ANNUAL REPORT

MONTANA STATE UNIVERSITY

COLLEGE OF AGRICULTURE
MONTANA AGRICULTURAL EXPERIMENT STATION

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Introduction

Preface

The College of Agriculture at Montana State University, headquartered in Bozeman, Montana, is comprised of the Montana Agricultural Experiment Station (MAES) and the College's academic programs in undergraduate and graduate studies. The MAES system is a network of eight Agricultural Research Centers, four farms, and two collaborative research programs with two USDA-ARS units (at Miles City and Sidney). It does not include the Montana Extension Service though Extension Specialists are housed within departments in the College of Agriculture. The College also does not have programs in Family and Consumer Sciences or Rural Development.

Expanded partnerships with the Montana Extension Service, MSU-Bozeman colleges, MSU-Billings, MSU-Great Falls, MSU-Havre, the 1994 Land Grant tribal colleges, and other state, federal, and private institutions in Montana and the region are being actively pursued. The location of extension specialists at our seven off-campus Research Centers is being discussed to expand and to improve our outreach capabilities statewide.

The Montana State University Plan of Work consists of 10 programs in research. Research programs have been listed under the one most prevailing goal. Programs are developed on a five-year or greater than five-year timeline although many individual projects have critical short-term goals. Stakeholder input has been solicited in the strategic planning process and will continue to be solicited as programs are developed and dollars are allocated to programs (See Stakeholder Input Process, page 41).

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Vision

The Montana State University College of Agriculture (COA)/Montana Agricultural Experiment Station (MAES) will provide focused and viable science-based education, research, and extension/outreach programs essential for providing knowledge and leadership in agricultural systems and natural resources to preserve the quality of the environment, improve the quality of life, and create added value from our resources for Montana and its people in a global economy.

Mission

As a land-grant institution, Montana State University-Bozeman provides instruction, research, and extension/outreach programs focused to meet the ever-changing needs of Montana and its people. In keeping with this mission, the COA/MAES provides science-based education, new knowledge, and leadership on agricultural and natural resource issues.

Values

- Provide visionary and responsive leadership based on scientific knowledge.
- Develop a community of scholars and learners committed to quality and excellence.
- Create a work environment of open communication, trust, honesty, and acceptance.
- Our conduct embraces the highest standards of ethics and citizenship.

Program Focus and Overarching Goals and Objectives

COA/MAES program focus and overarching goals and objectives include generating and disseminating knowledge and providing quality educational and outreach activities. Montana agriculture, Montana students, and the people of Montana are a primary focus of COA/MAES programs.

Enhance Economically Viable and Sustainable Agricultural Systems

- Provide a scientific basis for developing viable and sustainable plant and animal systems.
- Enhance the fundamental understanding of plant and animal biology.
- Enhance the development of value-added agricultural products.
- Improve plant and animal health through integrated pest management and other sustainable practices.
- Improve food safety and quality.
- Contribute to commodity and product marketing and economic development.
- Create educational programs that address plant and animal systems and biology.

Improve Natural Resource Management and Enhance Environmental Quality

- Provide a scientific basis for developing land and water use policies and practices.
- Enhance environmental quality and improve the sustainability of natural resource systems.
- Create educational programs that address natural resource needs and use patterns.
- Develop ecosystem improvement programs that promote sustainable management practices and are consistent with enhanced biodiversity.
- Provide programs to enhance understanding of disturbed, rural, and urban landscapes.

Strengthen the Quality of Life for Montana and Its People

- Enhance the development of educational programs and delivery systems, including distance learning, which improve basic learning and life skills among Montana's people.
- Improve recruitment and retention of students.
- Partnership with others to improve human nutrition and health, resiliency of families, and the viability of communities.
- Partnership with others to provide programs to enhance the development of new businesses and community development.
- Emphasize leadership development programs.

Goal 1. An Agricultural System that is Highly Competitive in the Global Economy

Program 1. Plant and Animal Improvement

Overview

Plant Improvement. A key factor in the success of agricultural marketing is reliable production of a high-quality product. Several factors underlie the ability of a region to obtain reliable production. These include the existence of species and varieties adapted to the climatic conditions of the region, and a knowledge base providing control strategies for important insects, diseases, and weeds. The major cash crops in Montana and the surrounding region are wheat and barley, primarily because these species are able to thrive under chronic moisture stress conditions. Traditional crossing and selection programs need to be augmented with emerging tools of molecular biology to insure the continued development of competitive varieties. There is also a need for diversification of Montana's agriculture. This diversification includes the development of new crops, such as oilseed crops that perform well in the area. Adapted varieties, however, need to be grown in conditions that provide the best chance of success. Thus, there is a critical need for an increased understanding of the biology of cropland pests in order to develop suitable control strategies. Similarly, an understanding of beneficial organisms will provide a knowledge base to enhance their activity.

Animal Improvement. The selection of breeding stock based upon quantitative genetic analysis and the prediction of breeding values continue to allow animal breeders the opportunity to develop systems to improve animals. Increasing efficiencies of producing food from animals, particularly, understanding physiologic mechanisms affecting reproduction, including the neonatal period and performance, is vital for an optimization of production efficiency and development of cost-effective production. Management of animals with high productivity capacities requires elucidation of factors regulating key biological processes, precise quantification of the nutrients required to support these processes, and development and evaluation of novel feedstuffs tailored to animal needs. Increased knowledge of micro constituents of plants, specifically minerals, feedstuffs, and animals and their possible regulatory role in function of cells and tissues are needed to enhance animal production. Evaluation of the plant-animal interface in more extensive production systems to better utilize forages and grasslands for food production is needed.

Animal Health. Infectious diseases cause millions of dollars in losses to the livestock industry in the context of reduced animal production. Reduced markets for meat products because infectious disease concerns cause additional financial losses to the livestock industry. Emerging infectious diseases found in wildlife populations, including bison, are becoming increasingly problematic for livestock producers. To reduce these losses, better vaccines, drugs, and diagnostic assays are needed for a number of infectious organisms of cattle, sheep, pigs, and other animals.

Program 2. Crop and Animal Production and Management Systems

Overview

Crop Systems. An ample, stable, and safe level of crop production forms the basis of the American standard of living. Montana landscape is dominated by dryland production of small grains and forages/range, though irrigated production is a significant

component, particularly in the production of higher-value specialty crops. Because Montana producers contend with a highly variable landscape and climate, as well as a thin profit margin, sustaining the state's agriculture requires crop varieties and management systems that provide stability in yield and quality across these variables while maintaining environmental quality. Successful implementation of cropping systems requires complex agronomic decision-making and input optimization to reduce risk and maximize economic returns in rain fed environments. Management of applied nutrients is a key component in the development of profitable and environmentally sound systems. Recently, GIS, GPS, remote sensing and other sensors have characterized inherent field variability and provide a mechanism to match field variability with variable rate application of nutrients. Understanding how applied and residual nutrients are utilized in diverse cropping systems will lead to enhanced decision-making and improved profitability, while preserving environmental quality.

Animal Systems. Profitability and competitiveness of the range livestock industry depend on its ability to control costs per unit of output. Production costs for the cow/calf or ewe/lamb sectors of the livestock industry are high. One problem is that forage quality and nutrient requirements of grazing livestock are often not synchronized, thus requiring the feeding of supplements and/or harvested forages to compensate for low forage quality. Another challenge is managing the seasonal variability in the amount and nutritional quality of the forage supply. The result is that harvested forages and supplements are the largest component of total costs. Systems for grazing livestock production that make more effective use of standing forages by grazing should improve both the profitability and sustainability of the industry. Range management is commonly the weakest component of grazing livestock operations, thereby limiting enterprise profit and promoting other less environmentally desirable range management practices. Many studies have documented the largest proportion of costs in the grazing livestock system comes from harvested and purchased feeds. Because these costs often account for one-third or more of the total, it seems logical that a major reduction in harvested and purchased feed could enhance profitability of the grazing livestock system.

Program 3. Agricultural Finance, Marketing, and Policy

Overview

In Montana and throughout the United States, the environment within which agricultural producers operate is becoming increasingly complex. Sources of this increasing complexity include the financial system, evolving marketing practices and systems, and the myriad government programs that influence producer behavior in agriculture. Agricultural producers, in dealing with financial and management issues, are presented with an increasingly complex set of tools with which to address the problems they face on a regular basis. This added complexity necessitates a continued academic effort that identifies and provides potential solutions for the continuously changing set of problems. With respect to marketing systems, the dynamics of changing foreign and domestic markets produces price volatility and marketing uncertainties to producers and agribusiness firms. These necessitate estimating price/production behavior, margin behavior, and developing appropriate marketing, financial and risk management strategies in an uncertain environment. Such information has the potential to improve the efficiency and competitiveness of the U.S. agricultural sector. Government policies

affect every aspect of agricultural and natural resource economic activity through their impacts on consumer and producer welfare, the welfare of farm input suppliers and food processors, and on rural communities and taxpayers. Economic analysis of selected policies under this plan of work will enhance the competitiveness and efficiency of U.S. agriculture.

Selected Impacts/Accomplishments Goal 1

• The relationships between plant genes and the physiology of the plant are being investigated both in temperature stress ('Studies of plants living in extreme environments within Yellowstone National Park') and light quality ('Genetically engineering plant light responses to improve crop quality'). In both studies changes of gene expression correlated with the physiological response have been demonstrated. Examination of the evolution of highly polymorphic self-incompatibility loci ('Genetics of Self-Recognition') represents another approach to the study of genome development and control. Genetic studies in legumes and grasses have led to a revision of the grass flora of Montana and a deeper understanding of the phylogenetic relationships among legume genera.

• Evidence suggests that δγ T cells are important in host responses against viral, bacterial, and protozoan infections. These δγ T cells are selectively recruited and proliferate in response to a number of infectious agents; however, their role in clearing these pathogens from the host is not understood. In the context of the recruitment of δγ T cells into different tissues, we have made progress in our characterization of tissue-specific adhesion molecules and chemokines that direct the migration of specific δγ T cell subsets into the gut versus peripheral tissues. Recently, new insights into the control of the selective migration of CD8+ δγ T cells into the gut mucosal have been gained. As stated last year, these studies have implications in the design of new adjuvants for the stimulation of the bovine immune system. Another area of progress has been in establishing the nation's first functional genomics research program on bovine δγ T cells. Initial analyses have shown differential regulation of >500 genes between CD8+ and CD8- δγ T cells.

• Several projects involve the genetic modification of organisms for specific purposes. In 'Genetic improvement of biological control agents for weed control' new strains of pathogenic fungi and bacterial are being developed for specific control of certain weed species. Grain quality in wheat and other small grains is being improved by modifying hardness genes and genes controlling specific steps in starch biosynthesis**.** Plant viruses are being designed for the delivery of drugs and other compounds to specific tissues of the body ('Mechanisms of plant virus transmission and assembly'). Both bacterial and fungal endophytes are being screened for potential valuable products and a number of patents have been awarded based on the utility of identified compounds.

• Development of plants resistant to common diseases and the understanding of the pathogens are two important goals. Tolerance to common root rot is being investigated and introduced into pea cultivars ('Miscellaneous plant diseases'). An understanding of

the genetics of mating types in Ustilago hordei is being explored to identify methods for controlling this fungus in barley ('Control of fungal disease by mating inhibition). In addition, investigation of the mechanism of defense-related genes in plants has provided insights on how plants block invasion by pathogens, possibly permitting the design of better chemicals for disease control ('Identification of defense related genes in a model plant defense system by serial analysis of gene expression'). Biocontrol agents for diseases in potato and sugar beet have been identified and are being modified for commercial production.

• Pathogenesis of and immunity to bovine shipping fever: Bovine respiratory disease complex (shipping fever) is a group of economically important diseases of cattle. The National Animal Health Monitory System (NAHMS) has estimated the annual loss of cattle associated with respiratory disease to be higher than any other cause of animal death; the estimated annual loss is in the billions of dollars. In addition, over $3 billion are spent annually for prevention and treatments of the disease complex. The overall objective of our research program is to understand the pathogenesis of and immunity to bovine shipping fever and to develop novel strategies for prevention and control of this economically important bovine disease complex. To accomplish this objective, we will establish the microorganism profiles in the different regions of the respiratory tract of calves during the course of shipping fever, with particular interests in identifying microorganisms unique to Montana. We will then investigate the kinetics of cytokine production and lymphocyte subpopulation accumulation in the lungs of calves with naturally occurring shipping fever, and to correlate these immune responses with the colonization of microorganisms and pathological changes. Results obtained from these preliminary studies should provide information helpful to the development of a research strategy that aims to understand the pathogenesis of and immunity to bovine respiratory diseases such as shipping fever. Such information is essential for future development of effective measures for prevention and treatment of this economically important disease to cattle industry.

• Brucellosis is a communicable disease, and poses a major threat to the Montana livestock industry. Montana must retain its *Brucella*-free status to sustain this industry. Thus, efforts spearheaded by VMB have focused on developing a better understanding of the bison immune system and the development of novel vaccine delivery systems and vaccines for bison. We have found that oral immunization does represent a route of delivery whereby appropriate mucosal immunity can be obtained in bison. To develop the next generation brucellosis vaccines, we have cloned nearly 70 *Brucella abortus* genes and have placed them into DNA eukaryotic expression vectors as a method to enable bison vaccination. Four bison were vaccinated with these DNA vaccines and then shipped to collaborators at Texas A&M University where the animals were then challenged. Three of the four vaccinated bison showed protection against *B. abortus* challenge whereas two of two vector –immunized bison showed no protection. Thus, these studies suggest that our DNA vaccine is protective for bison. On-going studies are optimizing the delivery of this vaccine for improved efficacy.

• Five potential biocontrol agents for use against invasive hawkweed species in North America are currently being considered. These were originally tested for use in New Zealand. We are assisting with the development of a host plant test list and the collection and propagation of these test species. In addition we are conducting host specificity tests for the gall wasp, *Aulacidea subterminalis*. Biocontrol is cost effective and environmentally safe, it is long term and self sustaining, it has the potential of increasing biodiversity by the reduction of pervasive weed populations, successful programs have improved habitat for domestic animals and wildlife and have improved the aesthetics of the environment by preserving native habitats.

• Activities focused on the impact of early cutting and raking of forages as alternatives to pesticide control of the alfalfa weevil. This research demonstrated that early cutting, an important cultural control, can be improved by addition of a raking step to the harvest process. As a result, a savings up to $15 per acre was calculated for alfalfa hay production due to decreased pesticide need for alfalfa weevil control. With 1.7 million acres of harvestable alfalfa hay in the state, if this technique saves an insecticide application on 10% of the total acres, a savings of $2 million can be realized.

• Montana produces 1 million calves per year, and feeds 10% of these calves within the state. We can improve the production efficiency of feed barley by 20% making feed barley as valuable per acre as is malting barley. We also believe that much of the feeding done in other states can be done in Montana. This will result in the conversion of $120.00 of locally produced barley into roughly $600 of locally grown beef, coming close to doubling the value of our state's beef industry. Color is the first general impression that consumers see when looking at meat. It is the most important factor affecting the decision to buy a meat product. If the meat does not have the color expected by the consumer then that consumer will not purchase the product. Finishing cattle on specific varieties of feed barley could result in increased color shelf-stability and thus increase the uses of barley for finishing rations. Furthermore, mapping of gene(s) associated with the improved color could lead to improvements in barley breeding. This would lead to selection of varieties especially for beef cattle finishing rations.

• Using sensors and remote sensing technologies such as yield monitors, satellite imagery, variable rate application equipment, tracking technologies, and field navigation devices, farmers and ranchers have new opportunities to incorporate precise, site-specific information into land management decisions.

• Crop rotations decreased spring wheat production costs by decreasing fertilizer inputs without compromising spring wheat yield or quality. It was documented that diverse crop rotations can positively influence spring wheat yield and quality. Diverse crop rotations and no-till planting can be used to effectively manage disease and weed problems in spring wheat production in Montana. Legume and oilseed crops left sufficient post-harvest residues for protection of soils from wind and water erosion. Differences in insect numbers were recorded among the various crops. Legumes for the most part had the fewest pest problems while wheat following fallow had the highest

number of potential pests. Plant diseases were less in no-till than conventionally tilled plots. Fusarium crown rot was found in higher levels in wheat produced with conventional tillage than wheat in zero tillage systems.

• The value-added high oleic safflower oil is higher in monounsaturates than olive oil and lower in saturates than olive oil. The product is grown on 50,000 acres, processed and marketed locally by the safflower oil processing plant, Montola Growers, Inc., in Culbertson, Montana. The safflower meal is utilized by the area livestock industry. The high quality Montola safflower oil has market potential in birdseed, cosmetics, infant foods, lubricants, in dietary food preparation, and as a feed additive for livestock.

• Researchers produced econometric estimates of the economic effects of imports from Mexico of feeder cattle. Those imports were found to affect U.S. feeder prices. For example, increased Mexican feeder imports from 1980-1999 reduced U.S. feeder price by $2.00/cwt. Reduced U.S. by-product exports due to the Asian economic crisis also had an effect, reducing producer prices by $2.20/cwt. In addition, Asian demand for U.S. red meats and by-products was found to significantly affect meat packer profits, hence, prices received by U.S. cattle finishers and cow-calf operators. The impacts of national income and exchange rates are significant. The research indicates that policy changes here and abroad could make a difference. For example, improved Japanese trade and income policies could add $1.50/cwt and $0.70/cwt to U.S. fed cattle and hog prices. Domestically, researchers have found that technology (cost savings) in meat packing have reduced farm-wholesale margins and increased livestock prices. From 1970-1998, technology resulted in a net reduction of .23cents/lb in the margin and a net increase of $1.73/wt in slaughter steer price. Already, policy shortcomings in China have adversely affected Chinese wheat production and marketing and consequently affected U.S. grain export markets. Project researchers also found that in Montana, grain producers will rely more upon modern grain marketing tools as government support programs are diminished and risks increase.

• Researchers found that the agency's crop insurance program appears to be characterized by adverse selection in its risk pool. That is, higher-risk producers are subsidized and insured to a greater extent than lower-risk producers. Current efforts to increase participation by reducing premiums will result in larger taxpayer outlays if simultaneous efforts are not made to adjust rates to more effectively link the rates of producers to their differing crop risk levels. An additional finding was that a number of producers appear to be submitting questionable insurance claims against the Risk Management Agency. This is important for producers because although the number of producers engaged in obviously questionable conduct is relatively small, the higher premium cost that is made necessary for honest producers, together with additional taxpayer outlays, added together, comprise a substantial amount. Policy adjustment to reduce that questionable conduct could improve the cost-effectiveness of the Agency’s programs. Project researchers are now proceeding on the development of more effective ways to identify and control questionable conduct, so that significantly lower insurance premiums can be made possible for the vast majority of producers. That should make crop insurance a more cost-effective risk management tool for those

agricultural producers. Additional analysis identified several aspects of RMA's current procedures and rating methods that may provide positive incentives. Recommendations were made with respect to possible changes in RMA procedures. RMA is evaluating the potential to implement several of the proposed changes.

Goal 1.

Executive Summary

Montana producers faced many challenges in 2001. To assist them, we were involved in a wide range of projects. These encompassed such things as experimental cattle feed to improve forage; cattle grazing in Montana climates associated with weight loss; cattle breeding programs for improved lean carcass yield; studies on the effect of mineral supplements influencing ovulation rate in beef heifers; neonatal lamb mortality; various projects on breeding ewes and cows; studies on copper and zinc levels in livers of cattle; feeding behavior and supplement delivery methods for cattle and sheep; contributing factors to the persistence of spotted knapweed.

The Montana Beef Quality Assurance (BQA) program for beef producers focused on best management practices to ensure food safety, feeder calf quality and consistency and source verification. Implementing a feeder calf certification program for beef quality-assurance trained producers based on best management practices for enhancing calf health. Implementing an electronic identification/tracking system to follow calves through various production channels. Conducting education courses focused on food safety, financial, genetic, nutritional, reproductive and marketing management. Providing Montana beef producers with the tools and information necessary to maximize profits from their beef marketing strategies through the integration of workshops, marketing clubs and on-line market information. The Montana Beef Network (MBN) has three primary objectives; 1) educational programs aimed at meeting beef quality assurance standards, production and marketing goals and providing additional educational programs through interactive-video conferencing, 2) certification of feeder calves that have met defined management protocols and 3) information feedback from the feedlot and packing plant to the cow-calf producer showing if the feeder calves met industry requirements for quality, consistency, safety and red meat yield.

Agricultural systems are continually being attacked by a broad array of arthropod pests. The overall emphasis of research and extension activities is to develop and implement management solutions to economic arthropod pests of small grains, sugarbeets, forages, canola, and potatoes. Pest management techniques using host plant resistance, cultural, biological and chemical controls have been examined for their impact on pest and beneficial insect populations and economics to assure Montana's farm economy remains globally competitive. Dryland crop diversification studies are being conducted in three locations in Montana to determine the influence of cropping sequences, tillage systems and different levels of inputs on crop production, pests, nutrient management, physical and biological properties of soil, economic profitability and environmental benefits.

Numerous field research projects have provided livestock producers and land managers new tools to increase uniformity of livestock grazing and correspondingly improve rangeland health and water quality. Infectious diseases cause millions of dollars in losses to the livestock industry in the context of reduced animal production. Reduced markets for meat products because of infectious disease concerns cause additional financial losses to the livestock industry. Emerging infectious diseases found in wildlife populations, including bison, are becoming increasingly problematic for livestock producers. During the past year, we have made significant strides in investigating a number of livestock- and wildlife-related diseases and in developing vaccine candidates for treating some of these diseases.

Several projects involve the genetic modification of organisms for specific purposes. New strains of pathogenic fungi and bacterial are being developed for specific control of certain weed species. Plant viruses are being designed for the delivery of drugs and other compounds to specific tissues of the body. Invasive species plants that have developed resistance to certain herbicides are being researched. It is possible that this knowledge can be exploited to permit the circumvention of this resistance or to develop new genes for the production of herbicide resistant crops.

Although we have developed an international reputation for our wheat and barley products, our costs of production continue to increase as producers address increasing pressure from pests due to the monoculture nature of our systems. Consequently, diversified systems or crop rotations are being studied to change our cropping systems into more sustainable systems for a semi-arid environment.

Projects were designed in recognition of a changing economic environment. The viability of each production unit depends critically upon those producers' ability to identify and analyze problems that have financial, production, organizational, or risk implications to the firm or to the industry. Our Research results provide management solutions to promote the economic competitiveness and environmental health of Montana agriculture and contribute to the production of high quality agricultural products. County Extension Agents receive the most recent information to pass on to our local population as invited participants in our Research Station advisory meetings.

Planned Programs by Key Themes
Key Theme. Plant Genomics
Activity
• Studies of Plants Living in Extreme Environments
• Genetically Engineering Plant Light Responses to Improve Crop Quality
• Genetics of Self-Regulation
• Genetic Studies of Legumes and Grasses

Impacts/Accomplishments
• The relationships between plant genes and the physiology of the plant are being investigated both in temperature stress (‘Studies of plants living in extreme environments within Yellowstone National Park’) and light quality (‘Genetically

engineering plant light responses to improve crop quality'). In both studies changes of gene expression correlated with the physiological response have been demonstrated. Examination of the evolution of highly polymorphic self-incompatibility loci ('Genetics of Self-Recognition') represents another approach to the study of genome development and control. Genetic studies in legumes and grasses have led to a revision of the grass flora of Montana and a deeper understanding of the phylogenetic relationships among legume genera.

Source of Funding
State, Hatch, USDA-NRICGP, NASA, NIH, NSF, Private Industry

Scope of Impact
National

Key Theme. Animal Genomics
Activity
• Functional Analysis of Bovine $\delta\gamma$ T Cells

Impacts/Accomplishments
• Evidence suggests that δγ T cells are important in host responses against viral, bacterial, and protozoan infections. These δγ T cells are selectively recruited and proliferate in response to a number of infectious agents; however, their role in clearing these pathogens from the host is not understood. In the context of the recruitment of δγ T cells into different tissues, we have made progress in our characterization of tissue-specific adhesion molecules and chemokines that direct the migration of specific δγ T cell subsets into the gut versus peripheral tissues. Recently, new insights into the control of the selective migration of CD8+ δγ T cells into the gut mucosal have been gained. As stated last year, these studies have implications in the design of new adjuvants for the stimulation of the bovine immune system. Another area of progress has been in establishing the nation's first functional genomics research program on bovine δγ T cells. Initial analyses have shown differential regulation of >500 genes between CD8+ and CD8- δγ T cells.

Source of Funding
State, Hatch, USDA-NRICGP, USDA-IFAFS

Scope of Impact
National

Key Theme. Biotechnology
Activity
• Genetic Manipulation of Small Grains to Improve Quality Characteristics
• Genetic Improvement of Biological Control Agents for Weed Control
• Bacterial and Fungal Endophytes
• Mechanisms of Plant Virus Transmission and Assembly

Impacts/Accomplishments

• Several projects involve the genetic modification of organisms for specific purposes. In 'Genetic improvement of biological control agents for weed control' new strains of pathogenic fungi and bacterial are being developed for specific control of certain weed species. Grain quality in wheat and other small grains is being improved by modifying hardness genes and genes controlling specific steps in starch biosynthesis**.** Plant viruses are being designed for the delivery of drugs and other compounds to specific tissues of the body ('Mechanisms of plant virus transmission and assembly'). Both bacterial and fungal endophytes are being screened for potential valuable products and a number of patents have been awarded based on the utility of identified compounds.

Source of Funding

State, Hatch, USDA-NRICGP, NSF, NIH, NSF, Private Industry

Scope of Impact

National

Key Theme. Plant Health

Activity

• Plant Diseases
• Control of Fungal Disease by Mating Inhibition
• Identification of Defense Related Genes in Plant Defense Systems
• Biocontrol Agents for Diseases in Potato and Sugar Beet

Impacts/Accomplishments

• Development of plants resistant to common diseases and the understanding of the pathogens are two important goals. Tolerance to common root rot is being investigated and introduced into pea cultivars ('Miscellaneous plant diseases'). An understanding of the genetics of mating types in Ustilago hordei is being explored to identify methods for controlling this fungus in barley ('Control of fungal disease by mating inhibition). In addition, investigation of the mechanism of defense-related genes in plants has provided insights on how plants block invasion by pathogens, possibly permitting the design of better chemicals for disease control ('Identification of defense related genes in a model plant defense system by serial analysis of gene expression'). Biocontrol agents for diseases in potato and sugar beet have been identified and are being modified for commercial production.

Source of Funding

State, Hatch, NSF-IPM, Private Industry

Scope of Impact

National

Key Theme. Animal Health

Activity

• Temporal and spatial distribution of Culicoides vectors of bluetongue.

• Determining the mechanisms by which the host resists infection to Trichomoniasis.
• Function of bovine rotavirus nonstructural proteins.
• Development of bovine vaccine delivery systems.
• Regulation of the Bovine Leukocyte NADPH Oxidase.
• Analysis of the Bison Leukocyte NADPH Oxidase.
• Drug discovery for the treatment and prevention of Coccidiosis.
• Development of a gnotobiotic calf model to study scours.
• Parameters affecting the efficiency of targeted mutagenesis in bovine cells.
• Bison innate immune system.

Impacts/Accomplishments

• Light trapping of adult midges indicated that the primary vector of bluetongue is present in parts of eastern and southwest Montana. A more comprehensive study will be initiated in 2002 to establish the vectorial capacity of the Culicoides complex.

• Results of experiments in which *Tritrichomonas foetus* was co-cultured with primary bovine macrophages indicate that these macrophages can kill the parasite. Direct macrophage exposure to trichomonads also suggests inflammatory responses are directly induced by trichomonads. Overall, these results suggest that innate immune responses and inflammatory responses are triggered by trichomonads. These studies also suggest the importance of innate immunity in destruction of *T. foetus*.

• Rotavirus is the major viral cause of diarrhea in cattle. We are focusing studies on understanding the functions of a viral protein (NSP1) that may be responsible for toxic effects in cells. Current studies are focused on understanding the mechanisms by which this inhibition occurs, with a long-term goal of developing deliverable therapeutics that prevent the action of NSP1.

• We investigated the feasibility of using an attenuated *Salmonella* vector to immunize heifers against bovine enterotoxigenic *Escherichia coli* (ETEC). Our results confirmed that variation in the expression of K99 fimbrial subunit within different compartments of *Salmonella* vaccine vectors alters the type of responses elicited. This vaccine is currently being evaluated in heifers to test its efficacy in challenged, new-born calves.

• Two of the essential cytosolic components of the NADPH oxidase are $p47^{phox}$ and $p67^{phox}$. Previously, only the human and murine homologues of these proteins have been sequenced. Thus, we carried out studies to clone, sequence, and express bovine $p47^{phox}$ and $p67^{phox}$. Studies showed that these proteins could substitute for the human proteins in reconstituting NADPH oxidase activity in a cell-free assay system, again demonstrating the high degree of conservation between human and bovine homologues. This study greatly contributes to our understanding of the potential structural/functional regions of $p47^{phox}$ and $p67^{phox}$ as well as gives us information that can be used to study the role of neutrophils in bovine inflammatory diseases.

• Almost nothing is known about NADPH oxidase function in wild ruminant species. We have now characterized bison neutrophil function and found unique differences that may

allow bison neutrophils to respond to the distinct host defense challenges bison encounter. Overall, these studies show that although bison and bovine neutrophils differ in certain functions, the bison and bovine NADPH oxidase genes are highly conserved between these two species, despite their divergence from a common ancestor >1 million years ago.

• Infectious diseases caused by coccidian parasites are some of the most important health problems of food animals and humans. Compared to the cells of their mammalian hosts, coccidian parasite development is highly unusual, and therefore, represents a major area for drug discovery. We have developed novel experimental models for the study of *Eimeria bovis* (causative agent of coccidiosis in cattle) and *Toxoplasma gondii* in order to characterize biochemical mechanisms responsible for successful parasitism by these microorganisms. One of the goals is to apply a modern functional genomic approach to these parasitic diseases. Over the last year, we have successfully established the technique for serial-analysis-of-gene-expression (SAGE) in the model coccidian *T. gondii*. This opens the door to apply this technique to infected animals and understanding why some tissues are susceptible to infection while others are resistant. From this information we can begin to devise strategies to make tissues resistant and hopefully eliminate these diseases.

• Rotavirus is a leading cause of acute gastroenteritis in neonatal calves. The nature of the host response against bovine rotavirus is not understood, but studies in mice suggest an important roll for T cells within the gut lamina propria. Experimental procedures will be developed to analyze the lymphocyte responses to rotavirus infection of newborn calves under gnotobiotic (germ-free) conditions. This approach will help to identify important regulatory mechanisms in clearance of rotavirus-infected cells in the gut. We intend to use this information to develop technology that will specifically stimulate the most effective early immune response in the intestine. A gnotobiotic facility was set-up in the past year, and preliminary experiments have been performed to work out the logistics of housing and handling animals under sterile conditions.

• Targeted mutagenesis can be used to create genetically modified animals; however, to date, other than one reported success in sheep, there are only published reports of success in mice. The proposed research is aimed at increasing the efficiency of targeted mutagenesis in bovine cells, which could in turn be used to create animals by cloning. We propose to produce bovine cell lines from a purebred breed of dairy cattle (American Holstein) and from an unrelated breed (free-range beef cattle from Montana). DNA from the Holstein cells will be used to produce vectors for targeted mutagenesis. Our goal is to measure how critical it is to use isogenic vectors for targeting mutations into bovine cells. Were targeted mutagenesis to become tractable in cattle, it could both increase the value of existing cattle-based commodities and allow creation of countless more valuable cattle-based products. Thus, it could allow production of particularly disease resistant herds or herds exhibiting increased milk or beef production. It could also allow cattle to be used for efficient production of protein-based pharmaceutical products, such as human insulin, human growth hormone, human blood clotting factors, and others.

• The innate immune system is a collection of potent but non-specific mechanisms that conduct the initial host response when pathogenic microorganisms invade an animal's body. One component of this system is a diverse group of molecules known as anti-microbial proteins (AMPs). These proteins can recognize and bind to molecular patterns that are on the surface of many microorganisms. Once they bind, the AMPs disrupt the outer membrane of the pathogen, and kill it. Recently, we identified what may be unique AMP's in bison neutrophils. Thus, a new project is planned to determine whether bison neutrophils do indeed contain unique AMPs that could be useful therapeutic agents in treating diseases such as bovine tuberculosis and Brucellosis in bison, diseases that are harmful and infectious to both bison and cattle.

• Pathogenesis of and immunity to bovine shipping fever: Bovine respiratory disease complex (shipping fever) is a group of economically important diseases of cattle. The National Animal Health Monitory System (NAHMS) has estimated the annual loss of cattle associated with respiratory disease to be higher than any other cause of animal death; the estimated annual loss is in the billions of dollars. In addition, over $3 billion are spent annually for prevention and treatments of the disease complex. The overall objective of our research program is to understand the pathogenesis of and immunity to bovine shipping fever and to develop novel strategies for prevention and control of this economically important bovine disease complex. To accomplish this objective, we will establish the microorganism profiles in the different regions of the respiratory tract of calves during the course of shipping fever, with particular interests in identifying microorganisms unique to Montana. We will then investigate the kinetics of cytokine production and lymphocyte subpopulation accumulation in the lungs of calves with naturally occurring shipping fever, and to correlate these immune responses with the colonization of microorganisms and pathological changes. Results obtained from these preliminary studies should provide information helpful to the development of a research strategy that aims to understand the pathogenesis of and immunity to bovine respiratory diseases such as shipping fever. Such information is essential for future development of effective measures for prevention and treatment of this economically important disease to cattle industry.

Source of Funding
State, Hatch, USDA-NRICGP, NIH, NSF, Private Industry

Scope of Impact
National

Key Theme. Emerging Infectious Diseases
Activity
• Vaccine development for Brucellosis in Bison
• Center for Bison and Wildlife Health

Impacts/Accomplishments

• Brucellosis is a communicable disease, and poses a major threat to the Montana livestock industry. Montana must retain its *Brucella*-free status to sustain this industry. Thus, efforts spearheaded by VMB have focused on developing a better understanding of the bison immune system and the development of novel vaccine delivery systems and vaccines for bison. We have found that oral immunization does represent a route of delivery whereby appropriate mucosal immunity can be obtained in bison. To develop the next generation brucellosis vaccines, we have cloned nearly 70 *Brucella abortus* genes and have placed them into DNA eukaryotic expression vectors as a method to enable bison vaccination. Four bison were vaccinated with these DNA vaccines and then shipped to collaborators at Texas A&M University where the animals were then challenged. Three of the four vaccinated bison showed protection against *B. abortus* challenge whereas two of two vector –immunized bison showed no protection. Thus, these studies suggest that our DNA vaccine is protective for bison. On-going studies are optimizing the delivery of this vaccine for improved efficacy.

• Emerging infectious diseases represent a growing threat to public and animal health. A potential major source of new and spreading infections is the interaction livestock and wildlife, which are in close association in Montana. Many infectious organisms, which have reservoirs in wildlife and livestock are also considered potent biowarfare agents. Therefore, it is essential that we begin to develop an understanding of these diseases and identify mechanisms to prevent their spread. The goal of this plan is to increase our research effort (facilities and personnel) directed toward understanding the pathogenesis of emerging infectious diseases and what mechanisms the host brings to bear against these diseases. We have developed a center focused on wildlife health. One of the goals of this Center is to carry out investigation of infectious disease affecting wildlife. Further participation of MAES researchers in this Center and acquisition of funding will be a goal during the Plan of Work.

Source of Funding

State, Hatch, USDA-NRICGP, USDA-Institutional

Scope of Impact

National

Key Theme. Invasive Species

Activity

• Knapweek control
• Monitoring of injurious insect pests.
• Biological control of invasive hawkweeds.
• Biological control of leafy spurge.
• Herbicide resistance.
• Integrated management practices.

Impacts/Accomplishments

• Spotted knapweed's success cannot be attributed to a universal greater competitive ability or efficiency than native grasses. Spotted knapweed does not significantly alter soil physical properties, but it uses soil water later into the summer than native grasses. This depletion persists into the following year, which affects soil water available for native species. These results may help identify successful strategies to restore native grasses.

• Monitoring systems are in place for the following: pale western and army cutworms, cereal leaf beetle, cabbage seedpod weevil, green peach aphid, and sugar beet root aphid. Results of monitoring systems are used to alert producers for these insect pests.

• Five potential biocontrol agents for use against invasive hawkweed species in North America are currently being considered. These were originally tested for use in New Zealand. We are assisting with the development of a host plant test list and the collection and propagation of these test species. In addition we are conducting host specificity tests for the gall wasp, *Aulacidea subterminalis*. Biocontrol is cost effective and environmentally safe, it is long term and self sustaining, it has the potential of increasing biodiversity by the reduction of pervasive weed populations, successful programs have improved habitat for domestic animals and wildlife and have improved the aesthetics of the environment by preserving native habitats.

• Research has shown that certain flea beetle species are associated with particular chemical and physical properties of the soil, chemical properties of the spurge roots and foliage, and levels of plant productivity. Habitat association models developed from soil, plant and flea beetle data from Europe were validated with similar information collected from 48 research sites in Montana, North Dakota, and Wyoming. The habitat association information will be helpful in guiding the release of flea beetles in the appropriate spurge habitats in the future, thus improving their chances for establishing and having an impact on leafy spurge in North America.

• Kochia is an invasive plant that has developed resistance to certain herbicides. The basis of this resistance appears to be an auxin binding protein (MONB00392, 'Molecular approaches to weed physiology'). It is possible that this knowledge can be exploited to permit the circumvention of this resistance or to develop new genes for the production of herbicide resistant crops. Biocontrol agents are being developed for control of houndstongue (*Cynoglossum* species) and other weedy species.

• A one-pass system to apply a herbicide and seed more desirable species have been implemented in a cost-effective manner.

Source of Funding

State, Hatch, Smith-Lever, USDA-NRICGP, Western Region IPM, BLM, Private Industry

Scope of Impact

National

Key Theme. Plant Production Efficiency

Activity

• Improving monitoring techniques and cultural controls for the management of insect pests of small grains, forages and oilseeds.
• Elucidating mortality factors of alfalfa leafcutter bees.
• Development of the canola industry in Montana.
• Wide utilization of cereal forages and introduction of Haybet awnless hay barley.
• Fifth year of air drill opener evaluation assisting growers in the selection of openers appropriate to specific production needs.
• The selection, evaluation and release sawfly resistant winter wheat cultivars.

Impacts/Accomplishments

• Activities focused on the impact of early cutting and raking of forages as alternatives to pesticide control of the alfalfa weevil. This research demonstrated that early cutting, an important cultural control, could be improved by addition of a raking step to the harvest process. As a result, a savings up to $15 per acre was calculated for alfalfa hay production due to decreased pesticide need for alfalfa weevil control. With 1.7 million acres of harvestable alfalfa hay in the state, if this technique saves an insecticide application on 10% of the total acres, a savings of $2 million can be realized.

• In western North America, managed populations of the leafcutting bee *Megachile rotundata* are used to maximize seed yield in alfalfa seed production. Producers also attempt to maximize bee production in order to sustain pollinator populations and market bees to other growers. Bee production is often constrained by mortality due to parasitoids and diseases, and by a condition called “pollen ball” (a cell containing pollen, but no developing bee). Research at MSU is aimed at identifying the biotic and abiotic causes of mortality and designing potential low-cost remedies.

• This project initiated canola and rapeseed variety evaluations in 1986, three years prior to private industry initiating contract production in the state and providing support for research. Canola acreage has stabilized around 30,000-50,000 acres in Montana.

• The popularity of Haybet has grown to the point that it is now seeded on more acres than any other feed grain barley variety. More barley is now grown for hay in Montana than is grown for feed grain.

• Selection and purchase of an inadequate opener type not only results in average direct cash loss of $5,000 per mistake, but wheat yield differences associated with openers can amount to as much as 25 percent. Economic impact potential is very significant. If only a 10 percent yield advantage was gained by equipping air drills with more appropriate openers, and such improvement was made on air drills involved with only 10 percent of Montana's air-drill-sown wheat (approximately 3.7 million acres total) which at 30 bushel per acre and $3.50 per bushel average yield and price respectively, would result in an average gross return increase of $3.9 million.

• The sawfly resistant winter wheat cultivars ‘Vanguard’ and ‘Rampart’ were released. Wheat stem sawfly causes up to $30 million in crop losses annually. The demand for Vanguard and Rampart seed is exceptionally high. These two varieties will have a major impact on reducing losses due to sawfly.

Source of Funding
State, Hatch, Smith-Lever, USDA-ARS, Private Industry

Scope of Impact
Regional

Key Theme. Animal Production Efficiency
Activity
• Nutritional strategies to improve neonatal lamb survivability.
• Genetic parameters for carcass traits.
• Winter grazing.
• Genetic Effects on endocrine function.
• Bull/cow interactions regulating anestrus.
• Trace mineral effects on performance.
• Livestock behavior and performance.
• Barley feed for rangeland cattle.
• Nutritional management of range beef cows.
• Integrated total quality management for beef production.
• Wheat stubble management using sheep.
• Efficiency and sustainability of beef cattle production.
• Breed selection to develop crossbred cows for the Montana environment.

Impacts/Accomplishments
• Lambs subject to a controlled cold stress at birth show an immediate and positive response to colostrum intake. There is a positive response to late gestation with supplemental vitamin E on lamb survival; however, no indication of an enhanced immune function. Additionally, giving supplemental vitamin E to the newborn lamb is not effective in improving lamb survival. Supplemental zinc may enhance serum vitamin E status.

• National genetic evaluation of carcass traits should accurately rank animals within the production systems in which their progeny will perform. This research identifies areas in current methodologies that may require modification.

• Windbreaks are of minimal benefit to cattle grazing foothill rangelands during winter. Cattle activity patterns and orientation were highly responsive to weather, which may explain minimal changes in backfat, body weight, immune response, and reproductive efficiency. Cattle gain considerable energy from the sun during winter, which lowers need to increase intake, or use endogenous reserves. Increased winter grazing could lower winter feed costs.

• Certain seminal, histomorphological, and physiological male reproductive characteristics have been altered by selection for a female reproductive trait. Theses changes may be associated with changes in the neuroendocrine-endocrine relationships within hypothalamic-hypophyseal-testicular axis of male offspring indicating that selection for a female reproductive trait can affect the male reproductive endocrine system. Changes in oviductal protein secretion patterns during puberty or after progestin-synchronized estrus may play a role in reduced fertility associated with reproductive events.

• Based upon the preliminary data for progesterone it appears that the postpartum anestrous interval to resumption of ovarian cycling activity in cows exposed to bulls is progressively reduced as time after calving to exposure to bulls increases. This is a significant finding and supports the hypothesis that the effect of bulls to reduce the postpartum interval to estrus may be dependent on physiologic-behavior interactions among cows, calves, and bulls.

• The presence of antagonistic minerals causes deficiencies of essential trace minerals. Many areas of the U.S. are apparently deficient in one or more trace minerals. The form of mineral supplement influenced ovulation rate in beef heifers, which has implications for marketing supplements.

• We have developed a technique which could have a large impact on the feedlot industry if adopted. Range livestock producers should benefit from the supplement study. Our research has been featured in several popular magazines serving the animal industry.

• Montana produces 1 million calves per year, and feed 10% of these calves within the state. We can improve the production efficiency of feed barley by 20% making feed barley as valuable per acre as is malting barley. We also believe that much of the feeding done in other states can be done in Montana. This will result in the conversion of $120.00 of locally produced barley into roughly $600 of locally grown beef, coming close to doubling the value of our state's beef industry. Color is the first general impression that consumers see when looking at meat. It is the most important factor affecting the decision to buy a meat product. If the meat does not have the color expected by the consumer then that consumer will not purchase the product. Finishing cattle on specific varieties of feed barley could result in increased color shelf-stability and thus increase the uses of barley for finishing rations. Furthermore, mapping of gene(s) associated with the improved color could lead to improvements in barley breeding. This would lead to selection of varieties especially for beef cattle finishing rations.

• We have identified characteristics that can be used in a selection program for superior forage quality barley. In addition, we have developed the first datasets thoroughly describing the genetic control of forage quality and nitrate accumulation in forage barley. We intend to develop a program of molecular marker-assisted selection for forage quality and low-nitrate potential characteristics in forage barley. This research

has provided the identification and mapping of Quantitative Trait Loci for barley forage quality based on North American Barley Genome Mapping Project populations, and will allow deployment of genes for improved forage quality via marker-assisted selection.

• To meet customer needs and return additional revenue to cattle producers, a systems network must be in place to ensure that a quality and consistent product is being produced. A systems approach was implemented which allowed for tracking of calves from the ranch in Montana to the feedlots in other states and eventually to the packing plant.

• Application of our project will help maintain or improve environmental quality and convert stubble from a wheat production liability into a livestock feed resource.

• On rugged and extensive rangelands, uneven livestock distribution limits the amount of forage available for grazing and may result in natural resource degradation. Cattle can be lured to previously undergrazed rangeland on rugged terrain and at long distances from water by strategically placing dehydrated molasses supplements. Grazing use was enhanced by 10 to 20 percent within 600 yards of supplement placement. In addition, producers may be able to improve livestock grazing patterns by selecting breeds that were developed in mountainous terrain. Research conducted at NARC demonstrated that cattle developed in the French Alps (Tarentaise) used higher terrain and steeper slopes than cattle developed in more gentle terrain in England (Hereford). Ongoing research is also investigating the potential of selecting individual animals within a breed to improve uniformity of grazing.

• Research shows that selected crossbred cows for Montana environment can wean heavier calves and return $70.00 per cow per year more when compared to straight bred cows.

Source of Funding
State, Hatch, USDA-NRICGP, USDA-Institutional, USDA-SARE, Private Industry

Scope of Impact
National

Key Theme. Precision Agriculture
Activity
• Applications of Geographic Information Systems (GIS) and Global Positioning Systems (GPS).
• Implementing mapping strategies with GPS and GIS for wild oats and wheat stem sawfly.

Impacts/Accomplishments
• Using sensors and remote sensing technologies such as yield monitors, satellite imagery, variable rate application equipment, tracking technologies, and field navigation

devices, farmers and ranchers have new opportunities to incorporate precise, site-specific information into land management decisions.

• Field with wild oats may be ecological sinks for sawfly larvae because larvae do not survive in the wild oat stems.

Source of Funding
State, Hatch, Smith-Lever, USDA-NRICGP, Private Industry

Scope of Impact
National

Key Theme. Diversified/Alternative Agriculture
Activity
• Dryland crop diversification studies.
• Feasibility of growing soybean as a new annual legume crop for south central Montana in irrigated rotations as a feed protein and high energy source.
• Dryland diversified cropping systems.

Impacts/Accomplishments
• Crop rotations decreased spring wheat production costs by decreasing fertilizer inputs without compromising spring wheat yield or quality. It was documented that diverse crop rotations can positively influence spring wheat yield and quality. Diverse crop rotations and no-till planting can be used to effectively manage disease and weed problems in spring wheat production in Montana. Legume and oilseed crops left sufficient post-harvest residues for protection of soils from wind and water erosion. Differences in insect numbers were recorded among the various crops. Legumes for the most part had the fewest pest problems while wheat following fallow had the highest number of potential pests. Plant diseases were less in no-till than conventionally tilled plots. Fusarium crown rot was found in higher levels in wheat produced with conventional tillage than wheat in zero tillage systems.

• Initial studies indicate yield potential and crop quality are superior to levels experienced in traditional mid-western soybean production areas. Added benefits would include rotation-related pest suppression in rotation crops as well as reduced nitrogen fertilizer use. A projected 25,000 acres of soybean would have a minimum economic impact of $ 7 million to the local economy. Computer-based information technology has been implemented to assist in dissemination of SARC research results and recommendations to the public. The center currently possesses full time internet connectivity and is equipped with an on-site server system. Web access at http://www.sarc.montana.edu currently provides current and historical weather information assisting crop management decisions.

• Demonstrated adaptability of alternative crops into wheat and barley systems. Over the long-term, this will disrupt pest cycles and decrease input costs.

Source of Funding
State, Hatch, Smith-Lever, UDSA-IFAFS, USDA-SARE, Private Industry

Scope of Impact
National

Key Theme. Adding Value to Agricultural Products
Activity
• Breeding and improvement of oilseed crops for eastern Montana has developed value-added safflower products (high oleic / low saturate and high linoleic / low saturate oils).

Impacts/Accomplishments
• The value-added high oleic safflower oil is higher in monounsaturates than olive oil and lower in saturates than olive oil. The product is grown on 50,000 acres, processed and marketed locally by the safflower oil processing plant, Montola Growers, Inc., in Culbertson, Montana. The safflower meal is utilized by the area livestock industry. The high quality Montola safflower oil has market potential in birdseed, cosmetics, infant foods, lubricants, in dietary food preparation, and as a feed additive for livestock.

Source of Funding
State, Hatch, Private Industry

Scope of Impact
Regional

Key Theme. Agriculture Competitiveness
Activity
• Winter wheat breeding and genetics.
• Spring wheat breeding and genetics.
• Barley breeding and genetics.
• Alfalfa breeding and genetics.
• Breeders seed purification and increase.
• Evaluation and improvement of barley for food and feed.
• Genetic studies and germplasm enhancement in cool season legumes.
• Quantitative genetics and crop development.
• Agricultural finance, marketing and policy.

Impacts/Accomplishments
• The development of new and better varieties of winter wheat. **'NuSky' and 'BigSky'** cultivars were released and portend to be excellent cultivars for Montana.

• The development of new and better varieties of spring wheat. The **MTHW9420** cultivar was released and appears to be an excellent cultivar for Montana.

• The development of new and better varieties of barley. The **Haxby** cultivar was released and appears to be an excellent one for Montana.

• The development of new and better varieties of alfalfa. The **Cooper** cultivar was released and portends to be an excellent cultivar for Montana.

• The quality of seed released for each cultivar is carefully monitored to ensure that the seed trade receives true-to-type seed with high germination rates and low levels of extraneous seed.

• Better feed barley is being developed to generate better weight gain in cattle before shipment out of state.

• Development of pea germplasm adapted to Montana conditions has been initiated in order to provide additional rotation crops.

• Much of this progress is dependent on statistical analysis of quantitative traits using molecular markers.

• Researchers produced econometric estimates of the economic effects of imports from Mexico of feeder cattle. Those imports were found to affect U.S. feeder prices. For example, increased Mexican feeder imports from 1980-1999 reduced U.S. feeder price by $2.00/cwt. Reduced U.S. by-product exports due to the Asian economic crisis also had an effect, reducing producer prices by $2.20/cwt. In addition, Asian demand for U.S. red meats and by-products was found to significantly affect meat packer profits, hence, prices received by U.S. cattle finishers and cow-calf operators. The impacts of national income and exchange rates are significant. The research indicates that policy changes here and abroad could make a difference. For example, improved Japanese trade and income policies could add $1.50/cwt and $0.70/cwt to U.S. fed cattle and hog prices. Domestically, researchers have found that technology (cost savings) in meat packing have reduced farm-wholesale margins and increased livestock prices. From 1970-1998, technology resulted in a net reduction of .23cents/lb in the margin and a net increase of $1.73/wt in slaughter steer price. Already, policy shortcomings in China have adversely affected Chinese wheat production and marketing and consequently affected U.S. grain export markets. Project researchers also found that in Montana, grain producers will rely more upon modern grain marketing tools as government support programs are diminished and risks increase.

Source of Funding
State, Hatch, USDA-Institutional, USDA-NRICGP, Private Industry

Scope of Impact
National

Key Theme. Risk Management
Activity
• Crop Insurance Risk Management Analysis.

Impacts/Accomplishments

• Researchers found that the agency's crop insurance program appears to be characterized by adverse selection in its risk pool. That is, higher-risk producers are subsidized and insured to a greater extent than lower-risk producers. Current efforts to increase participation by reducing premiums will result in larger taxpayer outlays if simultaneous efforts are not made to adjust rates to more effectively link the rates of producers to their differing crop risk levels. An additional finding was that a number of producers appear to be submitting questionable insurance claims against the Risk Management Agency (RMA). This is important for producers because although the number of producers engaged in obviously questionable conduct is relatively small, the higher premium cost that is made necessary for honest producers, together with additional taxpayer outlays, added together, comprise a substantial amount. Policy adjustment to reduce that questionable conduct could improve the cost-effectiveness of the Agency's programs. Project researchers are now proceeding on the development of more effective ways to identify and control questionable conduct, so that significantly lower insurance premiums can be made possible for the vast majority of producers. That should make crop insurance a more cost-effective risk management tool for those agricultural producers. Additional analysis identified several aspects of RMA's current procedures and rating methods that may provide positive incentives. Recommendations were made with respect to possible changes in RMA procedures. RMA is evaluating the potential to implement several of the proposed changes.

Source of Funding

State, Hatch, USDA-RMA, FCIC, NSF

Scope of Impact

National

TOTAL GOAL 1 Funding- $11,487,377 FTE- 108
(SEE Appendix A)

Goal 2. A Safe and Secure Food and Fiber System

Program 4. Plant Genetic Resource Conservation and Utilization

Overview

The science of plant breeding is responsible for approximately one-half of the dramatic yield gains experienced for most of our major crops over the past few decades. Additionally, genes for resistance to major insects and diseases have been incorporated into successful crop cultivars. The basis for plant improvement through breeding is the exploitation of genetic variability. In order for this variability to be accessible to plant breeders, plant collections must be developed, catalogued, and characterized. Finally, once superior varieties have been developed, it is vital that pure and healthy seed stocks be maintained throughout the seed production and commercialization process. Another source of important genes is the endophytes that live in association with plant species. Characterization of these species has led to the identification of medically and agriculturally important compounds.

Program 5. Food System Performance

Overview

The U.S. food and fiber system is responsible for providing consumers with adequate quantities, high quality, and safe food products at reasonable cost. Securing such a system requires responsibilities and efficiencies of relevant market players including producers of raw agricultural commodities, manufacturers/processors, and distributors and retailers. Factors such as flexible markets, price incentive structures, business organization structure and behavior, and public regulation and monitoring are essential to maintaining a progressive food and fiber system into the future. Many of the market and non-market parameters essential to a healthy and secure food system are in a dynamic state such as market concentration, price discovery, value-added opportunities, food-born illnesses, and regulation activities. Research in these areas is vital to examine economic effects on consumers and market participants from current and likely changes in the future.

Selected Impacts/Accomplishments Goal 2

• High quality seed free of weed seeds, disease, and other contaminants.

Goal 2.

Executive Summary

MAES is involved in two programs that meet the goal, A SAFE AND SECURE FOOD AND FIBER SYSTEM: Production and sale of certified seed is a major program at MAES. Certified seed assures a form of quality Food Handling. The Food Resource Management program provides one of the most basic needs of a plant breeding program, the maintenance and supply of germplasm that may contain useful genes not currently present in the breeding lines.

Planned Programs by Key Themes

Key Theme. Food Handline

Activity

• State Seed Testing Laboratory

Impacts/Accomplishments

• High quality seed free of weed seeds, disease, and other contaminants.

• Service ensures certified seed production and sale to growers.

Source of Funding

State, Private Industry

Scope of Impact

State, Regional

Key Theme. Food Resource Management

Activity

• Plant Genetic Resource Conservation and Utilization

Impacts/Accomplishments
• Supply of germplasm that contain genes not currently in breeding lines.

Source of Funding
State, Hatch

Scope of Impact
National

TOTAL GOAL 2 Funding- $142,676 FTE- 6.3
(SEE Appendix A)

Goal 3. A Healthy, Well Nourished Population

Program 6. Improving Human Foods and Health

Overview
The end use of a cereal defines what quality attributes are desirable in the grain. The milling and baking attributes of cereal such as wheat and barley are unique. Several factors underlie quality parameters of wheat and barley. These include environmental, variation, interaction of genotypes with the environment, and varieties adapted to the climatic conditions of the environment. It is important to understand and improve the quality of all wheat and barley market classes. Sources of new pharmaceutical chemicals have become limited. There is need to tap into the diverse array of microbes associated with plants that may prove to be a source of useful pharmaceutical compounds.

Selected Impacts/Accomplishments Goal 3
• The characteristics necessary for high quality flour have been analyzed. Wheat lines that produce better flour for bread or noodles have been identified and are being commercialized.

• Unique chemicals are produced through the interaction of plants with their endophytes. A number of medicinally important compounds, including taxol, have been identified through such analyses. Several new antibiotic compounds have been recently reported as part of this project.

• The investigation for crops that may serve as alternatives for wheat and barley in Northern Great Plains dry land crop rotations. These crops include minor oilseeds such as mustard seed and safflower, dry beans, and peas. The results of this research will improve the quality of information available.

Goal 3.

Executive Summary
Projects related to Human Nutrition and Medicinal Plants help MAES meet the goal, A HEALTHY, WELL NOURISHED POPULATION. The effects of improved food product content labeling on consumer purchases of dairy products are being investigated. Initial

results indicate that credible and accurate labeling about Bst content and organic and non-organic milk products leads to important changes in consumer purchases and, by implication, improved consumer choices.

Planned Programs by Key Themes
Key Theme. Human Nutrition
Activity
• End-use properties of wheat and barley.

Impacts/Accomplishments
• The characteristics necessary for high quality flour have been analyzed. Wheat lines that produce better flour for bread or noodles have been identified and are being commercialized.

Source of Funding
State, Private Industry

Scope of Impact
National

Key Theme. Medicinal Plants
Activity
• Endophytes of plants: their biology, economic value and potential use.

Impacts/Accomplishments
• Unique chemicals are produced through the interaction of plants with their endophytes. A number of medicinally important compounds, including taxol, have been identified through such analyses. Several new antibiotic compounds have been recently reported as part of this project.

Source of Funding
State, Hatch, NSF, Private Industry

Scope of Impact
National

Key Theme. Agricultural Competitiveness
Activity
• Structure of domestic and international markets and marketing channels for alternative crops.

Impacts/Accomplishments
• The investigation for crops that may serve as alternatives for wheat and barley in Northern Great Plains dry land crop rotations. These crops include minor oilseeds such as mustard seed and safflower, dry beans, and peas. The results of this research will improve the quality of information available.

Source of Funding
State, Hatch, USDA

Scope of Impact
Regional

TOTAL GOAL 3 Funding- $1,511,084 FTE- 4.7
(SEE Appendix A)

Goal 4. An Agricultural System which Protects Natural Resources and the Environment

Program 7. Integrated Pest Management

Overview

Montana producers are continually challenged by myriad pests to produce crops and livestock in an efficient and economical way. Many of these competitive pests require pesticides to significantly reduce their direct impact on food and fiber production. Increasing public concern related to food quality, natural resource biodiversity, and sustaining the quality of soil, air, and water are mandating less reliance on pesticides and more on non-chemical pest control options. IPM seeks to optimize grower profitability and natural resource sustainability through development, selection and implementation of appropriate pest management tactics that are economically sound and environmentally acceptable. IPM systems are dynamic and the application of IPM is site-specific in nature; selection of individual tactics is determined by the particular crop-pest-environment scenario. IPM research and education programs need to integrate new technologies that are rapidly advancing agriculture production (e.g., remote sensing, molecular biology, chemical ecology) into improving existing pest management systems and developing new ones.

Program 8. Improving Soil, Plant, and Water Resources in Ecosystems

Overview

Landscapes are diverse mixtures of biological, chemical and physical processes in soil, plant communities, and surface and groundwater systems. Land management practices impact these components and potentially change the quality and quantity of soil, plant, and water resources. As a headwater's state with multiple land uses, Montana is in a unique position to understand how land management practices, e.g. grazing of riparian areas, fate and transport of applied pesticides and natural constituents, impact ecosystems. From pristine to highly managed land uses, the multitude of practices that occur on the Montana land surface influence environmental quality, economic vitality, and, ultimately, quality of life. For example, rangelands comprise 70% of the land area in Montana. The greatest environmental challenge is better management of cattle grazing in concert with riparian habitats, wildlife, and clean water. Characterization and understanding of the complex interactive components will lead to improved soil, plant, and water resources in ecosystems.

Program 9. Economics and Sustainability of Public and Private Lands

Overview

In Montana and throughout the U.S., the relationship between economics and the sustainability of ecological systems has become one of the critical issues in modern agricultural and environmental policy. The sustainability of alternative land uses is equally critical for public and private lands. Because private and public lands comprise common ecological resources (e.g., river systems, wildlife) it is also important to study these lands together. Current and future changes in economic conditions, agricultural policy, and environmental policy raise serious questions about agriculture. Understanding how the various land uses (e.g., farming, ranching, timber, recreation, mining, development and subdivision) are determined is crucial in determining the sustainability of these lands. In order for farmers, ranchers, forestland companies, and public land mangers to adapt to changing conditions it is essential that they be provided with information in the link between economic decisions, government programs, land use, and sustainability. Economic analysis of these issues can provide this information.

Selected Impacts/Accomplishments Goal 4

• The wheat stem sawfly, a perennial small grain pest in Montana, cannot be managed by conventional agricultural practices (e.g., burning, tillage, swathing, insecticides). Thus, there is an urgent need to develop new tools for its management. Recent advances in the understanding of sawfly ecology are providing tools for development of innovative management strategies for this pest. These include the investigation of two sources of compounds discovered in wheat fields in Montana that are toxic to this insect. One source is microbial and the other is from commonly-occurring grass species. The compounds responsible for the plant toxicity are being characterized using analytical equipment and biological assays. Research efforts have also identified chemical odors that are used for sawfly mating and for location of host plants. Behavior-modifying chemicals, pathogens, and plant-derived toxins are highly desirable management tools because minute amounts are needed to be effective and they pose limited environmental challenge. New analytical equipment designs and recent chemical techniques have simplified ongoing research, and will lead to an integrated biorational sawfly management program.

• In Montana noxious weeds are of major economic importance. To control these pest species, a variety of control techniques must be utilized, including biological control with arthropods. The primary objective of the MSU Insect Quarantine Laboratory is to facilitate the importation, augmentation, study, and release of exotic arthropods or the biological control of noxious weeds of regional importance. During 2000 - 2001, thirteen species of arthropods were imported to the quarantine lab for the biological control of rush skeletonweed, leafy spurge, Russian knapweed, gorse, Dalmatian toadflax, field bindweed and spotted knapweed. Although the majority of the agents were for host specificity testing, approximately 3500 individuals were consigned to field sites in Montana and Oregon or for DNA analyses. Forty augmentative release of 15,000 flea beetles were made in 2001 throughout the state.

• Biodiversity documentation in Montana provides knowledge of the existence and distribution of species for management of public lands and the ability to use them without legal challenge. The Montana entomology Collection is the largest repository for information on the existence and distribution of species in Montana. It continues to grow apace; and it is used by public land managers to achieve and document compliance with appropriate laws.

• Habitat use patterns of rangeland cattle are influenced by a herd's social dominance hierarchy. Therefore, if total herd size remains unchanged, selective culling of individual cows based on their habitat use patterns is unlikely to reduce cattle use of any sites in a pasture.

• No-till research at Western Triangle Ag Research Center showed increased moisture conservation; improved stand establishment in dry years; increased winter survival; decreased air and water pollution; decreased soil erosion; decreased production costs; and increased crop yield. Grower adoption of no-till chem-fallow continues to be enhanced by this research activity. Stand establishment for canola has been far more successful with no-till than tillage systems because no-till maintains moisture closer to the soil surface.

• New methodology to measure in situ water contents across the entire soil wetness range, ability to maintain hydraulic continuity across a wide range of porous media, and efficiency based on using the same instrumentation for all measurements.

• This overall project assessed the economic sustainability of certain current public and private land uses and public policies that help shape those uses. Researchers also assessed the ecological sustainability of potential land use changes resulting from likely changes in economic conditions as well as changes in agricultural policy and environmental policy. The policies in question include endangered species programs, federal crop insurance, federal disaster relief, and land use policies such as conservation easements, restrictive zoning, and public land ownership.

Goal 4.

Executive Summary

MAES Research Centers are focused on Biological Control of Weeds, and Soil Quality. We are involved in two multi-institutional and multi-state projects. One is “An Evaluation of the Effectiveness of Livestock Distribution Practices of Grazed Watersheds,” and the other is “High-Value and Alternative Crop Production for Eastern Montana.” Also, successful patterns of sagebrush communities are being researched and considered in relation to fire recovery under a wide variety of conditions.

A survey of hunter management strategies used by ranchers in Montana has been completed. Findings led to the development of landowner/hunter education programs aimed at landowner concerns. A project currently underway includes a study attempting to identify prescriptions to use livestock grazing to improve habitat for elk. Elk and cattle habitat use patterns are being monitored.

IPM seeks to optimize grower profitability and natural resource sustainability through development, selection and implementation of appropriate pest management tactics that are economically sound and environmentally acceptable. In Montana, noxious weeds are of major economic importance. Studies are ongoing to deal with these pests.

Cropland weeds are the major pests impacting Montana cropland agriculture. Developing integrated weed management systems requires the study of weed biology, herbicide efficacy, and crop performance. Field and greenhouse studies were utilized to quantify these relationships and develop management strategies for the numerous weeds impacting small grain production.

Relationships among streamside and wetland vegetation, hydrology, water quality, and ag land management were emphasized in greenhouse and field studies. In cold winters, low-cost artificial wetlands potentially can treat wastewater from agricultural facilities and small towns in Montana. Correct selection of plant species greatly impacted nutrient removal and sediment retention. Results imply that species should be matched to site conditions to improve odds of successful ecological restoration.

The movement of chemicals through soils under different water conditions can negatively impact water quality. Water shortages, increased multiple use pressure for water resources, and surface water runoff all speak to efficient uses of irrigation water. Field and laboratory experiments were conducted to evaluate the calibration of approaches with TDR to provide real-time estimates of solute (i.e. fertilizer salts) distributions in soils. This increases our ability to more intensively manage agricultural inputs in fields, increase resource utilization efficiency, and improve environmental quality.

Planned Programs by Key Themes
Key Theme. Integrated Pest Management
Activity
• Wheat Stem Sawfly Management.
• Cereal Leaf Beetle Management.
• Grazing to Manage Insect Pests.
• Regional cutworm-monitoring program.

Impacts/Accomplishments
• The wheat stem sawfly, a perennial small grain pest in Montana, cannot be managed by conventional agricultural practices (e.g., burning, tillage, swathing, insecticides). Thus, there is an urgent need to develop new tools for its management. Recent advances in the understanding of sawfly ecology are providing tools for development of innovative management strategies for this pest. These include the investigation of two sources of compounds discovered in wheat fields in Montana that are toxic to this insect. One source is microbial and the other is from commonly-occurring grass species. The compounds responsible for the plant toxicity are being characterized

using analytical equipment and biological assays. Research efforts have also identified chemical odors that are used for sawfly mating and for location of host plants. Behavior-modifying chemicals, pathogens, and plant-derived toxins are highly desirable management tools because minute amounts are needed to be effective and they pose limited environmental challenge. New analytical equipment designs and recent chemical techniques have simplified ongoing research, and will lead to an integrated biorational sawfly management program.

Overlapping research approaches are being used for these novel naturally-occurring chemicals. The first focuses on pheromones that are produced by sawflies when they are searching for suitable mates. Second, plant odors from cereal crops and feral grasses that act to attract or repel sawflies and aphids are being identified. Third, we are investigating methods for enhancement of parasitoid efficacy. These natural enemies of the sawfly and cereal aphids are endemic to Montana. The parasitoids are attracted to odors produced by infested plants. Plants vary in the amount of odors that are produced; therefore this is a new tool that can be used by wheat breeders to promote biological control.

• Economic thresholds for cereal leaf beetle in barley and spring wheat were examined in 2001. Based on research conducted in irrigated barley, an ET of two cereal leaf beetle larvae per tiller was determined to cause a significant reduction in grain yield. This is lower than the previously used ET of 3 eggs and or larvae per tiller developed in Michigan. As this pest continues to spread into the Pacific Northwest, this research has the potential application to a much larger region. This research is being conducted in collaboration with University of Wyoming. In 2000-01, cereal leaf beetle monitoring studies indicated that populations were not economical and therefore insecticide applications were not needed. This saved at least 10,000 acres of malting barley from being treated with insecticide ($12 per acre) at a total savings of $120,000. At the current distribution of cereal leaf beetle in Montana, the potential acreage affected by this pest is 950,000 acres of spring wheat and barley. Improved economic thresholds and monitoring guidelines have the potential of saving Montana producers hundreds of thousands of dollars.

• Grazing research has focused on quantifying the abundance and community composition of grasshoppers and how they are affected by differential cattle grazing. Intensive grazing was shown to influence the species of grasshoppers that occupied rangeland. Important rangeland pest species were less abundant in heavily grazed plots than ungrazed plots.

• A regional cutworm-monitoring program has been in place for 10 years. Activity of adult pale western and army cutworms are monitored using pheromone traps to indicate relative activity of each species in an area and provide a prediction of cutworm larvae and damage the following spring. Correlations between trap catches and larval densities and critical weather data are being developed for a regional forecasting model. Because extensive larval cutworm damage can occur rapidly in the spring, cutworm

moth catches, reaching or exceeding economic thresholds in Fall 2000, were used to alert producers in those areas about potential cutworm problems the following spring.

Source of Funding
State, Hatch, USDA-NRICGP, USDA-Institutional, USDA-SARE, Western Regional IPM, Private Industry

Scope of Impact
National

Key Theme. Biological Control
Activity
• Insect Quarantine Laboratory.
• Biological control of Leafy Spurge and Spotted Knapweed.
• Biological control of rangeland weeds.
• Ecology of phyllosphere and rhizosphere and their role in biological control of disease.
• Managing plant microbe interactions in soil to promote sustainable agriculture.

Impacts/Accomplishments
• In Montana noxious weeds are of major economic importance. To control these pest species, a variety of control techniques must be utilized, including biological control with arthropods. The primary objective of the MSU Insect Quarantine Laboratory is to facilitate the importation, augmentation, study, and release of exotic arthropods or the biological control of noxious weeds of regional importance. During 2000 - 2001, thirteen species of arthropods were imported to the quarantine lab for the biological control of rush skeletonweed, leafy spurge, Russian knapweed, gorse, Dalmatian toadflax, field bindweed and spotted knapweed. Although the majority of the agents were for host specificity testing, approximately 3500 individuals were consigned to field sites in Montana and Oregon or for DNA analyses. Forty augmentative release of 15,000 flea beetles were made in 2001 throughout the state.

• Infestations of rangeland weeds, leafy spurge, spotted knapweed and Dalmatian toadflax continues to rank among the most serious pests affecting rangeland and agricultural production. The occurrence of these weeds on rangeland limits the amount of money that can be justified for conventional weed management. Many of these infestations occur in areas in which it is impossible or undesirable to apply herbicides. Thus, effective and environmentally safe methods of weed management, such as biological control, are being developed for long-term management of weeds on lands of low economic return. Habitat association models were developed for five flea beetle species that are established on leafy spurge. These models relate flea beetle abundance with particular chemical and/or physical properties of the soil, chemical properties of the spurge roots/foliage, and levels of plant productivity. A dynamic state variable model was developed for two seed head flies that attack spotted knapweed. Starch-gel electrophoresis was completed in 2000 on populations of seed capsule-feeding weevils. Results suggest that weevils found on Dalmatian toadflax are

genetically distinct from those found on yellow toadflax, indicating the possibility of host races in the weevil species.

• Two seed head flies (*Urophora* spp.), introduced in the 1970's, are widespread throughout Montana and are reducing knapweed seed production by a minimum of 50 percent. This program has reared and redistributed an estimated 313,000 *Agapeta zoegana* (root moth) and 93,000 *Cyphocleonus achates* (root weevil) during the past 9 years. Interaction with more than 120 cooperators has resulted in the release of these two insects at over 3100 sites in the state. These efforts are beginning to have measurable negative impacts on knapweed growth and survival. Knapweed infestation is conservatively estimated to cause $14 million in direct negative impacts and $28 million in indirect effects to the state of Montana.

• Organisms useful for the control of certain soil pathogens on sugar beet and potato have been identified and adapted to biological control practices as part of two projects. These organisms are now being developed into commercial products, usually associated with seed treatments for sugar beet and other crops.

Source of Funding
State, Hatch, USDA-ARS, USDA-APHIS, BLM, BIA, USDA-BOR, Private Industry

Scope of Impact
National

Key Theme. Biodiversity
Activity
• Montana Entomology Collection
• Grass Flora of Montana and Herbarium Collection

Impacts/Accomplishments
• Biodiversity documentation in Montana provides knowledge of the existence and distribution of species for management of public lands and the ability to use them without legal challenge. The Montana entomology Collection is the largest repository for information on the existence and distribution of species in Montana. It continues to grow apace; and it is used by public land managers to achieve and document compliance with appropriate laws.

• ‘The grass flora of Montana and integrating phylogenetic methods into studies of crop plants’ is a project by which certain grasses are examined for possible use as forages. Montana has many grasses related to crop species and several have proven useful either as forages themselves or as useful sources of genes for crop species.

Source of Funding
State, Hatch, NSF

Scope of Impact
National

Key Theme. Natural Resource Management
Activity.
• Shrub ecology and forage relationships.
• Influence of social hierarchy on distribution or rangeland cattle.
• Hunter-rancher relationships.
• Wildlife-livestock interactions.
• Artificial wetlands.

Impacts/Accomplishments
• Natural resource agencies are adapting policies based on this research.

• Habitat use patterns of rangeland cattle are influenced by a herd's social dominance hierarchy. Therefore, if total herd size remains unchanged, selective culling of individual cows based on their habitat use patterns is unlikely to reduce cattle use of any sites in a pasture.

• This study refutes many claims about the amount of private land being closed to hunters in Montana. Only 12 percent of the ranches in the state are closed to hunters.

• Management issues relating to wildlife and ranching are numerous and complex. Decision-makers need information on management systems that will simultaneously maintain or improve environmental quality, sustain the economic viability of ranches, and provide recreational opportunities for the public. This project will provide much needed information towards this end.

• Identified key plant species for optimum performance of nutrient uptake and sediment retention.

Source of Funding
State, Hatch, Smith-Lever, USDA-NRICGP, USDA-USFS, USDA-NPS, USDA-IFAFS, Private Industry

Scope of Impact
Regional

Key Theme. Soil Quality
Activity
• Stubble management to conserve moisture and protect crops and soils.

Impacts/Accomplishments
• No-till research at Western Triangle Ag Research Center showed increased moisture conservation; improved stand establishment in dry years; increased winter survival; decreased air and water pollution; decreased soil erosion; decreased production costs;

and increased crop yield. Grower adoption of no-till chem-fallow continues to be enhanced by this research activity. Stand establishment for canola has been far more successful with no-till than tillage systems because no-till maintains moisture closer to the soil surface.

Source of Funding
State, Hatch, Private Industry

Scope of Impact
Regional

Key Theme. Water Quality
Activity
• Soil water measurements.

Impacts/Accomplishments
• New methodology to measure in situ water contents across the entire soil wetness range, ability to maintain hydraulic continuity across a wide range of porous media, and efficiency based on using the same instrumentation for all measurements.

Source of Funding
State, Hatch, USDA-NRICGP, USDA-BOR, Private Industry

Scope of Impact
• National

Key Theme. Land Use
Activity
• Economic sustainability of public and private land uses and public policies.

Impacts/Accomplishments
• This overall project assessed the economic sustainability of certain current public and private land uses and public policies that help shape those uses. Researchers also assessed the ecological sustainability of potential land use changes resulting from likely changes in economic conditions as well as changes in agricultural policy and environmental policy. The policies in question include endangered species programs, federal crop insurance, federal disaster relief, and land use policies such as conservation easements, restrictive zoning, and public land ownership. The findings is this research included the following:

> Private landowners respond to costly U. S. Fish and Wildlife Service regulations under the federal Endangered Species Act by engaging in destructive land use practices that reduce the populations of endangered species and thus reduce the cost to them of regulatory compliance that come with the presence of listed species.

Federal crop insurance programs have increased the average amount of soil erosion, but by less than one third of the amount by which the Conservation Reserve Program has reduced soil erosion.

Sequestering carbon on agricultural lands in Montana may provide a means for increasing net farm or ranch returns and may thus provide a win-win situation for environmental protection and sustainability.

Source of Funding
State, Hatch, EPA, USDA-NRICGP, USDA-Crop Insurance Legislation, USEPA, US Department Energy, NSF

Scope of Impact
National

TOTAL GOAL 4 Funding- $3,392,254 FTE- 57.6
(SEE Appendix A)

Goal 5. Enhanced Economic Opportunity and Quality of Life for Americans

Program 10. Biobased Products and Food Science

Overview
The Montana State Legislature beginning in FY2002 approved startup funds for The MAES Institute for Biobased Products and Food Science. The Institute will provide the educational and research conduit for collaborative programs to address issues such as biobased product/value-added alternative crops, value-added meats, food safety, risk assessment, and product development. The Institute will focus on programs that meet goals 2 and 3. The Institute will synergize multi-disciplinary and multi-agency collaborative programs with MSU-Bozeman (Colleges of Agriculture, Engineering, Business, and Education, Health and Human Development, and Cooperative Extension), MSU-Billings (i.e., fuel cells), MSU-Northern (i.e., cooperatives program), MSU-Great Falls (i.e., technology), University of Montana (i.e., carbohydrates), Montana Manufacturing Extension Center, USDA-ARS units at Miles City and Sidney, State Departments of Agriculture and Commerce, and others. The Institute will provide user-friendly expertise to producers and agriculture-based industry, as well as frequent training seminars and short courses.

Selected Impacts/Accomplishments Goal 10
• Institute for Biobased Products and Food Science initiated and bas funding obtained.

Goal 5.

Executive Summary
The Montana State Legislature recently approved startup funding for the MAES Institute for Biobased Products and Food Science for the biennium 2002-2003 budget cycle. The Institute will provide the educational and research conduit for collaborative

programs to address issues such as biobased product/value-added alternative crops (i.e., plants that produce fuels, oils, lubricants, pharmaceuticals, neutraceuticals, fibers, etc.), value-added meats (i.e., beef, lamb, etc.), food safety, risk assessment, and product development. The Institute will synergize multi-disciplinary and multi-agency collaborative programs with MSU-Bozeman (Colleges of Agriculture, Engineering, Business, and EHHD, and Cooperative Extension), MSU-Billings (i.e., fuel cells), MSU-Northern (i.e., cooperatives program), MSU-Great Falls (i.e., technology), University of Montana (i.e., carbohydrates), Montana Manufacturing Extension Center, USDA-ARS units at Miles City and Sidney, State Departments of Agriculture and Commerce, and others. The Institute will provide user-friendly expertise to producers and ag-based industry, as well as frequent training seminars and short courses. MAES has expertise in the areas of biobased product/value-added alternative crops, cropping and animal systems, value-added meats, product development (i.e., cereals and meats), biotechnology, marketing, agri-business, trade, development, and human, plant, and animal nutrition, etc. Therefore, we have need for expertise in the areas of food science, food safety, risk assessment, and value-added livestock that includes genetics and diseases.

Planned Programs by Key Themes

Key Theme. Biobased Products and Food Science

Activity

• Institute for Biobased Products and Food Science

Impacts/Accomplishments

• Institute for Biobased Products and Food Science initiated and bas funding obtained.

Source of Funding

State, Private Industry

Scope of Impact

Regional

TOTAL GOAL FIVE **Funding $340,000** **FTE 3.69**
(See Appendix A)

Stakeholder Input

The Montana Agricultural Experiment Station (MAES) and College of Agriculture (COA) annually uses multiple approaches to obtain stakeholder input on programs conducted and actively solicits input on changes in program direction. Approaches include involvement with organizations and associations (SEE Appendix C), meetings, conferences, and events. MAES faculty serve as liaison representatives to many traditional and non-traditional organizations within the state. Most MAES departments and all off-campus research stations hold biannual meetings with their Advisory Boards to discuss policy issues, programs, and program direction. Stakeholder input is used to focus research programs, improve program quality, and realign research efforts.

MAES/COA Advisory Committee. MAES and COA continues to utilize the Dean's Advisory Committee for statewide program input. Membership on this Committee is balanced to represent the diverse geographical regions of the state, and the diverse agricultural interests of the state. Members are selected from among the membership of the advisory committees for each of the Research Centers in Montana of which there are eight in the various geographical regions of the state. Meetings are held three to four times per year, with additional meetings called at the request of the Dean and Director. Additional *ad hoc* members are added for any meeting, especially for an agenda that focuses on a special topic or program need.

Montana Agricultural Experiment Station. MAES supports research at seven off-campus research centers. Programs at the experiment stations are administratively responsible to the MAES Director and have joint programs with one or more departments. Experiment stations meet biannually with their Advisory Boards to discuss policy issues, programs, and program direction. Experiment Station Superintendents also meet three to four times a year with the MAES Director in a similar activity.

Council for Agricultural Research, Extension, Teaching (CARET). CARET members in Montana provide an avenue for MAES dialogue on a county and state level where program issues and needs are discussed.

Extension. The Cooperative Extension Service manages the budgets for extension programs, however, colleges are responsible for extension programs outlined by their faculty. The Dean of Extension now meets on a regular basis with department heads and the Dean and Director of MAES to discuss programs and future joint priorities.

USDA - ARS. Joint research programs are conducted with USDA - ARS in Miles City (Fort Keogh Livestock and Range Research Laboratory) and Sidney (Northern Plains Agricultural Research Laboratory).

Listening Sessions. Each year the Dean and selected administrative staff and faculty will, in collaboration with Montana's Extension Service, hold one or more open-to-the-public, out-in-the-state listening sessions. The purpose of these sessions is to gather stakeholder input and comments on past achievements, current activities, and proposed plans for our research programs. All listening sessions will be publicly announced through local and regional newspapers, appropriate newsletters, and through our county Extension offices. To better ensure attendance by traditionally under served populations our special contacts with trade groups, commodity associations, agricultural suppliers, and state agencies are used to request their assistance in extending invitations to a very broad community of stakeholders. In addition, "listening sessions" will also be held on campus to get input from faculty.

Under Served. Native Americans constitute the majority of those considered under served in Montana. The Native American population in Montana is more than 50,000.

There are 11 tribal groups and 7 reservations (5.5 million acres). Programs have been initiated, such as "Agriculture in a Global Context" with Dull Knife Memorial and Fort Peck Community Tribal Colleges. MAES and the COA are in the process of increasing partnerships and programming efforts with the Tribal Colleges in Montana.

Program Review

Hatch Projects are subject to a peer review process prior to submitting projects to USDA - CSREES. The MAES Office is responsible for oversight and conducts the peer review. MAES administration selects the reviewers after consultation with department heads. The peer review committee includes the principle investigator (PI), department head, MAES administrator, and three additional faculty external to the PI's department. Written comments are requested on the following items: relevance and importance; relation to previous research; objectives; approach and methods; scientific and technical quality; resources; and environmental, economic, and/or social impacts. Seminars are scheduled by the department with reviewers present. A meeting follows with the seminar reviewers, PI, Department Head, and MAES administrator. Written comments are summarized and shared with the PI. Projects are revised in response to the review process.

Multi-state Research

The Multi-state Research Program meets the multi-institution, -state, and -discipline requirement. Montana State University is a participating partner in numerous multi-state projects. (See Appendix B)

Impacts/Accomplishments

• Ongoing research from this project has shown the potential to manipulate cattle grazing to improve uniformity of grazing. The proposed research will continue the development and evaluation of novel management tools designed to prevent heavy grazing in sensitive rangeland areas and increase use of areas that typically under grazed. Improving the uniformity of grazing increases the sustainability of rangeland livestock operations, prevents degradation of fisheries and wildlife habitat and helps ensure the water quality is maintained and improved.

• Approximately 42,500 acres of sugarbeets were grown in the Mondak region area in 2000. A conservative value of $900 per acre generated more than $38 million in sugar beet payments to this region’s economy. Additionally, the local Holly Sugar Corporation processing plant has 400 employees with an annual payroll of $4 million. The sugar beet processing plant also spends annually $5.3 million in commodity purchases, $4 million in freight expenditures, and $3.6 million in fuel expenditures. Sugarbeets are the high value cash row crop grown in eastern Montana at this time and the sugar beet industry provides many jobs both in beet production and the processing, refinement, and marketing of the sugar. The Lower Yellowstone River Valley consistently produces the highest quality sugarbeets in the United States.

• Investments in sugarbeet research has supported the expansion of the Holly Sugar Corporation and the expansion of the sugarbeet acreage from 35,000 to 48,000 acres with a phase II expansion to 80,000 acres scheduled over the next five years.

• 'High-value and alternative crop production research for eastern Montana' has initiated a potato research and demonstration project in 1997 – 1998 with other co-sponsors to establish the economics and profitability of potato production to attract the french fry potato industry and other food processors into the MonDak region. The ability to produce sugarbeets, potatoes and other high-value / value-added crops will make irrigation development feasible and create new wealth and jobs through agriculture growth. An estimated one job will be created per 100 new irrigated acres with 5 – 10 fold added revenues per acre. Sprinkler irrigation has been installed on 25,000 acres in the MonDak region over the past 5 years.

• A number of MAES researchers collaborated together to develop a functional genomics program to study bovine immune cells. This effort was capped off by the acquisition of a large functional genomics grant from the USDA IFAFS program. This is the only functional genomics program in the northwest region that is focused on cattle. This program involves participation of investigators from the University of Minnesota and Washington State University. Two workshops have been held for this new consortium, which has provided a forum for the development of additional collaborations.

• MAES researchers formed a consortium with Texas A&M researchers to study brucellosis in bison. Ongoing vaccine trials are now underway utilizing capabilities at both locations.

• A number of MAES researchers set up collaborations with researchers at the University of Montana and the NIH Rocky Mountain Lab to form a center for studying emerging infectious diseases related to wildlife and livestock diseases.

• Predictions of winter wheat yield loss from weeds (*Aegilops cylindrica*) based on a minimum data set concept were evaluated from experiments conducted in CO, ID, KS, MT, NE, WA, and WY. Thirty data sets were utilized to evaluate different bioeconomic models to predict yield decreases from weed pressure. One model provided the best statistical fit to the data, but another model provided the best management tool by fulfilling the bio-economic model damage function objective of optimizing *A. cylindrica* management in winter wheat.

• The quality of water for numerous intended uses (i.e. drinking, livestock, fisheries) can be impacted by land management practices. In the western United States many lands are impacted by mine tailings, disturbed soils, and geothermal features. The chemical behavior of arsenic is influenced by different valence states (III, V). Numerous species of bacteria thrive in arsenic enriched environments that, if isolated, may be beneficial in bioremediation work. The fate and transport of arsenic is influenced by its chemical state.

• New technologies have emerged that allow for the precise acquisition of data to be manipulated and then acted upon in a precise manner. Precision agriculture components have been taught to farmers and school teachers in workshops in Montana, Idaho, and Wyoming. This NASA sponsored effort builds upon the leadership in this department and collaboration of scientists in MT, WY, ID, ND, and SD.

• Management issues relating to wildlife and ranching are numerous and complex. Decision-makers need information on management systems that will simultaneously maintain or improve environmental quality, sustain the economic viability of ranches, and provide recreational opportunities for the public.

This research is being conducted through the cooperation of the Wapiti Ridge Coordinated Resource Management Program (WP-CRMP) in Cody, WY and two ranches near White Sulphur Springs, MT. Elk and cattle habitat use patterns are being monitored twice monthly via systematic aerial surveys from fixed-wing aircraft. At each ranch, exclosures have been erected at sites representative of the following vegetation types: sagebrush steppe, riparian areas adjoining sagebrush steppe, coniferous forests, montane parklands, and 2 types of seeded tame pastures. Fecal samples from both cattle and elk are being collected each month.

A companion project also is being conducted in cooperation with the Wapiti Ridge Coordinated Resource Management Group (WR-CRM). All data collection occurs on these four ranches. Land managed by each ranch represents a combination of private, state, and federal (Bureau of Land Management and U.S. Forest Service) ownership.

Integrated Research and Extension Activities

Most Montana State agricultural faculty have a dual appointment involving two of the three functional areas (i.e., extension, research, or teaching). Faculty in MAES holding joint extension/research appointments have an integrated extension and research program with time allocated to each area. Nine percent of the FTE is devoted to integrated research and extension activity. However, most of our MAES and COA faculty have extensive extension/outreach initiatives, but are not credited for these activities. MAES and the Montana Cooperative Extension Service are assessing future joint appointment needs. (SEE Appendix B)

Impacts/Accomplishments

• Since 1994 management of sugarbeet diseases has been a major focus of research and extension education programs. These programs have lead to grower implementation of effective, environmentally friendly, economical controls for 4 different chronic diseases and one new disease. Management of the chronic diseases, Fusarium Yellows, Cercospora leaf spot, Rhizoctonia Crown and root rot and Aphanomyces root rot has increased grower profits on more than 88,000 acres in MT.

Fusarium Yellows. This disease is common on more than 40,000 acres and in 1994 only one resistant variety was available to growers and this variety had yield potential

15-20% less than high yielding varieties in the absence of disease. MAES research developed highly efficient methods to identify resistant germplasm and work with seed and sugar companies has resulted in the identification of many high yielding Fusarium Yellows resistant varieties and the near elimination of susceptible genotypes. Extension education programs have resulted in growers using these varieties on more than 39,000 acres for control of this disease and yields have increased by approximately 12%. Thus the impact of this work in the past 2 years has been more than $9.6 million income in MT. Management of this disease is one of the key factors for record yields in the Billings factory district (Western Sugar).

Cercospora Leaf Spot. This disease would reduce growers profits by $70-165.00 per acre on more than 60,000 acres in MT if no fungicides were applied for control. MAES research at the Eastern Agricultural Experiment Station demonstrated to both growers and the sugar companies that control of this disease was required to maximize economic return and that a weather-based disease prediction program could potentially reduce fungicide use as compared to calender spray programs. In 1994, less than 20% of the acres were sprayed for control and by 1997 this increased to over 99% in the Sidney factory district (Holly Sugar) and to 20-25% in the Billings Factory district (Western Sugar). In 1997 the weather-based Minnesota Prediction model for Cercospora Leaf spot infection and loss was implemented in 4 sites and validated for MT conditions. In 1998, through the use of extension education programs the weather-based prediction model was used on 17% of acres and in 1999 67% of acres were using this model to predict the need to spray. By 2000, extension education programs resulted in scouting for Cercospora and weather based forecasting being used on 100% of the acres in MT. Extension pathologists trained growers and both Coop and sugar company personnel on scouting and weather-based disease prediction and they implemented the scouting and weather monitoring program. This resulted in saving an average of 1 spray on 50,000 acres and 2 sprays on 30,000 acres with no loss in disease control in 1999 and 2 sprays on 77,000 acres in 2000. This resulted in saving more than $1.8 millionin 1999 and $2.3 million in 2000 as compared to a calendar based spray program. In Cercospora research, we demonstrated that use of a moderate level of resistance would allow growers to save 1 spray compared to that needed on susceptible varieties without reducing yields. This data will be used by the Holly Sugar-Sidney factory district to require new approved varieties have a Moderate level of Cercospora resistance (KWS score less than 5.5). The impact of this work is that approximately 50,000 acres would receive one less spray @$15.00 per acre = $750,000.

Rhizoctonia Crown and Root Rot. The new fungicide management program developed by MAES research and taught in extension education programs was used on 1500 acres in 1999 and more than 4500 acres in 2000 for control of this disease. Based on our research plot response this increased profitability by $109 (Based on current Western Sugar Grower Contract price) per acre or $490,500 for MT. Research used to develop the Quadris fungicide label was started here at MSU and based on our data the full label was granted in 2001.

Aphanomyces Black Root Rot. This disease is both difficult to identify and to control. MAES research identified this as a significant problem for MT growers in 1994 and this project began a research effort to develop control strategies. Control is difficult because resistance is incomplete and there are no varieties adapted to MT. The fungicide seed treatment Tachigaren is moderately effective in reducing seedling losses but must be used with pelleted seed due phytotoxicity. In 1995 several promising rhizosphere inhabiting Bacilli were identified that provided control equal to Tachigaren. These were tested in production fields in 1996. 1997. 1998, 1999, and 2000. The result of this research is the identification of MSU 341-16-5 a Bacillus pumilis strain that provides better control of Aphanomyces than Tachigaren, better control of Pythium and Rhizoctonia than the standard seed treatment Apron-Thiram and does not have to be used with pelleted seed. In 10 location years of data using commercially treated seed, this isolate provided higher final stands and an average of 670 lbs/A more extractable sugar per acre than the standard seed treatment Apron-Thiram or Apron-Thiram – Tachigaren. This isolate will be developed commercially.

Research on potato diseases has identified a new method to identify scab resistant lines using a laboratory assay that correlates well with field observations. The mechanism of resistance has been identified as well as resistant lines of cultivars that are highly susceptible. The lines are currently undergoing further selection for type and agronomic qualities. MAES research pioneered the use of azoxystrobin (Quadris) for control of Rhizoctonia black scurf control.

• Lamb survivability. An audit was conducted to identify the most critical factor on Montana sheep ranches limiting improved production. Lamb survivability was identified as the single most limiting issue. Based on this information a research project was initiated to identify ways that producers could improve lamb survivability without making large scale changes in their production/management system. Controlled trials at MSU showed that short term Vitamin E supplementation substantially increased lamb survivability in certain situations. Field demonstration trials were conducted on a number of ranches throughout Montana with positive results. Preliminary results suggest that short-term supplementation of ewes just prior to parturition may increase newborn lambs cold tolerance. As a result, many producers are now utilizing vitamin E supplementation. Currently, the effects of the inclusion of dietary oils in the diets of ewes on lamb survivability are being investigated.

• Influence of social hierarchy on distribution of rangelend cattle. The current phase of this project is testing the efficacy of reducing riparian impacts by selectively culling those cows from a herd that spend a disproportionately large amount of their time in riparian habitat. Project results revealed that cattle distribution was influenced by a cow's social rank within the herd's dominance hierarchy. Experimental results and experiences learned in this project were also shared in several extension educational programs in the past fiscal year. These offerings included a workshop for county agents from across Montana; a regional meeting of ranchers and range livestock industry consultants; and Montana Youth Range Camp.

• Management practices. A system to provide information feedback between various segments of the beef industry was implemented. This program is a cooperative effort between the Montana Stockgrowers Association and Montana State University. A systems approach was implemented which allows for tracking of calves from the ranch in Montana to the feedlots in other states and provinces and eventually to the packing plant. Information collected throughout the production chain is shared among all the owners of the cattle. Results of feedlot performance and information feedback to the cow-calf producer are being continually provided to the rancher as soon as animals are harvested. Funding was used to develop and publish training manuals and present over 60 Beef Quality Assurance educational programs in MT so producers could certify that calves were vaccinated using a standard health management protocol. County agents were trained to provide this educational program to producers at the local level.

The Montana Beef Network has three primary objectives; 1) educational programs aimed at meeting beef quality assurance standards, production and marketing goals and providing additional educational programs through interactive-video conferencing, 2) certification of feeder calves that have met defined management protocols and 3) information feedback from the feedlot and packing plant to the cow-calf producer showing if the feeder calves met industry requirements for quality, consistency, safety and red meat yield.

Funding was used to develop and publish training manuals and present over 60 Beef Quality Assurance educational programs in MT so producers could certify that calves were vaccinated using a standard health management protocol. County agents were trained to provide this educational program to producers at the local level. Approximately 23,000 calves were certified during the first year and 24,000 the second year. Additional projects started were 1) initiation of a state-wide audit of ranchers to determine value-added practices related to breeding, health management, nutrition and marketing and 2) a twenty ranch research project to determine if a standardized weaning protocol which includes both vaccinations and nutrition could reduce morbidity of calves once they entered the feedlot. Approximately 5,000 claves were committed to this project, 3) one-or two-day short courses were held each year in which issues pertinent to the beef industry were presented, 4) a breeding project for red meat yield vs. quality grade 5) six interactive- television short courses aimed at carcass evaluation, genetic management, opportunities for back grounding calves and marketing were presented during 2000.

• Biocontrol of pest management systems of plants. Noxious weeds continue to be one of the biggest concerns to land managers and the general public throughout the state. As a result, there is tremendous interest in my research (biological control of weeds). I participate in many extension-sponsored programs throughout the year to keep the public apprised of the research progress and I work closely with numerous county extension agents to coordinate the dissemination of biocontrol agents throughout the state.

Specifically, the research involves the use of natural enemies to biologically manage several noxious weeds, including spotted and diffuse knapweed, houndstongue, and sulfur cinquefoil. A total of 13 natural enemy species have been successfully introduced against the knapweeds. Significant reduction of the knapweeds is now occurring in some locations where large populations of some biocontrol agents exist.

• Integrated Pest Management.

• *Pale western and army cutworm.* Sporadic pests of Montana's 5 million acre wheat crop, cutworms are difficult to control because intensive monitoring for this pest is time consuming and costly. Typical spray applications for this pest are estimated to cost $10/acre. Significant damage can be sustained before management practices can be implemented. A monitoring program was initiated in 1992 for adult moths to forecast potential larval populations in the subsequent spring. However, its usefulness was limited by the inability to incorporate influential environmental effects into the forecast. Recently, competitive grant funds have been obtained through the Western Regional Integrated Pest Management Program to improve our ability to predict occurrence of damaging numbers of these pests and expanded the program into Wyoming, Nebraska and South Dakota. Both temperature and moisture have been incorporated into the forecast and have improved the ability to interpret monitoring program results. Results of this program have been delivered through numerous Extension programs in Montana and are available on the web at http://cutworm.org.

• *Cereal Leaf Beetle.* Decision-making for cereal leaf beetle management is based on an economic injury level that was developed in Michigan. Research being conducted by K. Miller is evaluating the economic injury level for Montana conditions and crops. There has been an increasing trend to treat fields with pesticides for this pest. In 1995 about 1,000 acres were treated, 5,000 acres in 1996 and 15,000 acres in 1997. However, a cereal leaf beetle monitoring program and treatment guidelines have resulted in a reduction of sprayed acreage in 1998 to 5,000 acres. With chemical application costs of $12.00/acre this resulted in a savings to Montana producers of $120,000. Development of an economic injury level that is more appropriate for Montana producers and continued emphasis on monitoring and using decision making guidelines is likely to yield substantial economic benefits each year.

• *Alfalfa Weevil.* An improvement in early cutting as a management strategy for alfalfa weevil has been developed at MSU and is responsible for reducing pesticide applications and improving the economics of alfalfa weevil control. Early cutting is a cultural control method for alfalfa weevil that is very effective in Montana. However, early cutting does not necessarily eliminate the need for a pesticide application following harvest to control the alfalfa weevil. By raking hay during harvest, alfalfa weevil populations can be reduced an additional 50% over early harvest alone. This reduction can make a post-harvest pesticide unnecessary resulting in a savings of $12 to $15 /acre. With 1.7 million acres of harvestable alfalfa hay in the state, if this technique saves a pesticide application on 10% of the total acres, a savings of $2 million can be realized. Non-irrigated alfalfa production represents 54% of the 1.7 million acres of

alfalfa harvested in Montana. Research conducted in 2000 found that insecticide treatment of dryland alfalfa resulted in a 35% yield increase due to pressure by spotted alfalfa aphid and the alfalfa weevil larvae. These results have been presented through Extension programs throughout Montana. Timing of insecticide treatments is also being investigated.

• Integrated management of annual grass weeds in small grain. This past summer a precision agriculture field day was held in Malta, MT to highlight activities, outcomes, and experiences of precision farming research. In addition, the weed research field day was held at the Post Research Farm in Bozeman to highlight all weed research activities across Montana. Information and data generated through this research program form the basic material for nearly all extension programming. All preliminary reports, abstracts, presentations, and manuscripts are posted on the MSU Weed Science Web Site.

APPENDICES

APPENDIX A
DETAIL OF EXPENDITURES, FUNDING SOURCES AND FTE FOR EACH PROJECT UNDER EACH GOAL

GOAL ONE – EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
ANIMAL & RANGE SCIENCES	172	Success of Spotted Knapweed: Competition or Site Alteration	54,752	USDA Grants	SYE	0.3
					PYE	1.0
					CYE	0.2
						1.5
	173	Nutritional Strategies to Improve Neonatal Lamb Survivability	41,735	Hatch	SYE	0.4
			37,290	Other Fed	Tech	0.2
			16,584	Sales	CYE	1.2
			125,849			1.8
	175	Systems Analysis of Livestock Enterprises	53,919	Hatch	SYE	0.4
			81,741	State	PYE	1.6
			16,584	Sales	CYE	0.1
			152,244			2.1
	176	Winter Grazing in MT	31,295	Hatch	SYE	0.3
			44,216	State	PYE	0.3
			16,584	Sales	CYE	0.1
			92,095			0.7
	183	Reproductive Performance in Domestic Ruminants	37,361	Multi State Res	SYE	0.3
			7,998	State	PYE	1.0
			16,584	Sales	CYE	0.4
			61,943			1.7
	194	Nutritional Management of Range Beef Cows and Calves	6,184	Hatch	SYE	0.4
			116,507	State		0.4
			16,584	Sales		
			139,275			
	196	Livestock Behavior and Performance	11,779	Other Fed	Tech	0.4
			47,397	State	CYE	0.2
			16,584	Sales		0.6
			75,760			
	200	Influence of Trace Mineral Supplements in Range Beef Cattle Production	60,460	State	SYE	0.2
			16,584	Sales	PYE	0.5
			77,044		Tech	0.3
					CYE	0.1
						1.1
	201	Lamb Survivability	14,345	Hatch	SYE	0.1
			11,962	USDA Coop	PYE	0.4
			4,442	State	CYE	0.3
			16,584	Sales		0.8
			47,333			

	204	Coordinated Elk Management for Sustainable Beef Cattle	71,816	USDA Grants	SYE PYE Tech	0.3 1.0 1.1 2.4
	207	Management Practices which Influence Morbidity, Feedlot Performance, and Carcass Characteristics of Montana Beef Calves	17,732 1,959 16,584 36,275	Hatch State Sales	SYE	0.1 0.1
	215	Bulls-Cows Interactions Attenuates the Cow-Calf Bond Regulating Anestrus	32,346	USDA Grants	SYE PYE	0.3 1.0 1.3
	216	Evaluation & Improvement of Barley for Food & Feed	132,201	USDA Grants	PYE	0.2 0.2
ENTOMOLOGY						
	148	IPM of Montana Field and Forage Crops	3,271 164	Hatch Other Fed	SYE PYE	.3 1.8
	153	Sawfly Management	13,409 323 78,103 5,383	Hatch USDA Grants State Other Non Fed	SYE PYE	.7 .7 1.4
	158	Curation Entomology	13,519 57,816 103,821 175,156	USDA Grants NSF State	SYE PYE CYE	.8 .9 ,1 1.8
	159	Exploratory Research	34,123 38,677 91,569 344,999	USDA Grants Other Fed Other Nonfed	SYE CYE	.1 .9
	167	Evaluation of Gall Mites	24,465 9 1,151 69,034	Hatch USDA Grants State	SYE PYE CYE	.3 .4 .7
	164	Containment, Augmentation and Release of Exotic Biocontrol Agents Through Quarantine	14,061 41,954 2,336 58,351	USDA Coop State Other Non Fed	SYE Tech	0.7 0.8 1.5
RESEARCH CENTERS						
CENTRAL AG RES CTR	503	Field Crop Production	3,385 94,783 5,416 11,842 115,426	Other Fed State Sales Other Nonfed	SYE PYE CYE	. 5 2.0 .3 2.8
EASTERN AG RES CTR	557	High Value & Alternative Crop Production Research for Eastern MT	41,621 161,750 14,847 32,367 250,585	USDA Coop State Sales Ind Grants	SYE Tech CYE	.8 .5 2.5 3.8

	558	Breeding/Improvement of Oilseed Crops for Eastern MT	109,096 267 109,363	State Ind. Grants	SYE Tech CYE	.4 1.2 2.7 4.3
NORTHERN AG RES CTR	703	Innovating Site-Specific Management for Farming/ Ranching	47,109 178,894 28,617 254,620	Other Fed State Sales	SYE Tech CYE	1.0 1.0 .3 2.3
	704	Dryland Cropping Practices	162,559 28,617 11,909 203,085	State Sales Other Nonfed	SYE CYE	1.0 1.3 2.3
	708	Beef Cattle Improvement	187,070 28,617 215,687	State Sales	SYE Tech CYE	0.8 1.0 0.4 2.2
	710	Efficiency and Sustainability of Beef Cattle Production From Rangelands	56,682 276,963 28,617 12,449 23,820 398,531	Other Fed State Sales Ind Grants Other Non Fed	SYE Tech CYE	1.0 1.0 3.0 5.0
SOUTHERN AG RES CTR	656	Field Crop Production for South Central MT	3,972 3,454 242,085 6,994 256,505	Other Fed Sales State Other Nonfed	SYE PYE Tech CYE	1.0 1.0 1.0 1.0 4.0
WESTERN TRIANGLE AG RES CTR	853	Field Crop Production	187,310 10,254 197,564	State Other Nonfed	SYE Tech	1.0 1.0 2.0
VETERINARY MOLECULAR BIOLOGY	428	Immunity & Inflammation of Trichomoniasis	17,180 66,628 76,637 114 160,445	Hatch NIH State Ind Grants	SYE PYE Tech CYE	.4 .2 .6 .4 1.6
	418	Molecular Mechanisms of Bovine Rotavirus Nonstructural Protein Function	8,305	USDA Coop	SYE	.1 .1
	405	Investigations of the Functions of Bovine Rotavirus Nonstructural Proteins	54,297 139,660 60,419 254,376	Hatch NIH State	SYE PYE Tech CYE	.8 .5 1.5 .2 3.0

51	Cytoskeletal-Association of Bovine Rotavirus Protein NSP1	4,153	Other Fed	SYE	.1
				Tech	.4
					.5
427	Vaccine Delivery Systems for Bison	336,520	USDA Coop	SYE	.1
					.1
419	Analysis of Gamma/Delta T Cells	69,211	Hatch	SYE	.4
		205,507	HHS	Tech	.5
		128,963	State	CYE	.2
		14,214	Ind Grants		1.1
		417,895			
412	Gamma/Delta T Cells Chemokines	22,363	USDA Grants	SYE	.2
				PYE	.1
				Tech	.5
					.8
415	Mucosal Immunity & Salmonella Vaccine Delivery	64,855	Hatch	SYE	.8
		296,774	NIH	PYE	0
		251,803	HHS	Tech	.9
		52,982	State	CYE	.2
		61,217	Other Non-Fed		1.9
		727,631			
410	Molecular Analysis of the Bovine Leukocyte NADPH Oxidase	231,635	NIH	SYE	.5
		72,087	HHS	PYE	0.7
		89,259	State	Tech	2.0
		37,039	Ind Grants	CYE	.2
		430,020			3.4
408	Leukocyte Adhesion Protein Expression & Cytokine Production In Mastitis	4,355	USDA Grants	SYE	.1
				Tech	.5
					.6
426	Modulation of Bovine Neutrophil Functions by Cell-Cell Interactions & Extra Cellular Matrix Proteins	23,345	USDA Grants	PYE	1.1
56	Genome Approach to Cell Cycle Gene Expression in Toxoplasma	299	Other Fed	SYE	.2
				PYE	.1
					.3
423	Characterization of Coccidian Paranuclear Body Proteins Using	59,601	Hatch	SYE	.7
		42,100	NIH	PYE	.2
		100,543	State	CYE	.2
		39,994	Other Non-Fed		1.9
		467,310			

Toxoplasr

PLANT SCIENCES
& PLANT PATHOLOGY

220	Misc. Plant Diseases	50,826	NSF	SYE	1.1
		3,529	Other Fed	Tech	1.0
		493,645	State	CYE	1.0
		83,365	Other Nonfed		3.1
		631,365			

224	Control of Fungal Disease by	48,314	Hatch	SYE	.5
	Mating Inhibition	12,742	Other Non Fed	PYE	.9
		61,056		CYE	.3
					1.7
228	Identification of Defense-Related	1,856	Hatch	SYE	.6
	Genes in a Model Plant Defense	87,151	State	CYE	.1
	System by SAGE	89,007			0.7
237	Genetic Improvement of Biocontrol	54,301	Hatch	SYE	.8
	Agents for Weed Control	82,846	USDA Grants	PYE	1.0
		17,385	Other Non Fed		1.8
		154,532			
230	Mechanisms of Plant Virus Trans-	64,790	Hatch	SYE	.6
	mission and Assembly	125,111	NSF	PYE	2.0
		30,999	NIH	CYE	.4
		872,104	NASA		3.0
		94,596	Ind Grants		
		1,187,600			
240	Population Genetics of Self-	18,740	Hatch	SYE	.2
	Incompatibility in the Solanacea	78,305	NSF	PYE	1.0
		97,045		CYE	.1
					1.3
241	Genetically Engineered Plant	23,666	Hatch	SYE	.3
	Light Responses to Improve	68,107	NSF	PYE	1.0
	Crop Quality	5,436	Ind Grants	Tech	.7
		13,517	Other Nonfed		2.0
		110,726			
242	Plants of Yellowstone Park	22,816	Hatch	SYE	.3
				CYE	.1
					. 4
313	Alfalfa Breeding, Genetics and	16,085	Hatch	SYE	.7
	Cultural Practices	63,817	State	PYE	.4
		688	Other Nonfed	CYE	.1
		80,590			1.2
315	Spring Wheat Breeding &	44,847	Hatch	SYE	.7
	Genetics	111,183	State	PYE	2.3
		59,185	Ind Grants	CYE	.3
		130,059	Other Nonfed		3.3
		345,274			
342	Barley Breeding & Genetics	65,060	Hatch	SYE	.5
		132,846	NSF	PYE	.6
		1,254	Other Fed	CYE	.6
		25,648	Ind Grants		1.7
		35,827	Other Nonfed		
		260,635			
348	Small Grain Quality and	4,403	Hatch	SYE	.4
	Molecular Biology	6,789	USDA Coop	PYE	.5
		106,386	State	CYE	.1
		83,158	Other Nonfed		1.0
		151,564			

	310	Phosphate assimilation in Rhizobium	15,999	Hatch	SYE	.8
		Bacteriods	80,680	NSF	PYE	4.3
			97,353	State	CYE	.5
			240,763			5.6
	346	Soil and Plant Nutrition for Montana	14,363	Hatch	SYE	.9
		Agriculture	91,393	State	PYE	.5
			10,534	Other Non Fed		2.1
			131,489			
	372	Pedology and Resource Inventory	22,325	Hatch	SYE	.8
		Methods for Evaluating Land Use	64,763	NASA	Tech	.5
		Potentials, Planning Site-Specific	165,747	Other Fed	CYE	1.3
		Management	70,563	State		2.6
			69,701	Other Nonfed		
			325,375			
AGRICULTURAL ECONOMICS						
	075	Impact Analysis & Decision	55,590	MultiState Res	SYE	.2
		Strategies for Agricultural Research			PYE	.1
					CYE	.4
						.7
	087	Ag Marketing, Price Analysis and	54,741	Hatch	SYE	0.1
		Trade Problems in Dynamic Markets	11,538	USDA Grants	PYE	0.1
			70,075	NSF	CYE	0.3
			232,022	State		1.5
			5,076	Other Non Fed		
			373,452			
	098	Ag Finance & Farm/Ranch	38,734	Hatch	SYE	2.3
		Management	65,310	USDA Grants	PYE	0.1
			29,405	NSF	CYE	0.1
			135,434	State		2.5
			208,799	Other Fed		
			524,055			
TOTAL GOAL 1:			**$11,487,377**		SYE:	29.7
					PYE:	34.0
					CYE:	24.4
					TECH:	19.9
					TOTAL:	**108.0**

GOAL TWO– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
PLANT SCIENCES & PLANT PATHOLOGY						
	318	State Seed Testing Lab `	76,907	State	SYE	0.9
			2,538	Other NonFed	Tech	3.3
			79,445		CYE	1.6

						5.8
	396	Plant Genetic Resource Conservation & Utilization	63,231	MultiState Res	SYE	.5
TOTAL GOAL 2:			**$142,676**		SYE:	1.4
					CYE:	1.6
					TOTAL	**6.3**

GOAL THREE– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
PLANT SCIENCES & PLANT PATHOLOGY						
	335	End-Use Properties of Wheat and Barley	164,643	State	SYE	.4
			17,165	Other Nonfed	PYE	1.1
			181,808		Tech	2.0
					CYE	.1
						3.6
	222	Endophytes of Plants: Their Biology, Economic Value &	3,508	Hatch	SYE	.6
			1,099,532	NSF	PYE	.5
			155,763	State		1.1
			70,473	Other Nonfed		
			1,329,276			
TOTAL GOAL 3:			**$1,511,084**		SYE:	1.0
					PYE:	1.6
					CYE:	.1
					TECH:	2.0
					TOTAL:	**4.7**

GOAL FOUR– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
Research Centers WESTERN AG RES CTR	806	Biocontrol of Rangeland Weeds	32,966	Other Fed	SYE	.6
			1,889	State	PYE	.5
			34,855		Tech	.3
					CYE	.2
						1.6
	854	Soils & Cropping Systems	3,600	Other Fed	SYE	1.0
			175,719	State	PYE	1.0
			179,319			2.0
EASTERN AG RES CTR	557	High-Value and Alternative Crop Production Research for Eastern Montana	41,621	USDA Coop	SYE	0.8
			161,750	State	Tech	0.5
			14,847	Sales	CYE	2.5
			32,367	Ind Grants		3.8
			250,585			
ANIMAL & RANGE SCIENCES	184	Shrub Ecology and Forage Relationships	22,395	Hatch	SYE	0.5
			209,606	State	PYE	0.3
			16,584	Sales	CYE	0.5
			4,061	Other Non Fed		1.3

			252,646			
	203	Sustaining Wildlife Habitat on Western Ranches	81,690	USDA Grants	SYE PYE	0.2 0.4 0.6
	204	Coordinated Elk Management for Sustainable Beef Cattle	71,816	USDA Grants	SYE PYE Tech	0.3 1.0 1.1 2.4
	206	Influence of Social Hierarchy on Distribution of Rangeland Cattle	12,967 8,608 16,584 38,159	Hatch State Sales	SYE PYE	0.1 0.5 0.6
ENTOMOLOGY						
	147	Biological Control	9,960 23,117 1,029 1,278 35,384	Other Fed State Ind Grants Other Nonfed	SYE PYE CYE	0.6 0.9 0.3 1.8
	153	Biological Control of the Wheat Stem Sawfly	13,409 323 78,103 5,383 97,218	Hatch USDA Coop State Other Non Fed	SYE PYE	0.7 0.7 1.4
	154	Biological Control in Pest Management Systems of Plants	48,103 89,733 18,916 156,752	Multi State Res USDA Coop State	SYE PYE	0.2 0.4 0.6
	158	Curation of the MSU Entomology Collection	13,519 57,816 103,821 175,156	USDA Coop NSF State	SYE PYE CYE	0.8 0.9 0.1 1.8
	160	Rangeland Insects	31,307 6,682 40,135 4,425 82,549	Hatch USDA Coop State Other Non Fed	SYE PYE Tech	0.8 0.5 1.0 2.3
	758	Miscellaneous and Pulse Crop Production	111,266 3,893 3,674 118,833	State Self-Gen Fund Other NonFed	SYE Tech CYE	0.7 0.9 0.9 2.5
PLANT SCIENCES & PLANT PATHOLOGY						
	243	Grass Flora of Montana & Integrating Phylogenic Methods in to Studies of Crop Plants	2,299 70,822 30,876 103,997	Hatch NSF State	SYE CYE	.4 .2 .6
	223	Ecology of Phyllosphere & Rhizosphere & Their Potential Role in Biocontrol of Disease	43,249 21,423 13,204 37,278 49	Hatch Other Fed Ind Grants Other Nonfed State	SYE Tech CYE	1.0 1.0 .5 2.5

			115,203			
	229	Managing Plant-Microbe Inter-	71,020	MultiState Res	SYE	.3
		actions in Soil to Promote	13,388	State	PYE	.2
		Sustainable Agriculture	5,236	Ind Grants	CYE	.2
			10,608	Other NonFed		.7
			100,252			
LAND RESOURCES AND ENVIRONMENTAL SCIENCES						
	199	Interactions of Vegetation, Grazing,	7,688	Hatch	SYE	.5
		& Watershed Processes on MT	49,668	State	CYE	.2
		Rangelands	57,356			.7
	300	Fate and Transport of Chemicals	1,393	Hatch	SYE	.5
		in Soils	36,775	NSF	PYE	3.2
			37,475	AID	Tech	.1
			13,131	Ind Grants		3.8
			88,774			
						302Soil Water and Soluble Ch
		Dynamics	32,798	Other Nonfed	PYE	2.3
			2,968	State	Tech	.3
			39,913		CYE	.8
						3.9
	316	Integrated Management for Spotted	9,435	Hatch	SYE	.4
		Knapweed Infested Rangeland	105,979	USDA Grants	PYE	5.0
			48,554	Other Fed	CYE	2.0
			132,785	State		7.4
			34,076	Ind Grant		
			50,392	Other Nonfed		
			381,221			
	323	Biological and Ecological Basis	71,265	MultiState Res	SYE	0.1
		for a Weed Management Decision	99	Other Fed	Tech	0.1
		Support Systems to Reduce Herbicide	31,674	State	CYE	0.1
		Use	103,038			0.3
	326	Biogeochemistry & Management	32,546	MultiState Res	SYE	.1
		of Salts and Trace Elements in Arid-			PYE	.1
		Zone Soils, Sediments and Waters				.2
	327	Improved Characterization &	38,110	MultiState Res	SYE	.2
		Quantification of Flow and Transport	22,054	State		.2
		Processes in Soils	8,409	Ind Grants		
			68,573			
	394	Integrated Management of Annual	39,978	Hatch	SYE	0.6
		Grass Weeds in Small Grain	50,498	State	PYE	2.0
			75,870	Other Nonfed	Tech	0.7
			166,346		CYE	2.5
						5.8
	398	Pesticides and Other Toxic Organics in	29,263	MultiState Res	SYE	.2
		Soil and their Potential for Ground and	49,587	State	PYE	.1
		Surface Water Contamination	78,850		Tech	.1
					CYE	.1
						0.5
	399	Ecology of Weeds in Small Grain	4,854	Hatch	SYE	0.6

		Production Systems of Montana	9,138	USDA Grants	PYE	3.1
			1,025	NSF	Tech	0.7
			5,475	NASA	CYE	0.8
			30,422	Other Fed		5.2
			54,947			
AGRICULTURAL ECONOMICS						
	074	Benefits & Costs of Resource	28,200	MultiState Res	SYE	.2
		Policies Affecting Public and			PYE	.6
		Private Land			CYE	.5
						1.3
	89	Climate Change and the Economic	14,986	Hatch	SYE	.5
		Sustainability of Montana and Great	209,015	DOE	PYE	.8
		Plains Agriculture	96,343	Other Fed	CYE	.5
			77,732	State		1.8
			398,076			
TOTAL GOAL 4:			**$3,392,254**		SYE:	13.4
					PYE:	24.5
					TECH:	6.8
					CYE:	12.9
					TOTAL:	**57.6**

TOTAL GOAL 5: **Funding $340,000** **FTE 3.69**
(See Appendix A)

APPENDIX C

U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Multistate Extension Activities and Integrated Activities
(Attach Brief Summaries)

Institution: **MONTANA AGRICULTURAL EXPERIMENT STATION**
State: **MONTANA**
Check one: ____ Multistate Extension Activities
__X__ Integrated Activities (Hatch Act Funds)

_____ Integrated Activities (Smith-Lever Act Funds)

ACTUAL EXPENDITURES					
Title of Planned Program/Activity	**FY2000**	**FY2001**	**FY2002**	**FY2003**	**FY2004**
Ecology of Phyllosphere & Rizosphere Micro-Organisms & their Potential Role in Biological Control of Plant Diseases	$37,889	$40,795			
Lamb Survivability	2,529	13,523			
Influence of Social Hierarchy on Distribution of Rangeland Cattle	2,382	12,387			
Management Practices which Influence Morbidity, Feedlot Performance & Carcass Characteristics of Montana Beef Calves	2,918	16,716			
IPM of Montana Field and Forage Crops	16,796	3,084			
Integrated Management of Annual Grass Weeds in Small Grain	10,876	37,686			
Biocontrol of Pest Management Systems of Plants	55,991	41,951			
Biological Control of the Wheat Stem Sawfly		12,641			
TOTALS	$129,381	$178,783			

DIRECTOR: Sharron S. Quisenberry DATE: 03/01/2002

INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

U. S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Multistate Extension Activities and Integrated Activities
Brief Summaries Follow

MONTANA AGRICULTURAL EXPERIMENT STATION
STATE OF MONTANA

INTEGRATED ACTIVITIES (HATCH ACT FUNDS)

TITLE OF PLANNED PROGRAM/ACTIVITY	ACTUAL FY01 EXPENDITURES
Ecology of Phyllosphere & Rhizosphere Micro-organisms & their Potential Role in Biological Control of Plant Diseases	37,889
Lamb Survivability	2,529
Influence of Social Hierarchy on Distribution of Rangeland Cattle	2,382
Management Practices which Influence Morbidity, Feedlot Performance & Carcass Characteristics of Montana Beef Calves	2,918
IPM of Montana Field and Forage Crops	16,796
Integrated Management of Annual Grass Weeds in Small Grain	10,876
Biocontrol of Pest Management Systems of Plants	55,991
Biological Control of the Wheat Stem Sawfly	12,641
Total	**178,783**

FORM CSREES-RPT (2/00)

SUMMARIES OF INTEGRATED ACTIVITIES

"Ecology of Phyllosphere and Rhizosphere Microorganisms & their Potential Role in Biological Control of Plant Diseases"

Since 1994 management of sugarbeet diseases has been a major focus of research and extension education programs. These programs have lead to grower implementation of effective, environmentally friendly, economical controls for 4 different chronic diseases and one new disease. Management of the chronic diseases,

Fusarium Yellows, Cercospora leaf spot, Rhizoctonia Crown and root rot and Aphanomyces root rot has increased grower profits on more than 88,000 acres in MT.

Fusarium Yellows. This disease is common on more than 40,000 acres and in 1994 only one resistant variety was available to growers and this variety had yield potential 15-20% less than high yielding varieties in the absence of disease. MAES research developed highly efficient methods to identify resistant germplasm and work with seed and sugar companies has resulted in the identification of many high yielding Fusarium Yellows resistant varieties and the near elimination of susceptible genotypes. Extension education programs have resulted in growers using these varieties on more than 39,000 acres for control of this disease and yields have increased by approximately 12%. Thus the impact of this work in the past 2 years has been more than $9.6 million income in MT. Management of this disease is one of the key factors for record yields in the Billings factory district (Western Sugar) in both 1999 and 2000.

Cercospora Leaf Spot. This disease would reduce growers profits by $70-165.00 per acre on more than 60,000 acres in MT if no fungicides were applied for control. MAES research at the Eastern Agricultural Experiment Station demonstrated to both growers and the sugar companies that control of this disease was required to maximize economic return and that a weather-based disease prediction program could potentially reduce fungicide use as compared to calender spray programs. In 1994, less than 20% of the acres were sprayed for control and by 1997 this increased to over 99% in the Sidney factory district (Holly Sugar) and to 20-25% in the Billings Factory district (Western Sugar). In 1997 the weather-based Minnesota Prediction model for Cercospora Leaf spot infection and loss was implemented in 4 sites and validated for MT conditions. In 1998, through the use of extension education programs the weather-based prediction model was used on 17% of acres and in 1999 67% of acres were using this model to predict the need to spray. By 2000, extension education programs resulted in scouting for Cercospora and weather based forecasting being used on 100% of the acres in MT. Extension pathologists trained growers and both Coop and sugar company personnel on scouting and weather-based disease prediction and they implemented the scouting and weather monitoring program. This resulted in saving an average of 1 spray on 50,000 acres and 2 sprays on 30,000 acres with no loss in disease control in 1999 and 2 sprays on 77,000 acres in 2000. This resulted in saving more than $1.8 million 1999 and $2.3 million in 2000 as compared to a calendar based spray program.
In Cercospora research in 1999 and 2000, we demonstrated that use of a moderate level of resistance would allow growers to save 1 spray compared to that needed on susceptible varieties without reducing yields. This data will be used by the Holly Sugar-Sidney factory district to require new approved varieties have a Moderate level of Cercospora resistance (KWS score less than 5.5). The impact of this work is that approximately 50,000 acres would receive one less spray @$15.00 per acre = $750,000.

Rhizoctonia Crown and Root Rot. The new fungicide management program developed by MAES research and taught in extension education programs was used on 1500

acres in 1999 and more than 4500 acres in 2000 for control of this disease. Based on our research plot response this increased profitability by $109 (Based on current Western Sugar Grower Contract price) per acre or $490,500 for MT. Research used to develop the Quadris fungicide label was started here at MSU and based on our data the full label was granted in 2001.

Aphanomyces Black Root Rot. This disease is both difficult to identify and to control. MAES research identified this as a significant problem for MT growers in 1994 and this project began a research effort to develop control strategies. Control is difficult because resistance is incomplete and there are no varieties adapted to MT. The fungicide seed treatment Tachigaren is moderately effective in reducing seedling losses but must be used with pelleted seed due phytotoxicity. In 1995 several promising rhizosphere inhabiting Bacilli were identified that provided control equal to Tachigaren. These were tested in production fields in 1996. 1997. 1998, 1999, and 2000. The result of this research is the identification of MSU 341-16-5 a Bacillus pumilis strain that provides better control of Aphanomyces than Tachigaren, better control of Pythium and Rhizoctonia than the standard seed treatment Apron-Thiram and does not have to be used with pelleted seed. In 10 location years of data using commercially treated seed, this isolate provided higher final stands and an average of 670 lbs/A more extractable sugar per acre than the standard seed treatment Apron-Thiram or Apron-Thiram – Tachigaren. This isolate will be developed commercially.

Potato

Research on potato diseases has identified a new method to identify scab resistant lines using a laboratory assay that correlates well with field observations. The mechanism of resistance has been identified as well as resistant lines of cultivars that are highly susceptible. The lines are currently undergoing further selection for type and agronomic qualities. MAES research pioneered the use of azoxystrobin (Quadris) for control of Rhizoctonia black scurf control.

“Lamb Survivability”
Rodney Kott

An audit was conducted at extension programs and ranch visits to identify the most critical factor on Montana sheep ranches limiting improved production. Lamb survivability was identified as the single most limiting issue. Based on this information a research project was initiated to identify ways that producers could improve lamb survivability without making large scale changes in their production/management system. Controlled trials at MSU showed that short term Vitamin E supplementation substantially increased lamb survivability in certain situations. Field demonstration trials were conducted on a number of ranches throughout Montana with positive results. Preliminary results suggest that short-term supplementation of ewes just prior to parturition may increase newborn lambs cold tolerance. As a result, vitamin E

supplementation is now being utilized by many producers. Currently, the effects of the inclusion of dietary oils in the diets of ewes on lamb survivability is being investigated.

"Influence of Social Hierarchy on Distribution of Rangeland Cattle"
Dr. Jeffrey C. Mosley
Department of Animal & Range Sciences
Montana State University
Bozeman, MT

The current phase of this project is testing the efficacy of reducing riparian impacts by selectively culling those cows from a herd that spend a disproportionately large amount of their time in riparian habitat. Project results revealed that cattle distribution was influenced by a cow's social rank within the herd's dominance hierarchy. Experimental results and experiences learned in this project were also shared in several extension educational programs in the past fiscal year. These offerings included a workshop for county agents from across Montana; a regional meeting of ranchers and range livestock industry consultants; and Montana Youth Range Camp.

"Management Practices which Influence Morbidity, Feedlot Performance and Carcass Characteristics of Montana Beef Calves"
James Paterson

A system to provide information feedback between various segments of the beef industry was implemented. This program is a cooperative effort between the Montana Stockgrowers Association and Montana State University. A systems approach was implemented which allows for tracking of calves from the ranch in Montana to the feedlots in other states and provinces and eventually to the packing plant. Information collected throughout the production chain is shared among all the owners of the cattle. Results of feedlot performance and information feedback to the cow-calf producer are being continually provided to the rancher as soon as animals are harvested. Funding was used to develop and publish training manuals and present over 60 Beef Quality Assurance educational programs in MT so producers could certify that calves were vaccinated using a standard health management protocol. County agents were trained to provide this educational program to producers at the local level.

The Montana Beef Network has three primary objectives; 1) educational programs aimed at meeting beef quality assurance standards, production and marketing goals and providing additional educational programs through interactive-video conferencing, 2) certification of feeder calves that have met defined management protocols and 3) information feedback from the feedlot and packing plant to the cow-calf producer showing if the feeder calves met industry requirements for quality, consistency, safety and red meat yield.

Funding was used to develop and publish training manuals and present over 60 Beef Quality Assurance educational programs in MT so producers could certify that calves were vaccinated using a standard health management protocol. County agents were trained to provide this educational program to producers at the local level. Approximately 23,000 calves were certified during the first year and 24,000 the second year. Additional projects started were 1) initiation of a state-wide audit of ranchers to determine value-added practices related to breeding, health management, nutrition and marketing and 2) a twenty ranch research project to determine if a standardized weaning protocol which includes both vaccinations and nutrition could reduce morbidity of calves once they entered the feedlot. Approximately 5,000 claves were committed to this project, 3) one-or two-day short courses were held each year in which issues pertinent to the beef industry were presented, 4) a breeding project for red meat yield vs. quality grade 5) six interactive- television short courses aimed at carcass evaluation, genetic management, opportunities for back grounding calves and marketing were presented during 2000.

"IPM of Montana Field and Forage Crops"
Project leader: Sue Blodgett
Pale western and army cutworm

Sporadic pests of Montana's 5 million acre wheat crop, cutworms are difficult to control because intensive monitoring for this pest is time consuming and costly. Typical spray applications for this pest are estimated to cost $10/acre. Significant damage can be sustained before management practices can be implemented. A monitoring program was initiated in 1992 for adult moths to forecast potential larval populations in the subsequent spring. However, its usefulness was limited by the inability to incorporate influential environmental effects into the forecast. Recently, competitive grant funds have been obtained through the Western Regional Integrated Pest Management Program to improve our ability to predict occurrence of damaging numbers of these pests and expanded the program into Wyoming, Nebraska and South Dakota. Both temperature and moisture have been incorporated into the forecast and have improved the ability to interpret monitoring program results. Results of this program have been delivered through numerous Extension programs in Montana and are available on the web at http://cutworm.org.

Cereal Leaf Beetle

Decision-making for cereal leaf beetle management is based on an economic injury level that was developed in Michigan. Research being conducted by K. Miller is evaluating the economic injury level for Montana conditions and crops. There has been an increasing trend to treat fields with pesticides for this pest. In 1995 about 1,000 acres were treated, 5,000 acres in 1996 and 15,000 acres in 1997. However, a cereal leaf beetle monitoring program and treatment guidelines have resulted in a reduction of sprayed acreage in 1998 to 5,000 acres. With chemical application costs of

$12.00/acre this resulted in a savings to Montana producers of $120,000. Development of an economic injury level that is more appropriate for Montana producers and continued emphasis on monitoring and using decision making guidelines is likely to yield substantial economic benefits each year.

Alfalfa Weevil

An improvement in early cutting as a management strategy for alfalfa weevil has been developed at MSU and is responsible for reducing pesticide applications and improving the economics of alfalfa weevil control. Early cutting is a cultural control method for alfalfa weevil that is very effective in Montana. However, early cutting does not necessarily eliminate the need for a pesticide application following harvest to control the alfalfa weevil. By raking hay during harvest, alfalfa weevil populations can be reduced an additional 50% over early harvest alone. This reduction can make a post-harvest pesticide unnecessary resulting in a savings of $12 to $15 /acre. With 1.7 million acres of harvestable alfalfa hay in the state, if this technique saves a pesticide application on 10% of the total acres, a savings of $2 million can be realized.

Non-irrigated alfalfa production represents 54% of the 1.7 million acres of alfalfa harvested in Montana. Research conducted in 2000 found that insecticide treatment of dryland alfalfa resulted in a 35% yield increase due to pressure by spotted alfalfa aphid and the alfalfa weevil larvae. These results have been presented through Extension programs throughout Montana. Timing of insecticide treatments is also being investigated.

"Integrated Management of Annual Grass Weeds in Small Grain"
PROJECT LEADER: A. J. Bussan
REPORT PERIOD: 10/1/99-09/30/00

This past summer a precision agriculture field day was held in Malta, MT to highlight activities, outcomes, and experiences of precision farming research. In addition, the weed research field day was held at the Post Research Farm in Bozeman to highlight all weed research activities across Montana. Information and data generated through this research program form the basic material for nearly all extension programming. All preliminary reports, abstracts, presentations, and manuscripts are posted on the MSU Weed Science Web Site.

"Biocontrol of Pest Management Systems of Plants"
Dr Robert Noweirski

Noxious weeds continue to be one of the biggest concerns to land managers and the general public throughout the state. As a result, there is tremendous interest in my research (biological control of weeds). I participate in many extension-sponsored programs throughout the year to keep the public apprised of the research progress and I work closely with numerous county extension agents to coordinate the dissemination of biocontrol agents throughout the state.

Specifically, my research involves the use of natural enemies to biologically manage several noxious weeds, including spotted and diffuse knapweed, houndstongue, and sulfur cinquefoil. A total of 13 natural enemy species have been successfully introduced against the knapweeds. Significant reduction of the knapweeds is now occurring in some locations where large populations of some biocontrol agents exist.

"Biological Control of the Wheat Stem Sawfly"
Dr. Wendell Morrill and Dr. David Weaver

The wheat stem sawfly, *Cephus cinctus* (Norton), is currently the most visible and destructive insect pest of wheat in Montana. Producers estimate that annual losses exceed $30 million. The larval stage of the sawfly bores within the plant stem, and grain weight is reduced by about 10%. Infested stems also lodge, and may be lost during harvest increasing losses. Some infested fields are swathed to minimize lodging losses, but this adds to harvest costs. These sawflies cannot be controlled with insecticides because of the lengthy adult flight period, and because the larvae are protected within plant stems. Cultural management practices, such as tillage and burning, have limited impact on the survival of this insect. Cereal aphids can cause up to $5 million in losses during outbreak years in Montana. Cereal aphid control relies primarily on insecticides, which are very costly to use in wheat production, because of the low profit margin for production.

Our recent advances in the understanding of sawfly ecology are providing tools for development of innovative management strategies for this pest. These include the investigation of two sources of compounds discovered in wheat fields in Montana that are toxic to this insect. One source is microbial and the other is from commonly-occurring grass species. The compounds responsible for the plant toxicity are being characterized using analytical equipment and biological assays. Also, our research has identified chemical odors that are used for sawfly mating and for location of host plants. Behavior-modifying chemicals, pathogens, and plant-derived toxins are highly desirable management tools because minute amounts are needed to be effective and they pose limited environmental challenge. New analytical equipment designs and recent chemical techniques have simplified our ongoing research, and will lead to an integrated biorational sawfly management program.

Overlapping research approaches are being used for these novel naturally-occurring chemicals. The first focuses on pheromones which are produced by sawflies when they

are searching for suitable mates. Second, plant odors from cereal crops and feral grasses that act to attract or repel sawflies and aphjids are being identified. Third, we are investigating methods for enhancement of parasitoid efficacy. These natural enemies of the sawfly and cereal aphids are endemic to Montana. The parasitoids are attracted to odors produced by infested plants. Plants vary in the amount of odors that are produced, therefore this is a new tool that can be used by wheat breeders to promote biological control.