ANNUAL REPORT

MONTANA STATE UNIVERSITY

COLLEGE OF AGRICULTURE
MONTANA AGRICULTURAL EXPERIMENT STATION

FEDERAL FISCAL YEAR 2001

MARCH 1, 2001

GOAL 1: AN AGRICULTURAL SYSTEM THAT IS HIGHLY COMPETITIVE IN THE GLOBAL ECONOMY

DEPARTMENT OF ANIMAL AND RANGE SCIENCES

1) Executive Summary
(Projects: 175, 176, 179, 183, 200, 201, 204, 216)

Two experimental barley lines, LB6 and LB57, developed by crossing Baronesse (2-row, feed type) and Lewis (2-row, feed and malting type), were evaluated feedlot performance, nutrient digestion, and carcass characteristics of steers. Results indicate that experimental barley line LB6 had improved feed efficiency and *in vivo* DMD compared with the parent cultivars, Baronesse and Lewis. Despite the importance of forage quality to animal performance, barley forage quality has not been used as a selection criterion in barley breeding programs. Our objectives were to evaluate the Steptoe/Morex doubled haploid (DH) population for forage quality, identify Quantitative Trait Loci (QTLs) for forage quality, and determine if there is a genetic basis for nitrate accumulation. Results suggest that genetic differences among Steptoe/Morex DH lines have an impact on forage digestion in the rumen, and this information could be used to select improved forage-quality barley varieties.

Cattle may graze foothill rangelands in northern latitudes as an alternative to feeding hay. However, winter winds may increase weight loss and lower body condition scores. Our initial objective had been to determine whether exposure to wind stresses mature (5-7-year-old) pregnant beef cows grazing foothill winter range. Diurnal activity patterns varied greatly from day to day and were correlated with weather. On cold days cattle oriented perpendicular to the sun to maximize heat gain. On windy days, they oriented parallel with the wind to minimize heat loss. We are developing a simple energy balance model which will identify when cattle are gaining heat from or losing heat to their winter environment, which will have implications for metabolic requirements, weight change, and reproductive efficiency.

Studies were conducted to estimate genetic parameters for carcass traits and the influence of slaughter end-point on estimated breeding values (BV). Data provided by the American Simmental Association. Genetic correlations among traits varied across groups and end-points, but suggested it should be possible to select for improved lean yield without sacrificing quality grade. Correlations were calculated among BV computed at different end-points. Adjustment to various end-points resulted in some changes in BV and re-ranking of sires, especially for PRC; however, number of records available had a larger influence than slaughter end-point.

We tested the hypothesis that temporal patterns of LH and testosterone (T) concentrations do not differ between rams from Rambouillet ewes selected for high (HL) or low (LL) reproductive rate, and among rams from HL or LL Rambouillet ewes with or without sexual experience before or after naloxone treatment. 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. Examining the effects of bulls on pulsatile patterns of LH secretion and resumption of ovarian cyclic activity in postpartum suckled beef cows under conditions that restrict calf identification at progressively longer intervals after calving. Specifically, we are testing the hypotheses that pulsatile patterns of LH concentrations and interval from calving to resumption of ovulatory cycles do not differ between first-calf cows that are either suckled continuously or restricted to twice daily suckling and exposed continuously to mature bulls beginning on either days 15, 35, or 55 postpartum. However, based upon preliminary analysis of the changes in progesterone concentrations 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 my hypothesis that the effect of bulls to reduce the postpartum interval to estrus may involve be dependent on the interaction of cows, calves, and bulls. An experiment was conducted to determine if the form of trace mineral supplement changes ovulation rate and fertility in yearling heifers. These data indicated that form of mineral supplement influenced ovulation rate in beef heifers.

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. 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.

Key theme – Animal Genomics

a. This study presents some results from selection for reproductive rate based on their dam's reproduction performance in Rambouillet sheep. This study evaluated the phenotypic and genetic effects of selection for reproductive rate on total kilograms of weaning weight per ewe exposed and per ewe lambing, number of lambs born per ewe exposed and per ewe lambing, and number of lambs weaned per ewe exposed and per ewe lambing. Selection began in 1968 when two populations of sheep were developed: a high line (HL) selected for high reproductive rate; a low line (LL)

selected for low reproductive rate. A random control line (CL) was established in 1972.

b. Impacts - These results show that selection for reproductive rate is effective and increases the lambs born per ewe exposed for breeding and lambing. However, the increase in lambs born translated to a much smaller increase in kilograms of lamb weaned per ewe. Earlier experiments have shown that the response to selection for number of lambs born was a change in ovulation rate.

c. Source of Federal Funds – Hatch

d. Scope of Impact – National

Key theme – Animal Production Efficiency

a. We are examining the effects of bulls on pulsatile patterns of LH secretion and resumption of ovarian cyclic activity in postpartum suckled beef cows under conditions that restrict calf identification at progressively longer intervals after calving. Specifically, we are testing the hypotheses that pulsatile patterns of LH concentrations and interval from calving to resumption of ovulatory cycles do not differ between first-calf cows that are either suckled continuously or restricted to twice daily suckling and exposed continuously to mature bulls beginning on either days 15, 35, or 55 postpartum. . Approximately 14,000 blood samples were obtained to evaluate pulsatile patterns of LH concentrations.

b. 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.

c. Sources of funding – USDA/NRICGP, Hatch

d. Scope of Impact - National

Key theme – Invasive Species

a. Our overall objective is to determine whether resource preemption, altered site conditions, or both contribute to the persistence of the invasive spotted knapweed *Centaurea maculosa* Lam. in semiarid grasslands. In one greenhouse study, western wheatgrass plants conditioned to 24 and 72 hour pulses of N availability had greater root and shoot mass than spotted knapweed; conversely, spotted knapweed plants conditioned to 24 and 72 h pulses had greater root and shoot mass than bluebunch wheatgrass. Overall, western wheatgrass acquired more $^{15}NO_3$ than spotted knapweed during an 8 h labeling period; conversely, spotted knapweed acquired more

$^{15}NO_3$ than bluebunch wheatgrass. In a follow-up study, we conditioned the same species combinations to high and low N for 8 weeks, and then labeled the plants with $^{15}NO_3$ for 8 h. Overall, spotted knapweed grew better when competing with bluebunch wheatgrass than western wheatgrass. Spotted knapweed had lower nitrogen use efficiency than the grasses, and its responses often depended on whether it was growing with bluebunch wheatgrass, western wheatgrass, or itself. At each of three field sites, we sampled paired plots (infested, non-infested) to determine affect of spotted knapweed on soil particle size distribution, organic matter content, total N, NH_4, and NO_3, pH, electrical conductivity, cation exchange capacity, $CaCO_3$ equivalent, and extractable P, K, Ca, Mg, and Na. Depth and time patterns of soil water were monitored with time domain reflectometry (TDR). Surface soil infiltration capacity was measured using disk permeameters under ponded and negative (-0.02, -0.06, -0.09, -0.15 m) water supply pressures. Soil cores were collected to determine three pools of soil organic matter (SOM): total, particulate, and mineralizable. Overall, these results indicated that spotted knapweed does not significantly alter soil physical properties which might inhibit restoring native grasses. However, spotted knapweed does use greater amounts of soil water later into the summer than native grasses. This depletion persists into the following growing season.

b. Impacts - 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.

c. Source of Federal Funds – USDA/NRICGP, Hatch

d. Scope of Impact – Regional

3) There were no changes in the peer review process from the original plan of work.

DEPARTMENT OF ENTOMOLOGY

Agricultural systems are continually attacked by a broad array of arthropod pests. A number of pests that attack various crops are being investigated relative to their economic impact on crop production. 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 systems are being developed for cereal leaf beetle, wheat stem sawfly, wheat curl mite, cutworms, and cereal aphids. Management solutions should promote the economic competitiveness and environmental health of Montana agriculture and contribute to the production of high quality agricultural products. 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. Rotations include pulse crops, oilseeds, small grains and annual forages. Crop rotations decreased spring wheat production costs by decreasing fertilizer inputs without compromising spring wheat yield or quality. 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.

The wheat stem sawfly causes an estimated $25-30 million in losses annually. An investment of $64,000 per year has resulted in economic returns of over $3 million per year. Sources of resistant winter wheat varieties for wheat stem sawfly have been a management focus for wheat stem sawfly. Breeding lines observed to withstand cutting by WSS in the field have been examined for morphological features that may contribute to potential resistance. Laboratory olfactometer experiments conducted in 1999-2000 has shown that sawflies produce a blend of chemical compounds used to find potential mats and locate suitable host plants. A dozen different chemical molecules were identified. A field test conducted in 1999 and 2000 with traps impregnated with a synthetic pheromone molecules was successful in capturing sawflies. It was determined that wheat plants infested by sawfly larvae release a blend of odors and these odors are used by predators and parasitoids to locate an attack sawfly larvae hidden inside plant stems.

Research and extension activities in forages are focused on improving monitoring techniques and cultural controls for the management of insect pests of alfalfa. Activities focused on the impact of early cutting and raking 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.

Development and improvement of IPM systems are occurring as new pests are being detected. Collaborative research initiated in 2000 was to determine the presence and impact of the green peach aphid to seed potato production in Montana. Activities determined that green peach aphid can overwinter in Montana on various winter-annual mustards, particularly field pennycress. This has potentially serious implications because this weed is common throughout the Gallatin Valley where the majority of seed potato production occurs. To facilitate GPA detection and monitoring, several aphid-monitoring

devices were compared in 2000. Yellow pan traps collected more aphids than green tiles and sticky cards making them more suitable for monitoring aphid populations in the field.

Montana has on-farm storage of wheat that has relied primarily on late harvest dates and harsh winters to reduce stored-grain insect population growth. In addition, grain protectant insecticides have been commonly used to limit insect growth. Continued regulatory loss of these protectants, coupled with changing storage conditions have resulted in a dramatic increase in the occurrence of infested grain. Research has bee conducted o the efficacy and costs of using night aeration t lower the temperature of newly-stored grain. This has shown to reduce insect population growth and decrease the ineffective use of grain fumigants and protectants. Specific impacts are a decrease in the occurrence of fumigation at 0.5 - 1.5 ¢ per bushel, exchange of 2-3 ¢ per bushel costs of unreliable protectants for 1-2 ¢ per bushel for preventative cooling, reduction of insect infestation associated costs ranging form 5 - 70 ¢ per bushel at the time of delivery to the grain elevator.

It is important that the public understand the diversity and role of insects in the world in which we live. The Department of Entomology held a week-long exhibit of live insects, art and cultural objects combined with exhibits on the impacts of entomology on public health and agriculture in Montana. Titled BugFest 2000, approximately 6,000 citizens, including 75 public school classes, visited the exhibits gaining a greater understanding of the role and importance insects have in their lives. Publicity was extensive and positive. Numerous stories via radio, television and print were generated by the interest raised by the event.

Programmatic impacts or producer benefits include better management of crop pests, reduction of pesticide usage, improved crop yields and quality. Improved crop protection techniques in Montana agriculture has resulted in a more ecological-based pest management system. Implementation of many non-chemical pest controls – biological, genetic and cultural – has increased adoption of IPM practices and enabled them to be better integrated into production systems. Research results have been delivered through a variety of methods including traditional print media, presentations to producer groups, radio and television appearances and interviews and electronic delivery.

DESCRIPTION OF PLANNED PROGRAMS BY KEY THEMES

Goal 1.

Diversified/Alternative Agricultural

Activity. Dryland crop diversification studies
Impact/Accomplishments. Crop rotations decreased spring wheat production costs by decreasing fertilizer inputs without compromising spring wheat yield or quality. 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.
Source of Funding. Hatch Act, State matching
Scope of Impact. Integrated research and extension

Invasive Species

Activity. Monitoring of injurious insect pests.
Impact/Accomplishments. Monitoring systems are in place for the following: pale western and army cutworms, cereal leaf beetle, cabbage seedpod weevil, green peach aphid. Results of monitoring systems are used to alert producers for these inspect pests.
Source of Funding. Hatch funds, Smith Lever, state matching
Scope of Impact. Multistate Extension (WY, NE, CO), Multistate research (WY, NE, CO)

Activity. Biological control of invasive hawkweeds
Impact/Accomplishments. 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.
Source of Funding. Hatch funds, state matching
Scope of Impact. British Columbia Ministry of Forestry, CABI Bioscience, MSU, U. of Idaho, &
U.S. Forest Service

Plant Production Efficiency

Activity. Improving monitoring techniques and cultural controls for the management of insect pests of small grains, forages and oilseeds.
Impact/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, 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.
Source of Funding. Hatch funds, Smith Lever, state matching
Scope of Impact. Multistate integrated research and extension with WY

MONTANA AGRICULTURAL RESEARCH CENTERS

On rugged and extensive rangelands, uneven livestock distribution limits the amount of forage available for grazing and may result in natural resource degradation. Since 1996, project MONB00710 'Efficiency and Sustainability of Beef Cattle Production' has provided livestock producers and land managers new tools to increase uniformity of livestock grazing and correspondingly improve rangeland health and water quality. 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.

MONB00708 'Beef Cattle Improvement' has shown breed selection to develop crossbred cows for the Montana environment can wean heavier calves and return $70.00 per cow per year more when compared to straightbred cows.

Plant Production Efficiency

Project MONB00503 'Field Crop Production' t played a significant role in the development of the canola industry in Montana. 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.

Project MONB00505 'Forage Crop Production' has contributed to wide utilization of cereal forages and introduction of Haybet awnless hay barley. The popularity of Haybet has grown to the point that it was seeded on over 80,000 acres in 1999 making it more popular than any other feed grain barley variety.

MONB00704 'Dryland Cropping Practices' is entering into the fifth year of air drill opener evaluation assisting growers in the selection of openers appropriate to specific production needs. 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.

Wheat stem sawfly causes up to $30 million in crop losses annually. Project MONB00853 'Field Crop Production' cooperated with researchers at M.S.U. Bozeman on the selection, evaluation and release of two sawfly resistant winter wheat cultivars 'Vanguard' and 'Rampart'. The demand for Vanguard and Rampart seed in 1997 was exceptionally high. These two varieties will have a major impact on reducing losses due to sawfly.

Precision Agriculture, GIS/GPS

Project MONB00703 is conducting research on applications of geographic information systems (GIS), global positioning systems (GPS), 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.

Adding Value to New and Old Agricultural Products

Project MONB00558 '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) at the MSU Eastern Agricultural Research Center. 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.

Diversified/Alternative Agriculture

Project MONB00656 'Field Crop Production for South Central Montana' is conducting field experiments to examine the 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. 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.

DEPARTMENT OF VETERINARY MOLECULAR BIOLOGY

Executive Summary

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. During the past year, MAES researchers made significant strides in investigating a number of livestock- and wildlife-related diseases and in developing vaccine candidates for treating some of these diseases.

Immunity and Inflammation of Trichomoniasis: Results of experiments in which *Tritrichomonas foetus* was co-cultured with primary bovine macrophages (adherent, PBMC-derived bovine monocytes from unimmunized animals) and the murine macrophage cell line, J774A.1 indicate that these macrophages can kill the parasite. Results of a fluorescence-based assay in which *T. foetus* were exposed to H_2O_2 then examined for viability indicated that H_2O_2 was toxic for the parasite in a dose-dependent manner. Additional results indicated that macrophage-killed parasites can be quickly destroyed and the debris phagocytosed. Direct macrophage exposure to *T. foetus* also leads to induction of expression of TNF- message in macrophages. Results of bioassays of macrophage supernatants confirmed the presence of functional TNF- . Intravaginal inoculation experiments in mice have demonstrated that mice in estrus are more susceptible to infection than mice in diestrus, SCID mice have similar susceptibility to BALB/c and that cyclophosphamide increases susceptibility. Overall, these results suggest that innate immune function may be crucial for controlling *T. foetus* infections.

Function of bovine rotavirus nonstructural proteins: Rotavirus is the major viral cause of diarrhea in cattle. Currently available vaccines are sub-optimal and fail to effectively control infections, and there is a need to pursue new methods to prevent rotavirus disease in cattle. Our studies focus on understanding the functions of a viral protein (NSP1) that may be responsible for toxic effects in cells. We have completed cloning and sequencing of NSP1 of bovine rotavirus strain B641 and expressed recombinant NSP1 in bacteria. Purified NSP1 then was used to immunize mice for polyclonal antibody production. We have obtained a high titer serum that reacts specifically with NSP1 in rotavirus-infected cells by Western blot. We also have isolated stably transfected MA104 cell lines inducible for expression of a luciferase reporter gene. Isolation of cell lines inducible for NSP1 is in progress. Ongoing studies include co-immunoprecipitation and cross-linking analyses of NSP1 in infected cells to identify host cell proteins that interact with NSP1.

We also have recently obtained data to suggest that NSP1 is involved in regulating rotavirus gene expression at the level of protein synthesis. These data are important in determining how the viral genome is efficiently replicated. By understanding these processes, new therapeutic strategies to inhibit bovine rotavirus replication in the host can be developed.

Functional analysis of bovine gd T cells: Evidence suggests that gd T cells are important in host responses against viral, bacterial, and protozoan infections. These 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 gd T cells into different tissues, MAES researchers made progress in our characterization of tissue-specific adhesion molecules and chemokines that direct the migration of specific gd T cell subsets into the gut versus peripheral tissues. These studies have implications in the design of new adjuvants for the stimulation of the bovine immune system. In the past year, functional genomics has been added as a new approach in the study of bovine gd T cells.

Development of bovine vaccine delivery systems: MAES researchers investigated the feasibility of an attenuated *Salmonella* vector to immunize young calves against bovine enterotoxigenic *Escherichia coli* (ETEC). Studies focused on the hypothesis that protective immunity to ETEC is dependent upon where the fimbriae is expressed in the vector. In an effort to develop a safe and effective vaccine for the prevention of $F5^+$ ETEC infections, a balanced-lethal asd^+ plasmid carrying the complete K99-operon was constructed and designated, pMAK99-asd^+. Introduction of this plasmid into attenuated *S. typhimurium* strain H683 resulted in the strain, AP112, which stably expresses the *E. coli* K99 fimbriae. Furthermore, *Salmonella* strains were developed where the K99 fimbrial antigen was either limited to the periplasmic compartment (AP114) or to the cytoplasmic compartment (AP116). To assess the effectiveness of each *Salmonella* construct in delivering the fimbrial subunit to mucosal inductive tissues, outbred CD-1 mice were orally immunized and showed elevated mucosal and serum antibody titers to K99. Peyer's patches and splenic lymphocytes from BALB/c and CD-1 mice were harvested one week after oral immunization with each construct and assayed using a cytokine-specific ELISPOT. 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 further demonstrated that cell surface or excreted passenger antigens might favor the stimulation of predominantly Th2-type cells.

Vaccine Development for Brucellosis in Bison: 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 the MAES investigators have focused on developing a better understanding of the bison immune system and the development of novel vaccine delivery systems and vaccines for bison. MAES researchers have recently tested a prototype vaccine for bovine scours in bison, and learned that the *Salmonella*-based vaccine is well-tolerated. After two oral vaccinations, elevated mucosal and systemic antibodies were found to the vaccine. In addition, immunized female bison calves produced and maintained elevated vaccine-specific antibody titers in their vaginal secretions. Thus, oral immunization does

represent a route of delivery whereby appropriate mucosal immunity can be obtained in bison. To develop the next generation brucellosis vaccines, MAES researchers 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. Further studies are currently in progress to determine whether such a vaccination scheme will provide a feasible method for eliciting protection against *B. abortus.*

Regulation of the Bovine Leukocyte NADPH Oxidase in Mastitis: Mastitis is the most common and costly disease afflicting dairy cattle in Montana. Although neutrophils play an essential role in the cellular defense of the bovine mammary gland and compromised neutrophil function has been linked to the development of bovine mastitis, little is known about the structure and regulation of the bovine neutrophil microbicidal systems. MAES researchers developed better methods for purifying bovine neutrophils from bovine milk, prepared antibody reagents that will be used in future studies on bovine neutrophil host defense proteins, and cloned and sequenced four proteins that play a role in the bovine neutrophil microbicidal NADPH oxidase system. These researchers also investigated the kind of leukocytes present in the milk of cows that had mastitis and showed different populations of leukocytes were present depending on the bacterial species causing the mastitis. These studies are helping to define the role that leukocyte subsets play in mastitis.

Drug Discovery for the Treatment and Prevention of Coccidiosis: 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. MAES researchers 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, MAES researchers have successfully established the technique for serial-analysis-of-gene-expression (SAGE) in the model coccidian *T. gondii*. With this technique, all ~7,000 parasite genes can be sorted from the nearly 15,000 host genes in a single genetic library prepared from infected animal cells. 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.

2. Planned Programs by Key Themes

Animal Genomics

- Develop animal transgenic and functional genomic approaches to study animal development and responses to infectious disease. Understanding gene expression patterns in host immune cells during responses to common infections will provide new insights into better development of vaccines and/or therapeutics. Functional genomic approaches will also be used in the analysis of gene expression in various infectious agents. It is anticipated that novel gene products will be identified in these studies that will be the target of new anti-infective compounds.

- Development of transgenic approaches to study cattle. This achievement will allow for expansion of research programs into animal development. An immediate goal will be to extend the approaches, which are routinely done in rodents, into cattle. One specific anticipated result in this initiative is the development of new, targeted mutagenesis approaches in bovine embryonic fibroblasts.

Animal Health

- Development of a gnotobiotic calf model to study scours. Rotavirus is a leading cause of acute gastroenteritis in neonatal calves. Currently available vaccines are based on passive transfer of virus-neutralizing antibodies through the colostrum of an immunized dam and generally lack efficacy. 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. Analysis of specific host immune responses to infection in newborns is complicated by the number and variety of infectious organisms a calf is exposed to in the environment. 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.

Emerging Infectious Diseases

- Develop research program focused on emerging infectious diseases. 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.

- Expand the Center for Bison and Wildlife Health. Veterinary Molecular Biology has 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.

3. Program Review-N/A

DEPARTMENT OF PLANT SCIENCES AND PLANT PATHOLOGY

EXECUTIVE SUMMARY

Agricultural Competitiveness

The development of new and better varieties of crops is a primary goal of the breeders. MONB00298 'Winter wheat breeding and genetics', MONB00315 'Spring Wheat breeding and genetics', MONB00342 'Barley breeding and genetics' and MONB00313 'Alfalfa breeding and genetics' all have been productive in the last year. The cultivars 'Scholar' (spring wheat), 'Valier' (barley), and 'Shaw' (alfalfa) all were released and portend to be excellent cultivars for Montana. A winter wheat cultivar 'Big Sky' is being prepared for release next year. The quality of the seed released for each of these cultivars is carefully monitored (MONB00386, 'Breeders seed purification and increase') to ensure that the seed trade receive true-to-type seed with high germination rates and low levels of extraneous seed. Better feed barley (MONB00341 'Evaluation and improvement of barley for food and feed') is being developed to generate better weight gain in cattle before shipment out of state. Much of this progress is dependent on statistical analysis of quantitative traits using molecular markers (MONB00307, 'Quantitative genetics and crop development).

Biotechnology

Several projects involve the genetic modification of organisms for specific purposes. In 'Genetic improvement of biological control agents for weed control' (MONB00237) 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 specific hardness genes in 'Small grain quality' (MONB00348). Plant viruses are being designed for the delivery of drugs and other compounds to specific tissues of the body (MONB00230 'Mechanisms of plant virus transmission and assembly').

Invasive Species

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.

Plant Genomics

The relationships between plant genes and the physiology of the plant are being investigated both in temperature stress (MONB00242 'Studies of plants living in extreme environments within Yellowstone National Park') and light quality (MONB00241, '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 (MONB00240, 'Population genetics of self-incompatibility in the Solanaceae) represents another approach to the study of genome development and control.

Plant Health

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 (MONB00220, '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 (MONB00224 '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 (MONB00228, 'Identification of defense related genes in a model plant defense system by serial analysis of gene expression').

DEPARTMENT OF LAND RESOURCES AND ENVIRONMENTAL SCIENCES

Wild oat is a tremendous pest problem in irrigated malt barley and dryland small grain fields. Characterization of wild oat populations and their impacts on small grain production within fields using GPS and GIS showed significant potential for reducing inputs and thus increasing profits for producers. It has become increasingly clear that the impact of wild oats is highly variable across fields as well as sites and years in most of Montana and thus site-specific assessment of weeds ant their impact on precision management could provide increased net returns.

Montana due to historical practices and farm policy provisions has developed into a primary wheat and barley state. 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 must be studied to change our cropping systems into more sustainable systems for a semi-arid environment. Key

issues include: water use, alternative uses of the forage and dry matter, and nitrogen dynamics can help to led the evolution of Montana cropping practices.

Spotted knapweed is an invasive specie that is rapidly destroying public and private rangelands by decreasing plant diversity, reducing forage production for wildlife and livestock, increasing erosion potential, and changing ecosystems. Management of these invasive species through cost-effective and reliable techniques to establish desirable plant species and species composition are key to long-term management strategies that enhance agricultural systems. Quantification of plant species composition and species performance, establishment of seeded desirable species and developing revegetation methods, nutrient availability manipulation, biological and chemical control methods integrated into site specific practices can lead to success revegetation efforts and restoration of rangelands.

Description of Planned Programs by Key Themes

Agricultural Competitiveness
Precision Ag/GIS/GPS
Activity- Implementing mapping strategies with GPS and GIS for wild oats and wheat stem sawfly.
Impact/Accomplishments- Field with wild oats may be ecological sinks for sawfly larvae because larvae do not survive in the wild oat stems.
Source of Funding- Hatch, Smith Lever, USDA-NRI.
Scope of Impact- Integrated research and extension.

Diversified Agriculture
Activity-Dryland diversified cropping systems.
Impact/Accomplishments-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-Hatch, Smith Lever.
Scope of Impact-Integrated Research and Extension.

Invasive Species
Activity-Integrated management practices.
Impact/Accomplishments-A one-pass system to apply a herbicide and seed more desirable species have been implemented in a cost-effective manner.
Source of Funding-Hatch, Smith Lever, Montana Noxious Weed Trust Fund.
Scope of Impact-Integrated Research and Extension.

DEPARTMENT OF AGRICULTURAL ECONOMICS

Executive Summary

Contributions to MAES FY 2000 Program Goals

GOAL 1:

In FY 2000, the Department's research projects made several contributions to meeting the MAES research program goals. In the area of Agricultural Finance, Marketing and Policy, two projects made particular contributions. The projects were designed in recognition of a changing economic environment, the viability of each production unit depends critically upon that producers' ability to identify and analyze problems that have financial, production, organizational, or risk implications to the firm or to the industry.

KEY THEME: RISK MANAGEMENT

The first project utilized project sponsorship from the USDA's Risk Management Agency. 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.

KEY THEME: AGRICULTURAL COMPETITIVENESS

In another project contributing to the goal on Agricultural Finance, Marketing and Policy, 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 on national income and on 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. 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.

TOTAL GOAL 1: $11,156,473 FTE: 105.074
(see table of expenditures, funding sources and FTE for each project in Appendix A)

Goal 2: A SAFE AND SECURE FOOD AND FIBER SYSTEM

Food Handling

Project MONB00318 'State seed testing laboratory' provides a service function to assure high quality seed that is free of weed seeds, disease, and other contaminants. This service is closely associated with the production and sale of certified seed to growers.

Food Resource Management

Project MONB00396 'Plant genetic resource conservation and utilization' provides one of the most basic needs of a breeding program, the maintenance and supply of germplasm that may contain useful genes not currently present in the breeding lines.

TOTAL GOAL 2: $155,720 FTE: 5.4
(see table of expenditures, funding sources and FTE for each project in Appendix A)

Goal 3: A HEALTHY, WELL NOURISHED POPULATION

Human Nutrition

New and improved uses of wheat and barley are being investigated in MONB00335 'End-use properties of whet and barley'. 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.

Medicinal Plants

Project MONB00222 'Endophytes of plants: their biology, economic value and potential use' investigates the unique chemicals 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.

TOTAL GOAL 3: 1,263,241 FTE: 6.0
(see table of expenditures, funding sources and FTE for each project in Appendix A)

GOAL 4: AN AGRICULTURAL SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT

DEPARTMENT OF ENTOMOLOGY

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. 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 lab is to facilitate the importation, augmentation, study, and release of exotic arthropods or the biological control of noxious weeds of regional importance. During 1999 – 2000, 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 2000 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 which 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 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.

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. We are developing an

understanding of the role of pheromones produced by the sawfly and used in mating and selection of host plants.
We are also assessing the impact of parasitoids on sawfly populations. It has been determined that the sawfly uses a complex 14 compounds to make a pheromone blend that is common, with some minor differences, to both sexes. Our goal is to use pheromones in the management of thisubiquitous pest. The impact that two parasitic hymenoptera have on larval sawfly populations isalso be examined.

Economic thresholds for cereal leaf beetle in barley and spring wheat were examined in 1999 and 2000. 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 1999, 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.

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 1999, were used to alert producers in those areas about potential cutworm problems the following spring.

One of the most damaging insect pest in canola production is the crucifer flea beetle. A two-year study, concluded in 2000, found that flea beetle damage to emerging canola plants was reduced when grown under a no-till system compared to conventional tillage. These findings suggest that an insecticide seed treatment can be eliminated when planting canola into no-till grain stubble. This would have a savings of $8 - 10 per acre and reduce seed treatment applications and foliar insecticide treatments. A relatively new pest was found in economically damaging levels in canola in 2000. Economic infestations of 35% were recorded in canola fields in northern Montana. This necessitates the need for development and implementation of a pest management program for this pest of canola.

Grazing research has focused on quantify 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.

MONTANA AGRICULTURAL RESEARCH CENTERS

Biological Control

Knapweed infestation is conservatively estimated to cause $14 million in direct negative impacts and $28 million in indirect effects to the state of Montana. Project MONB00806 'Biological Control of Rangeland Weeds' has introduced 12 biological control agents against spotted knapweed in Montana. 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.

Soil Quality

Project MONB00854 'Soils and Cropping Systems has investigated stubble management to conserve moisture and protect crops and soils with the goal of increasing and stabilizing crop production. 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.

DEPARTMENT OF PLANT SCIENCES AND PLANT PATHOLOGY

Biodiversity

'The grass flora of Montana and integrating phylogenetic methods into studies of crop plants' (MONB00243) 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.

Biological Control

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 projects

MONB00223 ('Ecology of phyllosphere and rhizosphere and their role in biological control of disease') and MONB00229 ('Managing plant microbe interactions in soil to promote sustainable agriculture'). These organisms are now being developed into commercial products, usually associated with seed treatments for sugar beet and other crops.

DEPARTMENT OF LAND RESOURCES AND ENVIRONMENTAL SCIENCES

Cropland weeds are the major pest 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. For example, herbicides applied to the 1-2 leaf stage of Persian darnel had 5-10% higher spring wheat yield than when applied at the 3-4 leaf stage. Heavy infestations of Persian darnel should therefore be treated with herbicides at the 1-2 leaf stage to minimize yield loss compared to a later growth stage.

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; however, restoring sites with favorable hydrology may face other barriers, that are not fully understood.

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.

Integrated Pest Management
Activity-Cropland weed control practices.
Impact/Accomplishments-Applications of herbicides at the 1-2 leaf stage reduced yield loss compared to applications at later growth stages.
Source of Funding-Hatch, Smith Lever, chemical companies.
Scope of Impact-Integrated Research and Extension.

Natural Resource Management
Activity-Artificial wetlands.
Impact/Accomplishments-Identified key plant species for optimum performance of nutrient uptake and sediment retention.

Source of Funding-Hatch, Smith Lever, state.
Scope of Impact-Regional.

Water Quality
Activity-Soil Water Measurements
Impact/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-Hatch, State, USDA-NRI, Montana Fertilizer Tax.
Scope of Impact-Integrated Research and Education.

DEPARTMENT OF AGRICULTURAL ECONOMICS

GOAL 4

KEY THEME: LAND USE

Departmental researchers also contributed to the Economics and Sustainability of Public and Private Lands goal of the MAES. 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, 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.

TOTAL GOAL 4 : $1,905,452 FTE: 48.0
(see table of expenditures, funding sources and FTE for each project in Appendix A)

FOCUS AREAS IN FY2001 CSREES BUDGET

Institute for Biobased Products and Food Science

The Montana Agricultural Experiment Station (MAES), Institute for Biobased Products and Food Science, was recently approved by the Montana State Legislative Subcommittee for Appropriations and Education, in the first round of legislative hearings 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.

Biennium Funding (2002-2003)

- Direct Institute Funding: $400,000 General Fund; $280,000 Private Funds.

Institute Positions to be hired immediately

- Institute Coordinator
- Risk Analyst
- Food Microbiologist

To be hired at a later date:

- Veterinary Molecular Biologist in Encephalitic Diseases (Food Safety)
- Animal Geneticist

STAKEHOLDER INPUT PROCESS

STAKEHOLDER SURVEY SUMMARY

Agricultural Experiment Station
College of Agriculture
Extension Service
Montana State University – Bozeman

Richard D. Williams
Special Projects Coordinator, Extension Service
Don D. Kress
Assoc. Dean, College of Agriculture

INTRODUCTION

The objectives of this summary were to describe the conduct of a stakeholder survey performed in the state of Montana and to report results from the survey. The purpose of the stakeholder survey was to collect input from a representative group of stakeholders in Montana. Questions in the survey were based upon the areas of emphasis in the strategic plans of the College of Agriculture/Agricultural Experiment Station and the Extension Service.

The Agricultural Research, Extension, and Education Reform Act (AREERA) of 1998, Section 102 (c) "Stakeholder Input Process", required the 1862 land-grant institutions, 1890 land-grant institutions, and 1994 land-grant institutions receiving agricultural research, extension and education formula funds from CSREES to establish a process for stakeholder input on the uses of such funds. CSREES will promulgate separately in the Federal Register regulations to implement this stakeholder input requirement. As a component of the 5-Year Plan of Work, each institution must report on the actions taken to seek stakeholder input that encourages their participation and a brief statement of the process used by the institution to identify stakeholders and to collect input from them. This report will be required annually and may be submitted with the Annual Report of Accomplishments and Results. This component will satisfy the reporting requirements imposed by the separately promulgated regulation on stakeholder input (Ref Federal Register/Vol.64. No. 74/ Monday, April 19, 1999/ Notices 19247).

METHODS

Population Description. The population sample consisted of households in the state of Montana. These households were selected from the Donnelley Marketing, Info USA 2000 database.

Sampling Procedures. The total number of estimated households in Montana as of July 1, 1998 was 346,000. (Ref. www.census.gov/populations/estimates/housing). The

sample size (subjects) for this survey was 6,000 households. A proportional stratified random sampling technique was used to select households. This random selection procedure identified 6,000 households with addresses in 312 cities and towns. Households were located in each of the 56 counties in Montana.

Development of Instrument. The principles of instrument design and administration were guided by Dillman's Mail and Telephone Surveys (1978). He described the Total Design Method as follows: "The TDM consists of two parts of which the *first* identifies each aspect of the survey process affecting either the quality or quantity of responses and shaping each of them in such a way to obtain the best possible responses. The *second* organizes the survey efforts to completely detail the design intentions. The *first* step is guided by a theoretical view about why people respond to questionnaires and provides the rationale for deciding how each aspect, even the seemingly minute ones, should be shaped. The *second* step guided by an administrative plan ensures implementation of the survey in accordance with design intentions. The failure of surveys to produce satisfactory results occurs as often from poor administration as from poor design (p. 12)."

Because the task in survey research is "to obtain information from a sample of respondents about their (or someone else's) behavior and/or attitudes" (Bradburn, 1983, P. 290), a critical element of survey research is the response rate. The goal of this survey was for a return rate larger than twenty-five percent.

The overall design and final review of the instrument was the responsibility of Dr. David A. Bryant, Vice Provost and Director of Extension, Montana State University and Dr. Sharron S. Quisenberry, Dean of the College of Agriculture and the Director of the Agricultural Experiment Station, Montana State University.

Initial survey questions were obtained from Dr. Richard D. Williams, Special Projects Coordinator, Extension Service, Montana State University and Dr. Don D. Kress, Associate Dean of the College of Agriculture, Montana State University. Further development of the questions was provided by Dr. David A. Bryant and Dr. Sharron S. Quisenberry.

Definitions of "stakeholder" and "stakeholder input" from the USDA-CSREES Federal Register were included on the cover of the instrument for informational purposes. Mission statements for the College of Agriculture, Agricultural Experiment Station and Extension Service were included in the cover letter.

Pilot Study. The instrument was pretested in late September and early October, 2000, by twenty-five randomly selected persons from across the state of Montana. These twenty-five were selected using "Research Randomized: Instant Random Sampling and Random Assignment" which was accessed on the web at http://www.randomizer.org. The range of numbers was entered as 1-6000, with instructions to select twenty-five. Those

numbers corresponded to the list of 6,000 names which were numbered using Microsoft© Excel software.

A cover letter with instructions, survey instrument (enlarged to allow room to write comments) and return prepaid envelope were sent to the identified people, requesting their participation in the pilot test. The pilot study was completed for the following purposes:

1. Testing the percentage of replies.
2. Checking if respondents have sufficient knowledge and understanding of the issues to answer the questions.
3. Analyze the results of the questionnaires to help validate the data collecting methods, coding procedure, clarity of instructions, documentation of validity and reliability, and comments.
4. Review the questions item by item to see which ones were left blank or answered differently than intended.
5. Determine any major disagreement in responses to a particular item to help in constructing additional items and assisting the researcher's understanding of the reasons for the disagreement.

There were no revisions made to the survey instrument following the return of pilot tests.

Field Testing. The instrument was further field tested by Dr. Don Kress, College of Agriculture; Dr. Clarann Weinert, College of Nursing; Mary Zartman, Director of Personnel; Suzi Taylor, Communications Specialist; and Ellen Huber, Administrative Assistant to the Vice Provost and Director of Extension; all at Montana State University. These individuals were asked to assess the instrument according to the following factors identified by Gronlund (1985) which may lower the validity of the survey results.

1. Unclear directions.
2. Reading vocabulary and sentence structure too difficult.
3. Inappropriate level of difficulty of survey instrument.
4. Poorly constructed survey items.
5. Ambiguity.
6. Survey items inappropriate for the outcomes being measured.
7. Survey length.
8. Survey layout.
9. Grammar.

Comments and suggestions from these individuals were constructive and beneficial in the preparation of the final survey instrument. Some are listed below:

1. "I'd stick more closely to Dillman - he is tried and true. At least put the responses in all CAPS."
2. "The cover is too cluttered. Move the definitions of Stakeholder and Stakeholder Input into your cover letter. Move the ID# to the back top. Drop the MSU logo and ag line to the bottom."

3. "Try to be as parsimonious with the directions as possible. Set off directions from questions with a double broken line."
4. "Section I, sentence 2: Delete: 'We would like your opinion on how we are doing to meet the needs of Montana.' Question 4: Delete 'Nutrition and health.' Question 1: Add: ... attended a meeting, read a report.'"
5. "Add definitions of College of Agriculture, Ag Experiment Station and Extension Service on survey cover."
6. "Insert: 'Regardless of response to Question 1, please answer any questions you feel comfortable with.'"
7. "The phrase in parenthesis needs to go immediately with its reference."

Return of Surveys. As the survey instruments were returned, each envelope was opened and the survey number was compared to a printed list of names with corresponding numbers. The envelopes were then placed in a separate pile from the surveys. The printed list had been divided to reflect which county each survey had been mailed to and as they were returned, they were marked off on that list.

Statistical Analysis of Data. Statistical analyses were conducted according to procedures available in the Statistical Analysis System (SAS, 2000). The Means Procedure was used to calculate means, standard deviations, minimums, and maximums. The General Linear Models Procedure was used to conduct analyses of variance to determine whether various sources of variation significantly influenced responses. Sources of variation were gender, race, employment of respondent, employment of spouse, location (farm vs. city), income level, county, and a linear regression (covariate) on age of respondent,. Frequency distribution graphs were used to present a visual summary of responses to each question.

RESULTS AND DISCUSSION

Return Rate. Five thousand nine hundred seventy-eight surveys were mailed to randomly selected households in Montana in October, 2000. From this mailing and two follow-up mailings, there were 1,863 questionnaires received by the cut-off date of January 10, 2001, for a return rate of 31.2%. Of those 1,863 returned, 1,795 or 30.0% proved to be usable.

Of the 1,795 usable returns, some residents of the household failed, for whatever reason, to complete all items. Thus some data will indicate the responses are less than 100%. However, it did not appear there was any particular pattern to missed responses. The principal researcher determined the lack of an occasional item's response did not constitute a threat to the validity of the survey process since missing data was determined to occur in a completely random pattern. Reasons that questionnaires were not used for data analysis were as follows:

1. Deceased
2. Died, 1999
3. Passed away, 1997

4. ”Return to sender”
5. Undeliverable as addressed. No forwarding order on file
6. Forwarding order expired
7. No receptacle
8. “I did not fill out and return the survey, as my eye sight is not very good, and its hard for me to do all that reading.”
9. “Lila is in the hospital and does not wish to fill out the survey”
10. “WA state resident”

Demographics. The average age of respondents was 53.3 years, with a range of 19 to 98 years. Respondents were from all 56 counties in the state of Montana. Figures 1 through 6 describe the other demographics of the respondents.

There were more respondents that were male than female (Figure 1). Most all respondents (1533) were Anglo/White (Figure 2) and the next largest group was Native American at 63. The most frequent location of primary residence (Figure 3) was cities of less than 5,000 with 428 respondents, and 287 respondents or 17.5% were from Farms/Ranches. The most frequent income bracket was greater than $35,000, while the other lower income levels were about equally frequent. The most frequent respondent employment status (Figure 5) was Full-Time (580), with Retired (436) and Self-Employed (393) not far behind.

Analyses of Variance. Analyses of variance for the priority ratings of each item indicated that age of the respondent was the source of variation that was most frequently significant ($P < .05$). However, age was significant for only 22 % (11 out of the total of 51) of the items. For the education and research areas, age was significant for the priority of overall education, education subitems of 2a (graduates ready for the marketplace), 2c (hands-on learning experiences), 2f (courses are relevant), and agriculture and natural resource systems subitems of 3e (integrated pest management) and 3f (natural resource management). The linear regressions of these items on age were .0072, .0095, .0092, .0104, .0103, and .0128, respectfully. Thus, all regressions indicated that older respondents rated these items with larger numbers and lower priority than younger respondents. For the Extension areas, age was significant for 8a (agricultural sustainability and profitability), 8f (growth management), 8g (value-added/technology transfer), 10 (the local Extension office provides leadership in educational programming), and 11 (the Extension Specialists provide leadership in educational programming). The linear regressions of these items on age were -.0056, -.0080, -.0074, -.0102, and -.0100. Thus, all of these regressions for Extension areas indicated that older respondents rated these items with smaller numbers and higher priority than younger respondents.

The other sources of variation that were most often significant ($P < .05$) were where respondents lived and income level. Where respondents lived was significant for 6 items (overall economic, 6a, 6c, 8a, 9a, and 9e). For the economic issues, respondents living on farms rated the priority level lower (higher number) and respondents living in cities of over 10,000 rated the priority level higher (smaller number), with the other respondents intermediate. For the Extension issues, the ratings were reversed with respondents from

farms rating the priority level higher (smaller number) and respondents from cities of over 10,000 rating the priority level lower (higher number), with the other respondents intermediate.

Income level was significant ($P < .05$) for 1 item (8b) and approached significance ($P < .11$) for 6 items (overall education, 2b, 2f, 5a, 8e, and 9d). For education and marketing items (overall education, 2b, 2f, and 5a), respondents from the highest income level rated the priorities higher (smaller number) and respondents in lower income levels rated the priorities lower (higher number). For Extension items (8e and 9d) the ratings were reversed with respondents from the highest income level rating the priorities lower (higher number) and respondents from lower income levels rating the priorities higher (smaller number).

The remaining sources of variation (county, gender, race, and type of employment) were seldom significant ($P < .05$) for the various items in the survey.

Means and Frequency Distributions for Teaching and Research. Figure 7 shows the mean priority rating for the overall areas of education, agriculture and natural resource systems, safety, global economy, economic opportunities, and the environment. All ratings averaged between 1.4 and 1.8, indicating that respondents rated all areas as high priority areas. Education had the lowest numerical average (highest priority) and competiveness in a global economy had the largest numerical average (lowest priority), but standard errors of these means from the analyses of variance were generally about .22 and would indicate that there were no significant ($P < .05$) differences among the overall areas.

The frequency distribution of responses for the priority of overall educational programs is presented in Figure 8. Most respondents (67%) rated education as high priority. Only 5% of respondents rated education as below average or low priority.

Figures 9 through 16 show the frequency distributions for the various items within education. In general, most respondents rated all items as high priority. However, recruitment and retention of students (Figure 10), increased enrollment (Figure 12), courses and degrees delivered by distance technology (Figure 15), and on-campus summer school programs (Figure 16) tended to be rated lower than the other items.

Responses for the overall area of agriculture and natural resource systems are shown in Figure 17. Most respondents (54%) rated this area as high priority and only 8% rated this area as below average or low priority. Figures 18 through 23 show the frequency distributions for the items within agriculture and natural resource systems. The most highly rated area was noxious weed management (Figure 21) with 55% of respondents rating the area high priority.

Figure 24 presents the frequency distribution for the overall area of safe and secure food system and well-nourished population, with 57% of respondents rating this area as high priority. Figures 25 through 30 show the frequency distributions for the items within the

safe and secure food system and well-nourished population area. The most highly rated areas tended to be animal and livestock diseases (Figure 26) and nutrition and health (Figure 30).

Figures 31 through 34 show the frequency distributions for the overall area of competiveness in a global economy and items within that overall area. High priority was the most frequent response for these items except for world trade policy where the most frequent response was above average (36%) and 29% of respondents rated world trade policy as below average or low.

The frequency distribution for the overall area of economic opportunity (Figure 35) showed that most respondents (49%) listed high priority. However, the frequency distributions for items within economic opportunity (Figures 36 through 38) showed that the most frequent response was for above average.

The overall area of agriculture and the environment (Figure 39) was dominated by high priority responses (57%). Figures 40 through 42 show the frequency distributions for the items within agriculture and the environment. Water quality (Figure 40) was the most highly rated priority among these items with 56% of respondents answering with high priority.

Frequency Distributions for Extension. Figures 43 through 58 present frequency distributions for priority and other responses for the various items listed under Extension Service in the survey. Overall, responses indicated that many of the items were high priority, but that participation in an Extension program in that area was low. A good example of this is the first item, agricultural sustainability and profitability (Figures 43 and 44). Most of the responses (56%) were high priority, but most respondents (91%) had not participated in a program in this area.

Family issues (Figure 45), natural resource/environmental issues (Figure 51), growth management (Figure 53), and value-added/technology transfer (Figure 55) were all Extension items where the most frequent response was above average rather than high priority. Youth development (Figure 48) and natural resource/environmental issues (Figure 52) were the areas of highest levels of participation at 17% and 15%, respectfully.

Regarding leadership that is provided by the local Extension office (Figure 57) and leadership that is provided by Extension Specialists (Figure 58) in educational programming, the responses were almost identical for local Extension and Extension Specialists. Most of the respondents (63% and 65%, respectfully) agreed that Extension personnel provide leadership in education programming, and those disagreeing or strongly disagreeing were 14% and 15%, respectfully.

CONCLUSIONS

The return rate of usable surveys was very good at 30% and respondents were from all 56 counties in the state, both of which lend credibility to the results. Age of respondents

significantly influenced priorities for some areas, but reversed for teaching/research as compared to extension. Older respondents tended to rate the priority of teaching/research areas lower, while rating the priority of extension areas as higher. Means of priority responses tended to be between 1.4 and 1.8, indicating that the mean rating for most areas was between "above average" and "high". Most respondents (67%) rated education as high priority, while only 5% rated education as below average or low priority. Both a safe and secure food system and agriculture/environment were rated highly by respondents with both areas receiving 57% of high priority ratings. Many of the Extension areas were rated highly, and participation by respondents ranged from 6 % to 17 %. For example, 56% of the responses for agricultural sustainability and profitability were high, and 9% of respondents had participated in an Extension program in that area.

REFERENCES

Bradburn, N. M. 1983. Response effects. In P. H. Rossi, J. D. Wright, and A. B. Anderson (Eds.), Handbook for survey research (pp. 289-328). San Diego: Academic Press.

Dillman, D. A. 1978. Mail and Telephone Surveys: The Total Design Method. New York: John Wiley and Sons.

Donnelley Marketing, infoUSA: www.infoUSA.com

Gronlund, N. E. 1985. Measurement and Evaluation in Teaching. New York: MacMillan Publishing Co.

SAS. 2000. SAS Users Guide: Statistics (Version 8.1). SAS Inst. Enc., Cary, NC.

www.census.gov/populations/estimates/housing

NOTE

Please access attached Powerpoint file for tables and graphs related to the survey results.

PEER REVIEW

DEPARTMENT OF LAND RESOURCES AND ENVIRONMENTAL SCIENCES

A review team of nationally respected scientists selected from AAAS reviewed ecology and environmental sciences programs in the Department of Land Resources and Environmental Sciences and the Department of Ecology. Recommendations for departmental consolidation were made, but have not been implemented. The Department of Ecology was created from the former Department of Biology as a first step. We are exploring opportunities for a join Ph.D. program with these two departments and

possibly, the University of Montana. Overall review comments were extremely strong towards research and education activities addressing Montana and other regional issues.

EVALUATION OF THE SUCCESS OF MULTI AND JOINT ACTIVITIES

MULTISTATE, MULTI-INSTITUTIONAL WORK AT THE RESEARCH CENTERS

In Cooperation with the ARS-Sidney and North Dakota State University, Project MONB00557 'High-value and alternative crop production research for eastern Montana', through investments in sugarbeet research at the MSU Eastern Agricultural Research Center (EARC), 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.

In Cooperation with the ARS-Sidney and North Dakota State University, Project MONB00557 '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.

DEPARTMENT OF VETERINARY MOLECULAR BIOLOGY

Multi-state, Multi-institutional, Multi-disciplinary Activities

- **Animal Genomics***:* 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 (Dr. Mark Jutila, Principle Investigator). 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.
- ***Brucellosis research***: MAES researchers formed a consortium with Texas A&M researchers to study brucellosis in bison. A grant proposal is currently being developed for submission to the Turner Foundation. In addition, vaccine trials are currently underway utilizing capabilities at both locations and directed by Dr. David Pascual.
- **Parasite genetics**: Dr. Michael White spent a month as a visiting faculty in the Department of Cell Biology at the University of Georgia (Nov. 2000). The goal

of this visit was to get training in techniques necessary to establish a new genetic complementation model for *Toxoplasma* at Montana State University. This training was highly successful, and resulted in the development of extremely useful tools for studying *T. gondii* and potentially other important parasites.

DEPARTMENT OF LAND RESOURCES AND ENVIRONMENTAL SCIENCES

Multi-state, Multi-institutional, Multi-disciplinary Activities

Reducing Site-to-site and Year-to-year Variation in Crop Yield Loss Functions-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 bioeconomic model damage function objective of optimizing *A. cylindrica* management in winter wheat.

Biogeochemistry and management of salts and potential toxic trace elements in arid-zone soils, sediments and waters-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.

GIS/GPS and Remote Sensing Applications -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.

DEPARTMENT OF ANIMAL AND RANGE SCIENCES

Multi-state, Multi-institutional, Multi-disciplinary Activities

Extension and research are very closely integrated in the Animal and Range Sciences Department. Most extension faculty also have MAES appointments and conduct applied research projects and are involved with the more basic projects in the department. Much of the research that the specialists conduct is directly applicable to livestock operations and natural resource management issues. In addition to the effective intergradation of

extension with the research component productivity as measured by either extension publication and presentations or referred publications has been significant.

Goal 1 (Agricultural Production Efficiency)
Project 203, Project 204

This research project involves faculty in the Animal and Range Sciences Department and the Agricultural Economics and Economics Department. The projects involve MAES faculty and Extension Specialists in both departments.

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. Forage sampling will begin in the spring. Habitat mapping will begin this summer.

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.

Data collection is mostly complete and on schedule. Wildlife counts, forage samplings, and fecal collections have been completed. Chemical analyses of forage samples will be completed within the month. All fecal samples have been sent to Washington State University for analyses of botanical composition. These analyses should be completed this winter. Collection of ranch management and economic data will be complete soon. These projects will provide beef cattle ranchers and wildlife management agencies need information on management systems that will simultaneously maintain or improve environmental quality, sustain the economic viability of ranch families, and provide recreational opportunities for the public. This research will provide much needed information towards this end.

Project # 207

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. The first group of calves (23,000 calves) was eartagged in the fall of 1999 and approximately 24,000 calves was eartagged in the fall of 2000. 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.

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 backgrounding calves and marketing were presented during 2000.

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 FY00 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
Total	**73,390**

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 millionin 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 informal 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

Accomplishments from 10/1/99 – 9/30/00

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. In Fall 1999, 10% of the herd of 155 cows was culled due to their disproportionately heavy use of riparian areas during late-summer 1999. Replacement heifers were added in Spring 2000 and the social dominance hierarchy was reidentified for the entire herd. The hierarchy was previously identified in Spring 1998 and 1999. To my knowledge this herd remains the only commercial-sized herd of cattle in the world whose social dominance hierarchy has been identified. After the hierarchy was reidentified, the herd entered its summer pasture. For 8 weeks, the location of each cow was recorded once daily. Locations were recorded while horseback using a GPS receiver. Several habitat variables were also recorded, including the location's vegetation type, slope, aspect, air temperature, wind speed, relative humidity, and insect density. All cows and calves were individually weighed immediately before and after the summer grazing period. This same procedure will be repeated in 2000-2001 and 2001-2002.

Project results from Summer 1998 and 1999 revealed that cattle distribution was influenced by a cow's social rank within the herd's dominance hierarchy. These results were reported in one MS thesis completed in Fall 2000. A journal manuscript is now in its final stages of preparation. In addition, an oral scientific paper was presented at the annual international meeting of the Society for Range Management in February 2000.

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. The first group of calves (23,000 calves) was eartagged in the fall of 1999 and approximately 24,000 calves was eartagged in the fall of 2000. 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.

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 backgrounding calves and marketing were presented during 2000.

"IPM of Montana Field and Forage Crops"
Project leader: Sue Blodgett
Report period: 1 Oct 99 – 30 Sept 00

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.

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	175	Systems Analysis of Livestock Enterprises	706	Reg. Research	SYE	.5
			165,559	State	PYE	.415
			26,230	Sales	CYE	.100
			192,495			1.015
	176	Winter Grazing in MT	113,161	State	SYE	.25
			17,928	Sales	PYE	.33
			10,766	Other Nonfed	CYE	.10
			141,855			.68
	179	Evaluation and Improvement of Barley for Food and Feed	35,118	Reg. Research	SYE	.10
	183	Reproductive Performance in Domestic Ruminants	89,913	Reg. Research	SYE	.75
			5,251	State	PYE	1.00
			832	Sales	CYE	.43
			95,996			2.18
	200	Influence of Trace Mineral Supplements in Range Beef Cattle Production	47,480	State	SYE	.300
			7,522	Sales	PYE	.585
			55,002			.885
	204		64,051	USDA Grants	SYE	.25
					PYE	1.00
					Tech	.464
						1.714
	216	Evaluation & Improvement of Barley for Food & Feed	836	Reg. Research	SYE	.05
			73,883	State	Tech	1.00
			11,706	Sales	CYE	.05
			86,425			1.10
ENTOMOLOGY						
	148	IPM of Montana Field and Forage Crops	39,900	Hatch	SYE	.3
			11,851	USDA Grants	PYE	2.7
			13,230	Other Fed	CYE	1.6
			126,190	State		4.6
			191,171			
	153	Sawfly Management	15,507	Hatch	SYE	.8
			3,406	USDA Grants	PYE	1.0
			74,875	State	CYE	.2
			93,788			2.0
	158	Curation Entomology	4,909	USDA Grants	SYE	.8
			90,472	NSF	PYE	2.3
			14,755	Other Fed	CYE	,2
			56,041	State		3.3
			166,777			

	159	Exploratory Research	10,073	USDA Grants	SYE	.1
			1,650	AID	CYE	.9
			26,117	Other Fed		1.0
			133,802	State		
			192,644	Other Nonfed		
			364,286			
	167	Evaluation of Gall Mites	25,538	Hatch	SYE	.3
			6,405	USDA Grants	PYE	.8
			1,318	State	CYE	.1
			26,471	Other Nonfed		1.2
			59,732			
RESEARCH CENTERS						
CENTRAL AG						
RES CTR	503	Field Crop Production	2,408	Other Fed	SYE	. 5
			79,766	State	PYE	1.0
			1,483	Sales	Tech	. 5
			8,841	Other Nonfed	CYE	.7
			92,498			2.7
EASTERN AG	557	High Value & Alternative Crop	35,302	USDA Coop	SYE	.8
RES CTR		Production Research for	49,727	State	Tech	.2
		Eastern MT	13,587	Sales	CYE	2.6
			241			3.6
			98,857			
	558	Breeding/Improvement of	105,682	State	SYE	.4
		Oilseed Crops for Eastern MT	18,626	Ind. Grants	Tech	1.3
			124,308		CYE	2.8
						4.5
NORTHERN AG						
RES CTR	703	Innovating Site-Specific	8,399	Other Fed	SYE	1.0
		Management for Farming/	175,809	State	Tech	1.0
		Ranching	16,600	Sales	CYE	.5
			20,689			2.5
			221,497			
	704	Dryland Cropping Practices	188,037	State	SYE	1.0
			16,600	Sales	CYE	.8
			12,282	Other Nonfed		1.8
			216,919			
	708	Beef Cattle Improvement	171,141	State	SYE	.8
			16,600	Sales	Tech	.5
			187,741		CYE	.3
						1.6
SOUTHERN AG						
RES CTR	656	Field Crop Production for	1,442	Other Fed	SYE	2.0
		South Central MT	5,601	State	PYE	1.7
			12,243	Other Nonfed	Tech	1.0
			19,286		CYE	.7
						5.4
WESTERN TRIANGLE						
AG RES CTR	853	Field Crop Production	174,590	State	SYE	1.0
			69	Sales	PYE	1.0
			13,109	Other Nonfed		2.0
			187,768			

VETERINARY MOLECULAR BIOLOGY	428	Immunity & Inflammation of Trichomoniasis	42,673 53,734 23,478 119,885	Hatch NIH State	SYE PYE Tech CYE	.5 .5 .3 .3 1.6
	418	Molecular Mechanisms of Bovine Rotavirus Nonstructural Protein Function	20,497	USDA Coop	SYE PYE Tech	.1 .5 1.2 1.8
	405	Investigations of the Functions of Bovine Rotavirus Nonstructural Proteins	7,362 109,073 95,917 212,352	Hatch NIH State	SYE PYE Tech CYE	.8 .5 .5 .2 2.0
	51	Cytoskeletal-Association of Bovine Rotavirus Protein NSP1	6,652	Other Fed	SYE Tech	.1 .2 .3
	427	Vaccine Delivery Systems for Bison	178,355	USDA Coop	SYE PYE Tech CYE	.1 1.5 .5 .4 2.5
	419	Analysis of Gamma/Delta T Cells	47,317 205,437 124,540 15,242 392,536	Hatch HHS State Ind Grants	SYE Tech CYE	.4 .9 .2 1.5
	412	Gamma/Delta T Cells Chemokines	81,198	USDA Grants	SYE PYE Tech	.2 .4 .2 .8
	415	Mucosal Immunity & Salmonella Vaccine Delivery	41,974 5,453 610,074 72,195 729,696	Hatch NIH HHS State	SYE PYE Tech CYE	.8 .1 .3 .8 2.0
	23	Mucosal Immunity to K99 Fimbrae Encoded by Salmonella: Vaccine For Bovine, Etc.	1,121	USDA Grants	SYE	.3
	410	Molecular Analysis of the Bovine Leukocyte NADPH Oxidase	41,823 256,877 45,320 147,023 491,043	Hatch HHS State Ind Grants	SYE PYE Tech CYE	.9 1.5 1.6 .2 4.2

	408	Leukocyte Adhesion Protein Expression & Cytokine Production In Mastitis	45,414	USDA Grants	SYE Tech	.1 .6 .7
	426	Modulation of Bovine Neutrophil Functions by Cell-Cell Interactions & Extra Cellular Matrix Proteins	21,021	USDA Grants	PYE	.6
	56	Genome Approach to Cell Cycle Gene Expression in Toxoplasma	3,701	Other Fed	SYE PYE Tech	.2 .3 .3 .8
PLANT SCIENCES & PLANT PATHOLOGY						
	220	Misc. Plant Diseases	50,826 3,529 493,645 83,365 631,365	NSF Other Fed State Other Nonfed	SYE Tech CYE	1.1 1.0 1.0 3.1
	224	Control of Fungal Disease by Mating Inhibition	45,714 5,744 51,458	Hatch USDA Grants	SYE PYE CYE	.5 .7 .3 1.5
	228	Identification of Defense-Related Genes in a Model Plant Defense System by SAGE	49,114 6,610 55,724	Hatch State	SYE CYE	.9 .2 1.1
	237	Genetic Improvement of Biocontrol Agents for Weed Control	52,968 143,524 15,516 580 62,357 274,945	Hatch USDA Grants Other Fed Ind Grants Other Fed	SYE PYE Tech CYE	.6 1.3 1.8 .1 3.8
	230	Mechanisms of Plant Virus Transmission and Assembly	64,790 125,111 30,999 872,104 94,596 1,187,600	Hatch NSF NIH NASA Ind Grants	SYE PYE CYE	.6 2.0 .4 3.0
	240	Population Genetics of Self-Incompatibility in the Solanacea	11,468 149,141 1,190 161,799	Hatch NSF Other Nonfed	SYE PYE CYE	.2 1.0 .2 1.4
	241	Genetically Engineered Plant Light Responses to Improve Crop Quality	19,272 131,834 6,483 157,589	Hatch NSF Other Nonfed	SYE PYE Tech	.3 1.0 .7 2.0
	242	Plants of Yellowstone Park	19,661	Hatch	SYE CYE	.2 .2 . 4

	313	Alfalfa Breeding, Genetics and Cultural Practices	50,524 12,855 13,988 77,367	Hatch State Other Nonfed	SYE PYE CYE	.7 .3 .3 1.3
	315	Spring Wheat Breeding & Genetics	251 201,128 51,962 200,598 453,939	Hatch State Ind Grants Other Nonfed	SYE PYE Tech CYE	.4 1.3 1.8 .1 3.6
	342	Barley Breeding & Genetics	57,869 558,239 24,883 42,631 52,816 736,438	Hatch NSF Other Fed Ind Grants Other Nonfed	SYE PYE Tech CYE	.5 .6 .9 .5 2.5
	348	Small Grain Quality and Molecular Biology	27,569 73,984 9,900 40,111 151,564	Hatch State Ind Grants Other Nonfed	SYE PYE CYE	.5 1.5 .1 2.1
LAND RESOURCES & ENVIRONMENTAL SCIENCES						
	296	Exploratory Research in Plant, Soil and Horticultural Sciences	61,259 58,298 502,574 16,188 638,319	NSF Other Fed State Other Nonfed	SYE PYE CYE	.8 .7 .6 2.1
	310	Phosphate assimilation in Rhizobium Bacteriods	40,725 115,419 89,477 37,791 283,412	Hatch NSF Other Fed State	SYE PYE CYE	.8 4.0 .4 5.2
	346	Soil and Plant Nutrition for Montana Agriculture	33,762 19,646 71,497	Hatch State	SYE PYE	.9 .5 2.1
	372	Pedology and Resource Inventory Methods for Evaluating Land Use Potentials, Planning Site-Specific Management	874 57,031 62,210 103,935 95,687 5,638 325,375	Hatch NASA Other Fed State Other Nonfed USDA Grants	SYE Tech CYE	.8 .5 1.3 2.6
AGRICULTURAL ECONOMICS						
	075	Impact Analysis & Decision Strategies for Agricultural Research	26,382	Reg. Research	SYE PYE CYE	.1 .1 .3 .5
	087	Ag Marketing, Price Analysis and Trade Problems in Dynamic Markets	56,765 20,176 252,002 328,943	Hatch USDA Grants State	SYE CYE	.8 .2 1.0

	098	Ag Finance & Farm/Ranch Management	2,714 223,184 23,779 106,566 167,812 524,055	Hatch USDA Grants NSF State	SYE CYE	1.5 .4 1.9
TOTAL GOAL 1:			**$11,156,473**		SYE: PYE: CYE: TECH: **TOTAL:**	29.6 34.73 21.48 19.264 **105.074**

GOAL TWO– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
PLANT SCIENCES & PLANT PATHOLOGY						
	318	State Seed Testing Lab `	102,914	State	SYE TECH CYE	.5 3.0 1.4 4.9
	396	Plant Genetic Resource Conservation & Utilization	52,806	Reg Research	SYE	.5
TOTAL GOAL 2:			**$155,720**		SYE: CYE: **TOTAL**	1.0 1.4 **5.4**

GOAL THREE– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
PLANT SCIENCES & PLANT PATHOLOGY						
	335	End-Use Properties of Wheat and Barley	143,998 29,133 173,131	State Other Nonfed	SYE PYE Tech CYE	.6 2.3 1.0 .1 4.0
	222	Endophytes of Plants: Their Biology, Economic Value &	3,352 767,042 201,518 67,675 50,523 1,090,110	Hatch NSF State Ind Grants Other Nonfed	SYE PYE	.6 1.4 2.0
TOTAL GOAL 3:			**1,263,241**		SYE: PYE: CYE: TECH: **TOTAL:**	1.2 3.7 .1 1.0 **6.0**

GOAL FOUR– EXPENDITURES AND FTE

DEPT.	PROJ #	PROJECT	EXPENDITURES/ FUNDING			FTE
Research Centers						
WESTERN AG						
RES CTR	806	Biocontrol of Rangeland Weeds	27,958	Other Fed	SYE	.6
			1,679	State	PYE	.3
			29,664		Tech	1.0
					CYE	.2
						2.1
	854	Soils & Cropping Systems	2,933	Other Fed	SYE	1.0
			161,266	State	PYE	1.0
			164,199			2.0
ENTOMOLOGY						
	147	Biological Control	15,000	USDA Grants	SYE	.6
			37,197	Other Fed	PYE	2.1
			18,599	State		2.7
			53,061	Other Nonfed		
			123,857			
	154	Biocontrol of Pests	40,451	USDA Grants	SYE	.2
					PYE	.8
					CYE	.6
						1.6
	160	Rangeland Insects	38,859	Hatch	SYE	.8
			43,770	State	PYE	1.3
			82,629			2.1
PLANT SCIENCES & PLANT PATHOLOGY						
	243	Grass Flora of Montana &	706	Hatch	SYE	.2
		Integrating Phylogenic	4,497	NSF	CYE	.2
		Methods in to Studies of	9,698	State		.4
		Crop Plants	14,901			
	223	Ecology of Phyllosphere &	43,110	Hatch	SYE	.9
		Rhizosphere & Their Potential	31,543	Ind Grants	Tech	1.0
		Role in Biocontrol of Disease	8,725	Other Nonfed	CYE	.5
			83,378			2.4
	229	Managing Plant-Microbe Inter-	45,014	Reg Res	SYE	.5
		actions in Soil to Promote	68,985	State	PYE	1.0
		Sustainable Agriculture	30,302	Ind Grants	CYE	.2
			144,301			1.7
LAND RESOURCES AND ENVIRONMENTAL SCIENCES						
	199	Interactions of Vegetation, Grazing,	2,006	Hatch	SYE	.6
		& Watershed Processes on MT	57,154	State	PYE	.6
		Rangelands	59,160		CYE	.6
						1.8
	300	Fate and Transport of Chemicals	13,056	Hatch	SYE	.5
		in Soils	80,790	NSF	PYE	3.5
			22,525	AID	Tech	.3
			8,729	Other Fed	CYE	.9
			29,519	State		5.2
			30,819	Ind Grants		

			185,438			
		Dynamics	38,898	Other Nonfed	PYE	2.3
			59,462		Tech	.5
					CYE	.4
						3.6
	316	Integrated Management for Spotted	12,022	Hatch	SYE	.4
		Knapweed Infested Rangeland	71,156	USDA Grants	PYE	2.8
			14,940	Other Fed	Tech	.8
			74,316	State	CYE	2.3
			648	Ind Grant		6.3
			57,281	Other Nonfed		
			230,363			
	323	Biological and Ecological Basis	87,577	Reg. Research	SYE	1.0
		for a Weed Management Decision	6,799	State	PYE	.1
		Support Systems to Reduce Herbicide	94,376			1.1
		Use				
	326	Biogeochemistry & Management	16,990	Reg Research	SYE	.1
		of Salts and Trace Elements in Arid-			PYE	.1
		Zone Soils, Sediments and Waters				.2
	327	Improved Characterization &	28,736	Reg. Research	SYE	.2
		Quantification of Flow and Transport	32,072	State	CYE	.2
		Processes in Soils	18,770	Ind Grants		.4
			79,578			
	394	Integrated Management of Annual	60,180	Hatch	SYE	.6
		Grass Weeds in Small Grain	25,401	State	PYE	2.2
			64,531	Other Nonfed	Tech	1.5
			150,112		CYE	2.2
						6.5
	398	Pesticides and Other Toxic Organics in	38,849	Reg. Research	SYE	.2
		Soil and their Potential for Ground and	739	State	Tech	.2
		Surface Water Contamination	39,588		CYE	.1
						.5
	399	Ecology of Weeds in Small Grain	976	Hatch	SYE	.6
		Production Systems of Montana	933	USDA Grants	PYE	2.0
			25,869	NSF	Tech	1.2
			11,054	NASA	CYE	.6
			14,533	Other Fed		4.4
			53,365			
AGRICULTURAL ECONOMICS						
	074	Benefits & Costs of Resource	15,875	Reg. Research	SYE	.2
		Policies Affecting Public and			PYE	.3
		Private Land			CYE	.6
						1.1
	89	Climate Change and the Economic	1,149	Hatch	SYE	.8
		Sustainability of Montana and Great	76,157	DOE	PYE	.5
		Plains Agriculture	65,295	Other Fed	CYE	.6
			94,082	State		1.9
			1,082	Other Nonfed		
			237,765			

TOTAL GOAL 4:	**1,905,452**	SYE: 10.4 PYE: 20.9 TECH: 6.5 CYE: 10.2 **TOTAL: 48.0**