value of cattle-based commodities, and produce herds with improved traits, including disease resistance and increased production. Research is continuing in collaboration with researchers at the University of Montana and the NIH Rocky Mountain Lab to form a center for studying emerging infectious diseases in wildlife and livestock.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	10	10

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

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

What has been done

Programs that focus on management, nutrition, and health maintenance have been developed that provide cow-calf producers in Montana the tools to produce safe beef and improve the quality of the beef that is raised. Our targeted grazing effort is a cooperative project between Montana Wool Growers Association and MSU dedicated to developing and implementing non traditional strategies that increase the competitiveness of Montana's lamb and wool in the world market. Our 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.

Results

More enterprises are using controlled estrus and developing management plans to improve the economics of raising healthy calves to market. Sheep grazing protocols and projects involving 1000 private landowners, county weed supervisors, and public agencies have been developed. The studies continue in 10 sites involving 30,000 sheep in over 100,000 acres of rangeland infested with leafy spurge and spotted knapweed. Beef Quality Assurance (BQA) education and feeder calf health certification of is an ongoing project for the Montana Beef Network. More than 260,000 calves and cows have been enrolled in the program through 2007. Studies show that age and source verified calves were worth \$12.83 per head more than non-certified calves.

4. Associated Knowledge Areas

KA Code	Knowledge Area
311	Animal Diseases

Outcome #3**1. Outcome Measures**

Number of novel vaccines developed per year

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

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

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

What has been done

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

Results

Studies, in cooperation with Texas A&M, have produced new subunit and live brucellosis vaccines that may effectively protect bison and cattle against brucellosis. Formulation trials are underway to make these vaccines available to livestock producers and wildlife managers. Our results from the bison and mouse vaccination studies are encouraging because protective efficacy was obtained in both animal systems. The discovery of novel proteins that are essential to cell division will have a significant impact on the identification of new drug and vaccine targets for control of coccidiosis in livestock. Over 150,000 "drug-like" candidates have been screened for their activity against agonists in cattle.

4. Associated Knowledge Areas

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

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

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.

4. Associated Knowledge Areas

KA Code	Knowledge Area
311	Animal Diseases

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
2008	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. Food safety is a very visible consumer and producer concern and has become a concern for the livestock industry at all production levels. Consumers, both domestic and international, are demanding more information about the beef they purchase, including the age and source of the animal and the health, nutrition, and handling management. Information is being demanded by consumers on labeling the country of origin (COOL) and to ensuring that the products they are buying are safe.

What has been done

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

Results

Identification of barley varieties that affect color stability could result in designing diets specifically for improved color and increase the use of barley as a finishing grain. A critical and stressful time for feedlot cattle is early in the finishing period. Valier Barley with increased levels of beta-glucan may make it possible to get enough beta-glucan through the rumen in order to stimulate the immune system of ruminants and result in an improvement of animal health. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent food safety events and irreparable harm to the beef industry. Using the processes and organizational structure developed by the Montana Beef Network, research and educational programs will continue to develop an animal identification and traceability system to address the animal health, biosecurity, and food safety concerns expressed by producers and consumers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
902	Administration of Projects and Programs
303	Genetic Improvement of Animals

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

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

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

1. Evaluation Studies Planned

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

Evaluation Results

Disease outbreaks have been minimized and quarantines implemented

Key Items of Evaluation

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

Program #3

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

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.5	0.0	13.2	0.0
Actual	0.0	0.0	13.2	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	410792	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	423087	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	340004	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 MSU TechRanch and MSU TechLink to facilitate technology transfer from BPI to the private sector. These collaborators have expertise in incubating new businesses and new products, as well as assisting existing enterprises in product expansion.

The Institute will:

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

2. Brief description of the target audience

Several products are being produced and marketed by private industry, LLC, or grower cooperatives in Montana. The Institute has developed additional collaborative relationships with MSU TechRanch and MSU TechLink to facilitate technology transfer from BPI to the private sector. These collaborators have expertise in incubating new businesses and new products, as well as assisting existing enterprises in product expansion.

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

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	50	0	0
2008	750	750	0	0

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

Patent Applications Submitted

Year	Target
Plan:	1
2008 :	7

Patents listed

- Strobel. Munumbicins, wide spectrum antibiotics from Streptomyces. U.S. Patent #7,259,004 (2008)
- Strobel, G.A. Use of M. albus in treating human wastes. U.S. provisional patent and full Patent #7,259,004. License to Phillips Environmental Products. (2007)
- Strobel, G.A. A Naphthlene producing endophytic fungus M. vitigenus. U.S. Patent #7,267,975 (2007)
- Strobel, G.A. Pestacin and isopestacin novel antioxidants. U.S. provisional patent, now full patent pending as Patent #7,192,939. License pending to HVM of Salt Lake City, Utah. (2007)
- Strobel, G.A. Endophytic Gliocladium Species and Methods of Producing Volatile Compounds and Hydrocarbons (provisional patent submitted 10/07). License pending to SGI of San Diego, California. (2007)
- Strobel, G.A. The genetic systems controlling hydrocarbon production in Gliocladium (provisional patent 10/07). MTA with Eli Lilly Co. (2007)
- Strobel, G.A. Volutellin A, an immunosuppressive peptide from Volutella sp. (provisional application) (2007)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	5	5

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Target	Actual
2008	2	0

Output #2

Output Measure

- Number of research citations

Year	Target	Actual
2008	6	10

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

O No.	OUTCOME NAME
1	Number of SBIR funding proposals submitted to federal agencies
2	Number of opportunities and value-added programs introduced in Montana through continued education, research, and partnering
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 Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	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 Biobased Products 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 research innovation and discoveries made from new products, new markets, and new dietary products with new Montana crops (e.g. gluten-free flour) and long-established agricultural commodities. Camelina was introduced as a sustainable energy crop; camelina oil can be used for production of biodiesel or as omega-3 oil. Camelina meal can be used for production of omega-3 enriched livestock. The expansion of camelina production across Montana has driven establishment of both small and large oil extraction and biodiesel manufacturing facilities. Omega-3 enriched livestock has higher market value than traditional livestock.

4. Associated Knowledge Areas

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

Outcome #2**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	2	2

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

Montana stakeholders are interested in the development of new crops and new uses for crops. MSU's Bioproducts Institute investigates new technology, new crops suitable for production in Montana's climate and soil conditions, and mechanisms to add value to existing cropping systems.

What has been done

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. OmegaMontana Eggs are commercially available across Montana. Direct return to the producer is 50% higher for these eggs than traditional eggs. Wheat Montana LLC has evaluated camelina oil in bread that will have a higher return per loaf than their existing products. Additional new crops or varieties developed by MSU include high protein oat (PrOatina), gluten-free Teff, high-yielding soybean, Fenugreek, and gluten-free timothy. The Great Northern Growers oat processing facility began processing Montana oatmeal in 2007.

4. Associated Knowledge Areas

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

Outcome #3**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	3

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

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

What has been done

The Biobased Products 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.

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
511	New and Improved Non-Food Products and Processes

Outcome #4**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	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 that enhance food safety and agricultural security for U.S. and global consumers. Food safety has also become a concern for the beef industry at all production levels. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent food safety events.

What has been done

Recommendations for food safety are made available to food processors, schools, consumers through different departments at MSU. Food Safety Works is a food safety education job-training program targeted to Montana high school students. This program has been very successful due to the cooperation among high school students, teachers, MSU Extension, and the food industry. Current and new crops have been evaluated for alternative uses beyond commodity products. Using the processes and organizational structure developed by the Montana Beef Network, research and educational programs continue to develop an animal identification and traceability system to address the animal health, biosecurity, and food safety concerns expressed by producers and consumers.

Results

In addition to publications, researchers have developed food products for individuals who may not be able to consume traditional grains. The development of flour from Indian ricegrass (Montina flour) at MSU is now produced and distributed by a Montana cooperative. The development of gluten-free crops, such as high-protein oat and timothy grass, will provide food options for those sensitive to gluten. Timothy flour is highly nutritious, gluten-free and can be used to produce a variety of baked products. Research-based information on food safety and other food management principles are made to producers through conferences and producer meetings.

4. Associated Knowledge Areas

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

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
2008	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

New Montana varieties of camelina were produced in MT, WA, ID, OR, SD, ND, WY, CO, and AK in 2008. Additional new crops or varieties developed by the Biobased Products Institute include high protein oat (PrOatina), gluten-free Teff, high-yielding soybean, Fenugreek, and gluten-free timothy. The Great Northern Growers oat processing facility began processing Montana oatmeal in 2007.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

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

- Economy
- Appropriations changes
- Public Policy changes

Brief Explanation

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

V(I). Planned Program (Evaluation Studies and Data Collection)**1. Evaluation Studies Planned**

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

Evaluation Results

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

Key Items of Evaluation

Evaluations are on-going through interactions at winter meetings.

Program #4

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			30%	
212	Pathogens and Nematodes Affecting Plants			30%	
213	Weeds Affecting Plants			20%	
215	Biological Control of Pests Affecting Plants			20%	
	Total			100%	

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	1.4	0.0	6.1	0.0
Actual	0.0	0.0	74.3	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	646072	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	667030	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2330242	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

- Crop producers, dealers, distributors, and crop protection company representatives
- Crop protection companies registration and research personnel
- Montana crop advisory boards

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	150	0	0
2008	1775	1775	0	0

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

Patent Applications Submitted

Year	Target
Plan:	1
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	15	15

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2008	10	15

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Target	Actual
2008	2	3

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

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

Outcome #1**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	3	3

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

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

What has been done

Educational programs are being developed to provide grower education for integrating biological controls with conventional disease, weed, and insect management practices in potatoes, sugar beets, and other crops. The application of pesticides in specialty crops needs to be understood by growers and applicators, especially since many of the crop protection products are relatively new and are issued under special local need or emergency exemption labels.

Results

The deployment of bio-fungicides could provide an important crop management tool missing in organic wheat production. Implementation of research results will reduce risk and increase sustainability of organic farming in the northern Great Plains. Educational programs will be developed to provide grower education for integrating biological controls with conventional disease management practices.

4. Associated Knowledge Areas

KA Code	Knowledge Area
213	Weeds Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants
215	Biological Control of Pests Affecting Plants
212	Pathogens and Nematodes 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
2008	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. We expect that the knowledge generated in these research and outreach programs will enhance producers' understanding of multi-trophic level interactions. This knowledge will, in turn, allow producers to develop specific actions to jointly manage cheatgrass, wheat stem sawfly, and Fusarium.

4. Associated Knowledge Areas

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

Year	Quantitative Target	Actual
2008	1	2

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

Systems integrating biological, cultural, and conventional controls of weeds, diseases, and insects are lacking for potato producers. The management of diseases in potatoes and sugar beets is becoming increasingly difficult according to growers who participated in MSU sponsored meetings. Tribal members who are involved in agriculture need an awareness of how to be environmental stewards and preserve natural resources, particularly in irrigated systems. An MSU program provides programming in sustainable agricultural practices that combine grazing intensity with preservation of surface and ground water, native plants, fisheries and wildlife.

What has been done

Integrated disease management programs are in place for potatoes and sugar beets that profitably provide growers with management programs using biological, chemical and host plant resistance options. MSU projects have identified effective and economical biological controls that will help growers manage plant diseases using methods low in toxicity to humans and the environment. 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. To promote good forest stewardship and healthy forests across Montana we have established a program to recruit, train, and maintain forest landowners who will actively manage their forested lands for multiple resource conservation objectives that are sound and scientifically based.

Results

Seven workshops in forest management and stewardship have been completed with a total attendance of 137 participants who together own and manage approximately 20,000 acres. Surveys of participants indicated that the majority took home new ideas and tools that helped them better meet their property objectives. In addition, 47 ownerships representing 13,857 acres had their stewardship plans reviewed and updated through this process. We have demonstrated that mycofumigation using *Muscodor albus*, or synthetic gases that mimic the natural gases, provides excellent control for a wide range of fungal, bacterial, and nematode pathogens. The research provides a basis for organic and other growers to control soilborne plant pathogens. Mycofumigation with volatile organic gases produced by *Muscodor albus* provides an alternative to methyl bromide fumigation for control of soil fungi and plant parasitic nematodes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 #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
2008	70	90

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

As a minimum requirement for certification, private applicators must show that they possess a practical knowledge of the pest problems and pest control practices associated with his agricultural operations; proper storage, use, handling and disposal of the pesticides and containers; and his related legal responsibility.

What has been done

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

Results

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

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

New products registered

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

A special local need label was issued in 2008 for Python Insecticide Cattle Ear Tag Sheep (zeta-cypermethrin and piperonyl butoxide) for control of midges to prevent bluetongue. A special local need label was also issued in 2008 for Endura fungicide (boscalid) for control of spring black stem and white mold in Seed Alfalfa.

4. Associated Knowledge Areas

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

Outcome #6**1. Outcome Measures**

Number of potential products/practices evaluated

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	3	3

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

Risk assessment is an important discipline to provide a better understanding to producers of the ecological and human-health risks associated with pest management options. Comparing biological and agricultural risk assessment from biotechnology crops, pesticides, and invasive species allows producers to selectively use a variety of management systems. Incorporating biopesticides into insect management plans can conserve natural enemies and pollinators.

What has been done

The purpose of one study is to examine the impact of several reduced-risk biopesticide products on alfalfa insect pests, natural enemies, and pollinators, while assessing alfalfa seed damage and seed yield. The research is aimed at providing growers with information on the efficacy of alternative pesticides to be used in seed alfalfa for control of lygus bugs, aphids, and alfalfa weevils, while minimizing impacts on natural enemies of these insects and on pollinators, both managed and native.

Results

Results indicate that several chemical treatments (including novaluron and neemix) significantly reduced lygus numbers while maintaining favorable numbers of beneficial insect predators, with no discernible impact on pollinators. Other pesticides (bifenthrin) exhibit a greater negative impact on natural enemy numbers. Educational outreach programs for adoption of reduced-risk insecticides in the seed alfalfa production system are being established. Ecological and human-health risk assessments of emerging infectious diseases and insecticides used to control disease vectors have revealed science-based risks and the uncertainty and variability associated with each risk type.

4. Associated Knowledge Areas

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

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

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

1. Evaluation Studies Planned

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

Evaluation Results

Evaluation studies are in progress.

Key Items of Evaluation

Evaluation studies are in progress.

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
202	Plant Genetic Resources			45%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			45%	
Total				100%	

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	4.8	0.0
Actual	0.0	0.0	38.3	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	534854	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	544136	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2063857	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

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

V(E). Planned Program (Outputs)

1. Standard output measures

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	2000	500	0	0
2008	2600	1000	0	0

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

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	6

Patents listed

Bergman, J. SemBioSys genetics license for Centennial safflower variety technologies; Safflower Technologies International, LLC license for Cardinal and MonDak safflower varieties technologies. (2007)

Giroux, Sherwood. Transgenic Plants Expressing Puroindolines and Methods for Producing Such Plants. U.S. Patent #7,425,669 (issued 9/16/08)

Bruckner, P.L. U.S. Plant Variety Protection Certificate No. 200600284, Wheat, Common,

'Yellowstone' (2007)

Bruckner, P.L. U.S. Plant Variety Protection Certificate No. 200600285, Wheat, Common,

'Bynum' (2007)

Bruckner, P.L. U.S. Plant Variety Protection Certificate No. 200600286, Wheat, Common,

'Norris' (2007)

Bruckner, P.L. U.S. Plant Variety Protection Certificate No. 200600291, Wheat, Common,

'Hyalite' (2007)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	10	10

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Target	Actual
2008	15	26

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Target	Actual
2008	4	10

Output #3

Output Measure

- Number of research citations

Year	Target	Actual
2008	12	15

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

O No.	OUTCOME NAME
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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	100	100

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

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

What has been done

Barley research continues to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. Continued productivity of our breeding program will improve our understanding of the genetics of key traits and allow the development of new selection tools. The broader impacts of the work are a larger food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat. Research results will increase the competitiveness of Montana wheat producers through improved winter wheat varieties with enhanced yield potential, pest resistance, and end-use qualities.

Results

Successful genetic research is increasing the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and desirable end-use qualities. MSU is also participating in the wheat CAP program. Hockett, a high yielding 2-rowed dryland-adapted malting barley variety was released in 2007. As a result, Anheuser-Busch contracted 20,000 acres of Hockett in 2008. MSU recently released new feed, forage, and malt barley varieties for Montana's production environments that will provide added-value to growers throughout the Northern Plains. The replacement of older barley varieties with new ones (Haxby, Hays, Charles, Craft, and Eslick) should generate a yield improvement of about 15% with a net of about \$45 million per year in added revenue to dryland barley growers. Three malting barley varieties (Craft, Geraldine, and Hockett) should result in about \$80 million in added revenue.

4. Associated Knowledge Areas

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

Outcome #2**1. Outcome Measures**

The number of new molecular techniques used to enhance breeding results

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	0

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

Reliable high quality wheat yield is essential for the long-term marketing of Montana products. The broader impacts of MSU research are a larger food supply for the world, and an improved ability of Montana farmers to compete in a global marketplace. Asian consumers prefer noodles that remain bright in color over time. Grain hardness has a major influence on the end-use properties of wheat. The purpose of one project is to examine the effect of polyphenol oxidase (PPO) and grain protein on Asian noodle color, and to understand the genetic basis for grain hardness and its influence on end use quality in wheat.

What has been done

MSU research is examining the degree to which puroindoline proteins control wheat grain hardness and cereal quality and their effect on end-product quality. Further research will address the effects that modifying the starch biosynthetic pathway has upon grain hardness, milling quality, yield, and end-product utilization. Researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs. Future productivity of the breeding program will be addressed by our efforts to improve our understanding of the genetics of key traits, and to develop new selection tools. A combination of genetic, molecular and biochemical tools will be used to improve our knowledge of cereal N recycling, with the long-term goal of improving N use efficiency. Based on preliminary data on the biochemistry and molecular biology of wheat PPOs, the biological basis for variation in this commercially important trait will be established.

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 and plant varieties. In addition, we are investigating the role of PPO enzymes in noodle darkening. Experiments were conducted and analyzed to determine the effect of an added copy of the Ha locus on grain texture. The most direct impact from our work in 2007 has been the confirmation of the agronomic importance (grain protein content and yield) of the GPC locus, which has been under study in our program since 2001.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	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 marketplace. Researchers evaluate germplasm and identify traits that produce wheat and barley cultivars that meet increasing world demands for quality, while maintaining yields for producers.

What has been done

Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality. Hockett, a high yielding 2-rowed dryland-adapted malting barley variety was released in 2007. As a result, Anheuser-Busch contracted 20,000 acres of Hockett in 2008.

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. 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.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)

Outcome #4**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	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. Montana stakeholders rely on MSU new cultivar development to ensure that they can remain competitive in the global market.

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 MSU Cereal Quality Laboratory.

4. Associated Knowledge Areas

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

Outcome #5**1. Outcome Measures**

Number of improved variety recommendations by districts across Montana

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	5	5

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

Montana crop producers want improved hard red and hard white winter wheat cultivars that are adapted to Montana conditions and suitable for both domestic and export markets. Producers want the highest yielding and most pest resistant barley varieties as well. Montana is recognized for production of high quality bread wheat. This reputation is essential in maintaining domestic and foreign markets. The export trade in recent years has accounted for about 3/4 of our wheat market.

What has been done

About 10 to 15 new small grain varieties are released (or changed through a collaborative process) 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. Variety recommendations are established each year for wheat (spring, winter, and durum) and barley for the six Montana growing districts and published in the Performance Evaluation and Recommendations guides by MSU-MAES.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	3	5

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

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

What has been done

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

Results

As wheat and barley varieties are developed, information is reviewed by MSU researchers and recommendations made for the year. Genou is the top winter wheat variety planted in Montana. Farmers planted 513,200 acres of the variety or 19.7% of the total winter wheat acreage. The variety was released by MSU in 2004. Yellowstone rose from the 11th to 3rd and accounted for 8.4% of the state's planted acreage with 218,400 acres seeded. Yellowstone is a hard red winter wheat developed by the MAES and released in 2005. Choteau was the 2nd most common spring wheat variety planted in 2008 with 564,700 acres planted or 22.6% of Montana's spring wheat acres. Choteau was developed by the MAES in 2003. McNeal is ranked third for the second year in a row with 294,300 acres planted or 11.8% of all acres seeded. McNeal was developed by the MAES and released in 1995. Haxby is the top barley variety planted for feed purposes in 2008 for the 2nd year in a row. It was seeded on 49,400 acres in 2008 and represents 5.4% of the state total. Haxby is a two-rowed barley developed by MSU.

4. Associated Knowledge Areas

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

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

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

Brief Explanation

A variety of weather patterns influenced Montana agriculture in 2008, including areas of extreme drought, a highly active weather system extending into June, and hail and rain events sporadic across the state that increased crop stress and affected yields.

V(l). 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. The rapid adoption of new varieties demonstrates the successful plant breeding programs established at MSU.

Key Items of Evaluation

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

Program #6

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%	
Total				100%	

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	1.6	0.0	3.6	0.0
Actual	0.0	0.0	28.4	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	248748	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	252304	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2001040	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

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

V(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	300	100	0	0
2008	1050	1050	0	0

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

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	8	8

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Target	Actual
2008	5	10

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

O No.	OUTCOME NAME
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	Increased number of new crops adapted to Montana through percent acres increased
4	Number of field days, news releases and presentations at conventions
5	Number of new producers per year adopting measures to improve agricultural efficiency (e.g. better seed quality, higher numbers of fields with soil tested, optimization of fertilizer use)
6	Percent increase in acres per year of alternative crops compared to wheat and barley

Outcome #1**1. Outcome Measures**

Number of strategic planning meetings with state groups and agencies

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	10	14

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

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

What has been done

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

Results

MSU research continues to provide new small grain varieties and alternative crops that meet the need of Montana producers. Researching new crops and finding new markets for existing crops are potential ways to enhance growth in sustainable agriculture in Montana. As technology advances and producers begin to rely more on computer-aided information, the role of MSU research and outreach will continue to increase in their importance and impact. As more input is provided to MAES leadership, we refine and redirect our programs and stakeholders increase their knowledge of realistic timeframes for outputs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

Participation at off-campus educational outreach programs presented by the MSU Department of Agricultural Economics resulted in over 2000 participants per year. Extension agents in cooperation with researchers from the College of Agriculture hold commercial and private pesticide applicator workshops, including applicators ranching in reservation lands. Between 2005 and 2007, we assisted the Tribal Lands Department in writing three Noxious Weed Trust Fund Grants to the State of Montana. These grants were funded on three separate noxious weed control projects covering 347 acres of treatment in 2006, 1090 acres in 2007, and 688 acres for 2008. These projects reduce noxious weeds on wild lands and increase the carrying capacity for wildlife and livestock. In addition to these activities, we provided one-on-one help in sprayer calibration, label interpretation, and pest identification to new applicators.

4. Associated Knowledge Areas

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

Outcome #3**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	5	5

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

Surveys at Montana farm conferences indicate a strong interest in diversified crop rotations for increasing on-farm receipts while reducing a monoculture of small grains. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. The Biobased Products Institute at MSU has been instrumental in identifying potential oilseed crops suitable for production in Montana for use as culinary oils, biolubricants, omega-3 oils, feeds, and production of biodiesel and bioenergy products.

What has been done

Oilseeds (including Camelina sativa, canola, soybean, and safflower) are rapidly emerging as important Montana crops for production of oils. Barley varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. A significant potential exists in the Pacific Northwest for the production of canola seed and its use as a biolubricant. Additional initiatives will provide new insights into food safety and risk assessment, including the use of vegetable oils as feedstock for fuel cells, the development of new wheat varieties, non-corrosive biobased de-icers, and the optimization of ethanol production from various feedstocks.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #4

1. Outcome Measures

Number of field days, news releases and presentations at conventions

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	10	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

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

4. Associated Knowledge Areas

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

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
2008	100	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

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

4. Associated Knowledge Areas

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

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
2008	5	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Growth in the production of specialty crops has been strong from 2004 through 2008. 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 high prices for the traditional wheat and barley crops. Growers continue to investigate crops for biofuels, especially with increasing ethanol production and biodiesel interest. Specialty crops dipped in acreage planted in 2008 in response to high energy costs and high prices for traditional wheat and barley crops. As prices stabilize, more growers will return to alternative crop rotations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
215	Biological Control of Pests Affecting Plants
213	Weeds Affecting Plants
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

Brief Explanation

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

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

1. Evaluation Studies Planned

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

Evaluation Results

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

Key Items of Evaluation

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

Program #7

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%	
	Total			100%	

V(C). Planned Program (Inputs)

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

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	1.0	0.0	3.4	0.0
Actual	0.0	0.0	25.0	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	107557	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	109728	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2291839	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

•Organizations receiving information include U.S. Geological Survey (USGS), National Resources Conservation Service (NRCS), the Montana Department of Natural Resources and Conservation (DNRC), irrigation districts, conservation districts, downstream and in-stream 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

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	300	400	0	0
2008	450	450	0	0

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

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	5	5

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations.

Year	Target	Actual
2008	12	15

Output #2

Output Measure

- Successful external grants

Year	Target	Actual
2008	1	9

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

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

Outcome #1**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	1

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

Soil water is a primary limiting factor for plant growth in semiarid and arid regions like Montana. In order to provide sustainability to Montana producers and urban dwellers, several programs are in place to evaluate, monitor, accurately measure quantity (and some quality characteristics), and provide cropping and irrigation recommendations to agricultural and urban stakeholders. Improved ability to monitor soil water and chemical distributions in soils will contribute to better land management opportunities.

What has been done

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

Results

Research fills critical gaps in our knowledge about soil water availability in space and time and the soil processes controlling carbon cycling, global change ecology, and soil gas emissions. We developed a user-friendly software application to generate synthetic Time Domain Reflectometry (TDR) waveforms. The program may be used to design and evaluate probes for specific conditions (e.g., high salinity), to predict and improve analysis outcomes, and as a tool to instruct TDR methodology and basic signal processing concepts. 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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Finding crops that require less water per acre and will grow in our short growing season requires innovative solutions. This is being partially accomplished through our extensive crop breeding programs, water management research, the introduction of new drought tolerant crops, along with other conservation practices. In addition, enhancing our knowledge of water quantity and quality will also influence water-related decisions. The development of critical research information on irrigated cropping systems by the cooperative installation, deployment, and use of precision irrigation systems is providing information on the role these systems play in improving water and soil quality

Results

Irrigation management and cultural practices that promote water use efficiency, reduce negative effects of soil compaction, and enhance environmental benefits have been developed. The effect of farming practices and the interaction among irrigation methods, crop rotation, and tillage is generating quantitative data on yields, pest problems, and soil water movement. Water quality and irrigation management bulletins are made available by crop to producers in Montana. The right combination of irrigation and fertilizer management practices can add significantly to yields of Montana crops when compared to dryland cropping.

4. Associated Knowledge Areas

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

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
2008	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. Understanding natural resource management and the teaching of such in a secondary curriculum requires many school teachers to develop skills in the areas of biology, ecology, hydrology, chemistry, biochemistry, physics, agronomy, and soil science.

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 project is developing, delivering, and evaluating an on-line, experiential course in the science of water quality for place and profession constrained, in-service secondary science teachers. A 3-credit, 8 week, hands-on Stream Side Science graduate course, taught via internet access and WebCT platform, is being developed as part of MSU's National Teacher Enhancement Network (NTEN). 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

Newspaper releases have been created aimed at informing the audience of our project goals and purpose, the importance of agriculture in eastern Montana, and on general topics related to water conservation and watershed protection. A new program for teachers called Stream Side Science will become a permanent, tuition-supported component of the MSSE program, as well as serve as a model for institutions developing similar courses. Enrollment in years 1 and 2 included 23 secondary teachers. Assuming each teacher passes skills and knowledge gained in the course on to 50 secondary students, 1150 students could potentially be reached during the grant period. The course is expected to have impacts far beyond the life of the grant, since it will be offered annually and because teachers will undoubtedly present water quality unit studies to their students for years to come. 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.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	0

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

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

What has been done

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

Results

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

4. Associated Knowledge Areas

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

Outcome #5**1. Outcome Measures**

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

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	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. Sustainable management of water is one of the biggest challenges we face in an era of increasing water demand (through population growth and better living standards) and climatic uncertainty and change. For improved forecasting and water resource management there is a need for quantifying factors affecting watersheds. The uncertainty of potential climatic changing scenarios increases the need for quantifiable results.

What has been done

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

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2008	2	2

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

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

What has been done

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

Results

We have developed management guidelines for salinity and sodicity standards applicable to Montana climate, crops, and soil on Tribal lands. We are also establishing a benchmark research site to examine the impact that mountain resort development has on stream function and water quality. The results of our study will give insight into the impact of human alteration of natural landscapes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
610	Domestic Policy Analysis

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

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

Brief Explanation

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

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

1. Evaluation Studies Planned

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

Evaluation Results

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

Key Items of Evaluation

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