

2012 Montana State University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Joining the nation in celebrating 150 years of a land-grant university system, the Montana Agricultural Experiment Station (MAES) and the Montana State University College of Agriculture (COA) engaged with the agricultural and natural resource communities and led the state in science, education, and innovation. With Montana's history intricately intertwined with the agricultural industry, it is fascinating to compare the advancements in research and technology with the basic components of agriculture -- crop and livestock production and other natural resource studies. While areas of Montana dealt with historical problems like persistent drought and wildfires, investigators made significant advancements in spring and winter wheat varieties, pest and weed mitigation and management, and initiated a new genetic program for animal health management and enhanced production.

Montana is a unique state boasting its "big sky" and "wide open spaces" both of which are indicative of the value Montanan's place on agriculture. Montana is a rural state with 989,000 people inhabiting 93 million acres which equates to fewer than seven people per square mile. The state's commitment to agriculture is clear with approximately 29,000 farms and ranches comprising 66 percent of Montana lands. This commitment goes back to 1893 with the founding of the Agricultural College of the State of Montana which boasted eight male students. Now the student enrollment in the Montana State University College of Agriculture exceeds 1,000 students and half are women. The students are from diverse backgrounds hailing from 18 countries and 47 other states.

While the campus at Montana State University is nestled at the base of the Bridger Mountains in Bozeman, Montana, the students have the globe as their classroom. Students and faculty are exploring the Arctic Circle, investigating thermal pools in Yellowstone National Park, visiting farms in China, and exchanging knowledge at sheep stations in Australia. Here in the Gallatin Valley outdoor opportunities to teach and learn outside the classroom are also abundant. The COA faculty teach and learn in laboratories, greenhouses, farms and ranches in Montana and around the world. Through collaborative research experiences and cooperation with rural, urban, and scientific communities, investigators are achieving significant impacts and outcomes.

Montana again ranks 2nd in the U.S. in acres devoted to farms and ranches with annual crop and livestock cash receipts exceeding \$3 billion. Although Montana experienced droughts throughout the southern part of the state and struggled through a brutal fire season, the agricultural revenue for 2012 reflected a 14 percent increase from 2010. According to the "2012 Montana Agricultural Statistics," the 2011 value of crop production increased to \$2.1 billion (19 percent above 2010). The value of livestock increased to \$1.4 billion, up \$156 million from 2010. Net government payments decreased by nine percent in 2011 to \$299 million. Overall agriculture receipts reflected a 14 percent increase.

Montana farmers saw an increase in the production of corn and sugar beets with production up 17 percent from 2011. Dry edible pea production, and canola were up as well, but hay production fell by 26 percent this year. In 2011 the state ranked 1st in the production of lentils and dry edible peas; 2nd in spring wheat, barley, Austrian winter peas, and flaxseed; 3rd in the production of winter wheat, durum wheat, hay, safflower, and canola; 4th in garbanzo beans; 5th in sugar beets and canola; 6th in the production of all hay; and in the top 10 for pinto beans.

Montana is among the top ten producers of beef cows and sheep in the nation and excels in honey and wool production. The value of Montana's livestock exports increased in 2011 to \$1.4 billion. Livestock products represented 41 percent of the cash receipts in 2011 with the majority being cattle and calves.

The geography of Montana provides world-renowned research opportunities in the areas of climate change and food security as well as studies aimed at balancing the needs and desires of tourism, agriculture and outdoor recreation. While agriculture remains the number one industry, Montana also prides itself on rugged beauty, open spaces, and recreational activities which directly impact tourism. Many of these activities are centered around the two National Parks and the state's waterways which include the headwaters of the Missouri, Yellowstone, and Columbia Rivers. Researchers in the COA and MAES work to balance the needs of agriculture and value-added activities with conservation, recreation and environmental issues, so there will be enough water and other resources for multiple users.

Montana is home to seven American Indian reservations and twelve tribal nations. Nine percent of Montana's land base is "Indian Country," and the Native Americans represent the largest group of potentially underserved citizens in Montana comprising 6.2 percent of the population. MSU works with tribal councils and colleges across the Rocky Mountain region, and educators provide a variety of academic programs and opportunities on MSU campuses and within tribal communities. Cooperative efforts with MAES provide resources and training in: livestock management, certification, childhood obesity, nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, and pesticide certification. American Indian students enrolled in the College of Agriculture comprise about 5 percent of the undergraduate populace, representing all seven reservations.

Researchers at Montana State University COA continue learning as they focus on diversity and efficiency in agricultural operations. MSU is committed to leading the way toward being better stewards of natural resources and even more effective in developing intellectual and human capital across generations.

Priorities of 2012: The Montana agricultural community worked together to reinforce the priorities for the College of Agriculture and the Montana Agricultural Experiment Station. Investigators and stakeholders facilitated focus groups and community meetings throughout the state ensuring the research priorities were current and valid for the target population. Following is a list of priorities:

- Add value to Montana's high quality crop and livestock systems
- Create new business opportunities for rural communities
- Develop effective livestock disease control methods
- Develop higher yielding and higher quality cultivars
- Expand research on agricultural and natural resource interactions
- Explore alternative and new crops
- Improve beef production practices and evaluate genetics to improve herds
- Increase research programs on alternative energy sources, including crops for biofuel

Investigators collaborate and share results for many of the priorities ensuring Montana remains on the cusp of the latest agriculture research.

Input Section: The MAES solicits stakeholder input in the strategic planning process and reaffirms the input as investigators fund, develop, implement, and revise the different research programs. The COA and MAES have 24 advisory committees and boards with more than 250 members. These include: the Animal and Range Science Advisory Committee, Center for Invasive Species Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Assistant Dean's Student Advisory Council, Eastern Agricultural Research Center Advisory

Committee (MonDak Region), Equine Advisory Committee, Foundation Seed Advisory Committee, MAES State Advisory Council, Beef Advisory Committee, Montana Farmers Union, Montana Pulse Growers Association, Montana Seed Growers Association Board, Montana Seed Lab Advisory Committee, Montana Wool Growers Advisory Committee, Northern Agricultural Research Center Advisory Committee, Northwestern Agricultural Research Center Advisory Committee, Organic Certification Association of Montana, Potato Certification Board, Southern Agricultural Research Center Advisory Committee, Thermal Biology Institute Scientific Advisory Board, Variety Release and Recommendation Committee, Western Agricultural Research Center, and the Western Triangle Advisory Committee. Members of these committees represent agricultural educators, agricultural organizations, communities, conservation groups, county extension agents, farmers and ranchers, financial organizations, private citizens, reservation groups, scientists, small businesses, and tribal councils. The COA and its MAES faculty respond to input from these stakeholders and state/national/international trends by continually developing new programs and evolving existing ones. Faculty members also serve on local and state committees.

Funding: Several sources fund MAES faculty research. They include: BIA, BLM, Canadian provinces, conservation and wildlife groups, Montana crop and animal agricultural groups, Montana Departments of Agriculture, Environmental Quality, Natural Resources and Conservation, and Transportation, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, NASA, NIH, NRCS, NSF, other states, grants, overhead investments from sponsored programs, private donations, private industry, the State of Montana, USDA, USEPA, and USFS.

Outcomes and Impacts: MAES and the COA conducted research (integrated with teaching) to enhance economically viable and sustainable agricultural systems relevant to agriculture and producers in Montana with globally transferable solutions. The research also focused on issues and concerns relevant to fields traditionally outside agricultural parameters, but which involve similar advanced knowledge acquisition such as cancer research and energy development. They focused on interdisciplinary studies with far reaching impacts in science, technology, energy consumption, food security, safety, and hunger. Investigators in Montana are also keenly aware of the environment and the implications of climate change.

Superior instructional programs emphasized student research skills and training in fields critical to the nation's agricultural and natural resources infrastructure. Outreach programs linked researchers with educators, stakeholders, producers, and consumers through face-to-face communication, print media, and electronic methods. Information technology specialists continued enhancing electronic workflow for the research centers throughout Montana and increased video conferencing capabilities. This allowed the centers and advisory committee members to better communicate with each other, the university offices and other states' research centers during a time of limited resources, saving both time and money.

MSU president, Waded Cruzado, launched the 2012 Field Day Tours with a bus tour for MSU leadership, faculty, students, and key stakeholders to selected ag businesses and the Central Ag Research Center's Field Day. The other agricultural research centers scattered throughout Montana hosted field days in cooperation with USDA-ARS (two Montana locations) and allied communities. At field days the staff shared key research programs with members of the agriculture community, stakeholders, producers and those pursuing careers in agriculture and/or research. Staff members facilitated discussion forums where attendees exchanged valuable information and ideas. The field days (attended by agricultural clientele, elected officials, and the general public with participation by faculty, staff, and students) are valuable for sharing new and ongoing research efforts.

Program Areas:

Program #1 Climate Change and Environment

Situation: MSU College of Agriculture has expanded research in the planned program, climate change. The original studies focused on carbon dioxide in the hot springs of Yellowstone National Park (YNP) and carbon sequestration in rangelands and crops. Now as researchers learn more about climate change they are concerned about the potential impact on forests and rangelands and associated ecosystems. Experts warn a warmer climate will likely result in more disturbances such as wildfires, floods, droughts, insect infestations, and an increase in invasive plants. While agriculture is vulnerable to climate change as diminished water resources constrain crop growth, it also must be considered in the context of rising timberlines, land use and invasive species.

Priorities: The 2012 Plan of Work priorities were to investigate how climate change may impact crop production, water systems, and range and forestry management. The College is also exploring the impact a changing climate may have on native plants, insects and wildlife. Scientists are developing models and projects to ensure crop and livestock producers and land managers have timely and accurate information. This year researchers continued developing alternative crop varieties and high yielding cultivars that can grow in warmer and drier climates.

Input: Focus groups, multistate research committees and meetings of stakeholders identified climate change strategies in cooperation with investigators.

Research Activities: In 2012 research in the climate program included looking at carbon sequestration in rangelands and croplands, the movement of energy and materials through agro ecosystems, and microbial ecosystems. With YNP less than 90 miles from the MSU campus, investigators continued studying geothermal microbial mats, as well as rising timberlines, soil carbon sequestration, greenhouse gas emissions and the impact of climate change on new plant cultivars.

Research on the microbial mat communities in YNP continue to reveal enormous diversity of highly adapted microorganisms. Understanding the mechanisms of growth of organisms and native plants in geothermally-modified soils helps researchers gain insight into how climate change may impact agricultural production. In 2012 researchers focused on a bar-code analyses that provided a robust demarcation of species populations and their distribution and responses to environmental change. These observations will help scientists understand the basis for efficient light utilization and CO₂ sequestration in the microbial community. This will then help researchers translate findings into bioenergy research and development.

As the climate changes, new cultivars of Montana crops are critical, so researchers evaluated new crops and cultivars suitable for a warmer and drier climate. Advancements continued in drought resistant spring wheat, winter wheat, and barley.

By understanding the relationships among agriculture-biofuel production, carbon sequestration, and natural resource conservation, as well as traditional commodity production, Montana agricultural producers can react effectively and sustainably to the demands of climate change. Because these processes occur over a broad range of time and space, MSU researchers are conducting long-term studies as to how energy and materials move through agro-ecosystems and soil carbon sequestration in rangelands and croplands.

Several MSU projects are gathering and compiling data to produce scientific publications and information for the general public that will improve the ability of public decision-makers to formulate policies regarding climate change and greenhouse gas mitigation. Researchers have set up websites to keep producers informed about study results and potential impacts.

Sustainable management of water is another challenge Montana researchers face as the demand increases and water resources decline. Researchers are designing forecast and water management

models for watershed and runoff controls.

Program #2 Food Safety - Animal Health

Situation: Infectious disease can cause considerable losses each year for producers by reducing production and sales due to food safety concerns thus in turn impacting the U.S. economy. A focus on disease management, reproduction, and carcass traits helps ensure Montana meat products maintain the highest standards. Promoting and maintaining animal health (cattle, sheep, horses, and wildlife interactions) has led to advances in genetics, improved performance, and increased reproduction success. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent perceived food safety events that harm the beef market.

Priorities: Disease management and research programs that increase the quality of meat, milk, and fiber products remain high research priorities. According to a leading scientist with Immunology and Infectious Disease (ImID) at MSU, digestive and respiratory diseases still account for more than 50 percent of the non-predator deaths in calves in Montana and scientists at MSU are working diligently to discover vaccines and treatments to minimize these losses. MSU studies help ensure Montana producers raise safe beef while improving quality. Research and educational programs address the animal health, biosecurity, and production efficiencies that concern producers and consumers. Extension and research efforts include beef quality education, and carcass data and management from the packing plant.

Input: Stakeholders provided input for the strategic planning process and offered valuable insight as programs were developed, implemented, and sometimes changed. Stakeholders include: advisory committees for the Northern Agricultural Research Center, the Montana Beef Council, Montana Wool Growers, Montana Stockgrowers, USDA-ARS, and other organizations.

Research Activities: The Animal Bioscience Building combined with state-of-the-art laboratory equipment has led to the successful recruitment and hiring of three new faculty two of which are core users (beef geneticist and rumen microbiologist) of molecular techniques. New facilities and new faculty enhances retention and will improve graduate student recruitment and training in the animal science profession. MSU research programs will be more competitive for state, regional and national funding sources with the investment in new lab technologies and faculty.

ImID scientists also utilize molecular approaches to address basic and applied problems in infectious disease research. Researchers continued investigating diseases and animal productivity in cattle, sheep, and bison. MSU animal health projects are long-term with minimal yearly changes, but the quality research allows agriculture to remain the top Montana industry, and the advances in cattle and sheep management translates into an economic benefit to all Montana livestock producers.

ImID is the primary research entity in Montana focused on animal health, particularly the study of infectious diseases of cattle, so the research they do combating diseases is invaluable to Montana and the region. Viral pneumonias cause substantial morbidity and mortality in the cattle industry creating a need to develop effective vaccines. Investigating the mechanisms by which calves resist lung infections is helping scientists better understand why calves become susceptible to infection.

Investigators are exploring novel approaches to both the compounds and the delivery methods. Researchers want to develop products and procedures that are safe, simple, and low cost, but will still stimulate immunity. Amphotericin B (AMB) is currently used to fight fungal infections in humans, and COA/MAES researchers are testing AMB in calves and dairy cows using different delivery methods like strips that dissolve on the tongue.

Rotavirus is the most important viral agent of neonatal diarrhea and generally affects calves less

than six weeks of age. Researchers studied the molecular interactions between enteric viruses and host cells to better understand rotaviruses. The results are important, because to enhance an effective defense response to viral infection, scientists must understand the molecular details of the pathways. The research in this field is important as it has the potential to develop vaccines consisting of viruses with weakened evasion strategies, or to target viral protein antagonists for antiviral drug development.

Staphylococcus aureus (*S. aureus*) is one of the most common causes of mastitis in cows, the dairy industry's most costly disease, and current treatments are primarily dependent on ineffective antibiotics. A MSU research team is investigating the incidence and characteristics of *S. aureus* in Montana's dairy herds and studying the antimicrobial potential of a chemokine (a signaling protein) found in bovine milk. This year scientists isolated a chemokine, a protein acting as a chemical messenger, which appears to have an important role in mammary immunity.

At several of the research centers, investigators are developing new reproductive, genetic, and nutrient management strategies for rangeland-based animal agriculture. Research in targeted mutagenesis of cells in cattle will make milk and beef production more efficient, increase the value of cattle-based commodities, and produce herds with improved disease resistance and increased production capabilities.

At the Northern Agricultural Research Center (NARC), researchers evaluated 276 replacement heifers and developing bulls through the GrowSafe system. They will use the data to evaluate long-term maternal productivity on the northern mixed grass prairie. Reproduction, longevity and RFI are evaluated and the impacts of heterosis relationships will be examined. Long-term tracking and monitoring for the entire herd of NARC is planned. Correlations and investigations evaluating reproduction, future productivity, and progeny performance are ongoing. The animal handling and maintenance equipment assists in facility sanitation, pollution prevention, and overall implementation of best livestock management practices at the field research facilities.

Projects between the Montana Wool Growers Association and MSU continue developing and implementing non-traditional strategies that increase the competitiveness of Montana's lamb and wool in the world market. Neonatal lamb mortality is a major source of lost income to the U.S. sheep industry, so research focused on nutritional strategies during late gestation that could potentially impact fetal survival and immune functions.

Program #3 Food Safety - Sustainable Agriculture

Situation: MAES and the COA researchers are committed to helping reduce the incidence of food-borne illnesses and assisting producers in providing a safer and sustainable food supply. Consumers are demanding foods free of harmful compounds and agents. The global market is also driving changes to the agricultural industry with constraints on grain and animal products. Montana farmers and ranchers historically practice sustainable production methods because of the difficult semi-arid and harsh climate throughout the state. The shorter growing season and limited water encourages innovative adaptive research. Methods focus on pest control options, tillage systems and increasing crop diversity and sustainability.

Small grains, forages, and short-season specialty crops make up the bulk of the cropping activity in Montana. In a semi-arid state most crops are dependent upon irrigation from surface water and groundwater. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for their water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 8.9 million acre-feet of water annually. Education and research activities have precipitated a general trend toward more efficient irrigation systems and more drought tolerant crops.

Priorities: Sustainable agriculture research at MSU interconnects program objectives in plant and animal genomics, global food supply, and sustainable energy. Long-term strategies ensure Montana agricultural products are more desirable in U.S. and world markets. The establishment of new value-added crops for nutritional enhancement and biofuels, and the development of higher yielding small grain cultivars are priorities among agronomic researchers. Greater disease and insect resistance in wheat and barley, increased nutritional value of forages, and more efficient use of natural resources are key priorities. Crop diversity has improved production for dryland agricultural producers in Montana and the Northern Plains.

Input: Surveys at farm conferences in Montana highlight strong producer interest in increasing crop diversity. Information and financial assistance come from alternative energy groups, conservation tillage equipment companies, crop protection companies, fertilizer check-off, the Montana Wheat and Barley Committee, the Organic Certification Association of Montana, and state agricultural advisory committees. The increasing use of computer modeling and surveys also add to data being collected. The Montana Wheat and Barley Committee provides financial support through a competitive grant process. This financial support helps direct research programs to improve the quality of spring/winter wheat and barley, and to adopt improved integrated pest management practices.

Research Activities: Researchers are exploring livestock and crop genetics using cutting-edge technology and investigating practical applications in rangeland, forest, crop, and livestock management. As outlined in the 2012 Plan of Work, researchers focused on the feasibility of growing a variety of pulse crops (peas, lentils, chickpeas, and soybeans), herbs, mustard, safflower, sunflower, canola, turf grasses, and specialty grains, many of which are included in long-term rotation studies.

Research information on water utilization and management in the Northern Rockies is limited. Investigators are currently evaluating riparian protection as a tool to protect and promote water quality in pristine, agricultural, and impacted watersheds. Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses will help protect riparian areas and improve the state's fisheries and wildlife habitat. Finding crops that require less water per acre and will grow in a short growing season requires innovative solutions. This is being partially accomplished through the crop breeding programs, water management research, the introduction of new drought tolerant crops, and conservation practices.

Targeted grazing (TG) will increase the competitiveness of Montana lamb and wool in world markets. Wool research is designed to develop, evaluate, and implement tools and technologies for improving the quality, marketing efficiency, and international competitiveness of U.S. wool. Investigators established studies to define grazing parameters in rangeland that maintain profitable agricultural enterprises while sustaining ecological systems. Ranching enterprises are important to the preservation of wildlife habitat, and research shows manipulating cattle grazing patterns can protect and improve fisheries and wildlife habitats.

The "Mother Nature Network" selected the new bachelor of science degree in sustainable food and bioenergy systems from MSU as one of the top ten best college environmental programs in the U.S. The degree offers four specific options: 1) agroecology, 2) sustainable crop production, 3) sustainable food systems, and 4) livestock production. The program includes courses in the Colleges of Agriculture, and Education, Health, and Human Development. Students work at a 2.5 acre vegetable farm that is part of the College's agricultural research program and participate in internships on small farms in the Gallatin Valley. After graduation the College expects students to land jobs in sectors like food safety, local production, food systems, and agricultural biosecurity. Enrollment is currently at 174, and the program saw its first twelve graduates in 2012.

Program #4 Global Food Security and Hunger - Integrated Pest Management (IPM)

Situation: Weeds, diseases, and insects continually challenge Montana producers who are often producing crops under less than ideal conditions. Montana's stakeholders need new and improved methods for controlling insects, weeds, and diseases. Comprehensive programs have been established at MSU to investigate low impact control options and to promote sustainable practices utilizing biological controls. Difficult-to-control pests require producers and researchers to evaluate new IPM methodologies to maintain a competitive position in U.S. and world markets while helping to alleviate global hunger. The increase in public concern about food safety, food quality, cost, natural resource biodiversity, and sustainability and quality of soil, air, and water resources is mandating less reliance on traditional pesticides and research into more environmentally friendly systems, including biological controls and organic production.

Invasive weeds are one of the greatest threats to rangeland health. The ecological impacts of rangeland weeds are complex, but researchers believe weeds alter the structure, organization and function of rangeland plant communities by threatening biodiversity and displacing native plants, hence impacting wildlife and livestock. Disturbances like fire, overgrazing, and drought often result in an increase in weeds.

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

Inputs: Summaries of survey information from the Montana weed coordinators have identified critical research needs in the management of invasive plants on private, public, and agency lands. This has led to new state funding, research, and educational initiatives that align with the multi-agency and citizen supported Montana Weed Management Plan. The source of funds contributing to the research conducted include: Montana crop and animal agricultural groups, Montana Ag Business Association, Montana Department of Agriculture, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, other states, private donations, private industry, Sustainable Agriculture Research and Education (SARE) program, and USDA. Stakeholder input was collected in county and reservation sponsored input meetings, listening sessions during pesticide applicator education programs, and a Farm Bill Forum. The development of more environmentally-friendly chemical and non-chemical alternatives requires on-going interaction with chemical and biological pest control product manufacturers, state and federal agencies, and researchers in other states.

Research Activities: Integrated Pest Management research activities focused on both rangelands and croplands throughout the region. Reducing all input costs in farming operations continues to be a top priority for COA/MAES researchers. Researchers conducted experiments with pulse crops, tillage operations, and biological control agents all to develop better pest management systems.

An important development in 2012 was the confirmation of glyphosate-resistant kochia populations in Montana. Kochia is especially troublesome in wheat-fallow cropping systems, because it spreads quickly. Researchers are working with farmers in Montana to educate them on herbicide-resistant kochia management.

Researchers continued exploring targeted sheep grazing as an economical and ecologically

sustainable tool to manage lands with large infestations of invasive plants. Research findings this year supported the suggestion that August is the optimal time to prescribe sheep for spotted knapweed. The increased consumption of the knapweed in August versus July suggested either the knapweed was preferred in August or the ewes were becoming adapted to it.

MSU COA researchers are also exploring biological control agents for Russian knapweed, hoary cress, invasive hawkweeds, and rush skeleton weed. Invasive plant species are a serious economic and ecological problem for range and forested lands. Research projects contributed to the selection of potential new control agents and an increased understanding of how to use them. Scientists introduced three new insects into Montana for controlling Russian knapweed and orange hawkweed: *Jappiella ivannikovi* (a gall midge) and two stem galling wasps. Researchers released 20 gall wasps in 2009 and found an equal number of galls infesting the Russian knapweed. Since then, the numbers have increased exponentially with thousands of galls present in 2012.

During the 2012 field season, researchers completed experiments quantifying the impact of management on both target species (spotted knapweed, cheatgrass, Canada thistle and Dalmatian toadflax) and non-target species.

Montana wheat growers estimate losses of up to \$100 million worth of grain per year to the wheat stem sawfly. The wheat stem sawfly (*Cephus cinctus*) is one of the most important insect pests of agronomic crops in Montana and cannot be effectively managed using conventional tools or agricultural practices. Current management is based primarily on the adoption of solid-stem cultivars that offer partial resistance. Research activities include investigating the sawfly's chemical ecology, and evaluating host plant resistance, pathogens, and cropping strategies. The research results indicate the complex interactions in managing sawfly make a total systems approach necessary to reduce damage to small grains. MSU is examining the integration of natural enemies, pathogens, cultural practices, and plant and insect produced odors for management of sawfly and is developing new sources of host-plant resistance.

Lepidopterous insects represent one of the largest insect pest groups of food and fiber crops worldwide. Sex pheromones have been identified from hundreds of moth species and are used in IPM programs as lures to monitor and trap pest species and to disrupt mating. A research study identified and characterized the odorant receptor proteins from male moth antenna that detect the female produced sex pheromone.

A multistate partnership focuses on insecticidal and non-insecticidal approaches in laboratory and large scale field trials. The primary focus of entomological research will be to ensure reduction of grain storage losses at a lower cost than conventional chemical methods with less reliance on chemical intervention.

MSU's Seed Laboratory provided testing and information on seed quality for state and federal agencies, private seed companies, farmers, and ranchers. The service provided by the laboratory helped maintain high quality in the seed industry throughout the Rocky Mountain region and the Great Plains.

Program #5 Global Food Security and Hunger - Plant Breeding, Genetics and Genomics

Situation: MSU is a recognized international leader in the development of new cultivars of small grains sought by global buyers. The MSU wheat breeding programs are important to Montana agriculture, and an aggressive plant breeding program ensures development of higher yielding, disease and insect resistant wheat and barley cultivars.

Montana farmers planted 2.2 million acres of winter wheat in 2012, ranking fifth in the United States for the number of acres planted, according to the USDA NASS, Montana Field Office. Three of the top four

varieties planted in Montana this year were developed by the MSU Winter Wheat Breeding Program. "Yellowstone," "Genou," and "Rampart" made up more than half of the total winter wheat acres planted. Winter wheat brings in about \$600 million in revenue each year to Montana and maintaining an adequate supply requires a rigorous breeding program to support the Montana wheat producers. The research team relies on a combination of field, greenhouse, and laboratory efforts for successful cultivar development.

Montana's spring wheat acreage during the past five years has ranged from 44 to 55 percent of the total wheat acreage planted. In 2012, Montana producers planted 2.9 million acres of spring wheat, up from 2.45 million in 2011. The state remains the second largest spring wheat producer in the country, according to the USDA NASS, Montana Field Office. "Vida," "Choteau," "Reeder," and "Corbin" accounted for more than 55 percent of all Montana's 2012 spring wheat acreage and two of them were developed by the Montana Agricultural Experiment Station. Hard red spring wheat is grown in all areas of the state, with more than 97 percent of the acreage on dryland.

The wheat stem sawfly, wheat rust diseases and leaf diseases including Septoria, remain threats to wheat growers in areas across Montana, and require the planting of resistant varieties.

Montana is recognized for production of high quality bread wheat, and this reputation is essential in maintaining domestic and foreign markets. The export trade in recent years has accounted for about three-fourths of the state's wheat market.

Researchers also evaluate germplasm and identify traits that produce wheat and barley cultivars to meet increasing world demands for quality, while maintaining yields for producers. Additional work in the development of alternative and pulse crops continued to produce new market opportunities.

Priorities: MSU seeks to maintain its role as a leading university in small grains genetics research. The agricultural community and allied industries depend on new cultivars to remain competitive in a global marketplace. Primary breeding objectives included increasing yield potential, improving winter hardiness, improving wheat resistance to sawfly, and enhancing dual-purpose end-use quality grains.

MSU's intensive genomic research continues helping Montana producers remain competitive and has provided improved cultivars adapted to Montana's climatic conditions and cropping systems. Continued productivity of the breeding program enhances understanding of the genetics of key traits and allows the development of new selection tools. The broader impacts of the work are a larger food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat.

The development of new, highly nutritious crop cultivars with characteristics that improve health and well-being are priorities at MSU. Researchers work to improve animal and human nutrition, add value to raw products, improve safety of products, and increase product development of biobased chemicals, fuels, lubricants, pharmaceuticals, and nutraceuticals.

Input: Recommendations and priorities are established by foreign trade teams, international trade missions, faculty, staff, and students. Farmers cooperated by providing dryland and irrigated fields for cultivar trials and by providing associated inputs. Research funding was received from the Montana Wheat and Barley Committee. The College applied for PVP Title V status on released wheat and barley cultivars, which in turn increased revenues for research. Partnerships have been created among producers, the agricultural industry, faculty, and other institutions in the region. Input from focus groups and meetings of stakeholders were used to identify strategies for marketing safe agricultural commodities and consumer products.

Research Activities: Montana crop producers want improved hard red and hard white winter wheat

cultivars adapted to Montana conditions and suitable for both domestic and export markets. Developing hard red spring wheat cultivars with excellent qualities will ensure Montana wheat retains or increases its share of Asian and domestic markets. The goals of selection are high grain protein and gluten strength, high flour extraction and low ash content, good dough mixing and bread baking quality, and superior noodle color and texture.

MSU COA researchers cooperated with entrepreneurs in the State to develop value-added wheat products for use in Montana and exported flours, pasta, baked goods, and organic products. Bread making characteristics, especially dough strength and extensibility, are considered when evaluating spring wheat cultivars. The Asian noodle market remains an important business thrust. The quality of noodles made from different wheat samples is evaluated on entries from nurseries. Research projects addressed the effects that modifying the starch biosynthetic pathway have upon grain hardness, milling quality, yield, and end product quality. In addition to improved cultivar characteristics, researchers are evaluating more efficient screening, selection, and breeding strategies to maximize efficiency and genetic progress in breeding programs.

Barley research continued to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. The MSU barley improvement program uses quality field research technologies, extensive on-station and on-farm trials, and state-of-the-art genomics tools to develop well-adapted, high yielding barley cultivars for farmers in Montana and the western U.S. Barley cultivars with improved feed quality provide regional grain producers a marketing opportunity directed to beef producers.

Researchers with the Experiment Station continued improving crop lines for both food and forage uses. They made significant progress in four areas: peas and lentils, hooded barley, spineless safflower, and winter triticale. Researchers also successfully planted Austrian winter, green, and yellow peas during the fall planting with several consecutive successful harvests. Scientists selected improved hooded hull-less barley lines for forage and grain production with higher levels of beta-glucan, a soluble fiber. Developing shorter season safflower offered another rotational crop producers can market as bird seed, cattle forage, and upland game bird habitat. The triticale, a cross between rye and wheat, offers producers an alternative forage crop that also has good potential for food as it is often found in seven grain breads and grows well in Central Montana.

New crop research and development aimed at celiac disease sufferers continued as researchers pursued Timtana, Camelina, Montina, and Proatina as potential grains for a celiac diet. This activity led to increased sales and increased acreages of each grain. A researcher spoke at the last seven national annual meetings of the Celiac Sprue Association. As specific enzyme and DNA tests are now available, the number of people that are aware of their celiac disease has increased in the past five years. The outputs in this project are several advanced lines of *Avena nuda* that are gluten-free and selected for both agronomic potential and for high protein. These have the potential to being higher in nutritional value than current oats for human use (bread, and breakfast cereal and as a feedstock for gluten-free malt). The oats now are on sale to the public and to bakeries (Proatina) by collaborating farmers in Montana.

Program #6 Sustainable Energy

Situation: The development of biobased alternative fuels is a priority to reduce U.S. dependence on petroleum-based fuels. While current fluctuations in the prices of oils and fuels produced from crops (especially corn, soybeans, and oilseeds) are creating uncertainties in the development of processing plants and in incentives for growers, long-term opportunities continue to be promising. Corn grain is the major feedstock for fuel ethanol production in the U.S., yet little corn grain is produced in Montana. MSU initiatives in the development of sustainable energy alternatives primarily rely on oilseed crops (camelina, safflower, canola, and soybeans) to provide opportunities for creating renewable biobased products.

Priorities: The goals identified in the 2012 Plan of Work were to improve the quality and diversity of agricultural commodities, expand production and pest management strategies with reduced inputs, identify and develop new Montana crops, and develop biofuels and energy alternatives. Researchers concluded that increasing productivity in a biobased economy, would positively impact manufacturing, product development, rural development, job opportunities, and farm and ranch incomes. The Montana State University COA and MAES planned to lead this project, providing administration and research expertise for product development, enterprise budgeting, and marketing.

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

Research Activities: While many projects were terminated due to market considerations (petroleum costs and camelina), there are still several ongoing research projects impacting sustainable energy. Through various projects researchers strive to increase the profitability of Montana agriculture and reduce reliance on non-renewable energy sources. The primary objective of COA/MAES research is to develop value-added, agriculturally-based end-use products that are suitable for production in rural Montana. We conducted research that is innovative and responsive to the needs of the region by: 1) developing value-added end-use products with a competitive edge; 2) enhancing agricultural production approaches; 3) establishing biobased products; and 4) conducting outreach activities related to biobased products and food science for producers and agribusiness.

MAES researchers have been instrumental in identifying potential oilseed crops suitable for production in Montana for use as culinary oils, biolubricants, omega-3 oils, feeds, and production of biodiesel and bioenergy products. Oilseeds (including camelina, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of oils. Initiatives will provide new insights into the use of vegetable oils as feedstock for fuel cells, the development of new wheat cultivars for the production of ethanol, non-corrosive biobased de-icers, and the optimization of ethanol production from other feedstocks, such as barley straw. New oilseed crops and cropping systems are being evaluated to produce low cost feedstocks for biodiesel production. A dual-purpose forage crop study for bio-ethanol feedstock and for livestock feed has been completed, and a new oilseed-cereal rotation project was initiated to investigate the cropping systems for oilseed biodiesel feedstock production. Investigators are continuing to evaluate barley straw as a feed stock in ethanol production. Barley straw contains a large quantity of fructan (polymers of fructose). Researchers hope this process will permit on-farm straw-to-ethanol production for regional barley growers.

Program #7 Childhood Obesity

The Montana State University College of Agriculture does not have formal childhood obesity programs in Montana and no activities were included in the 2012 Plan of Work. However, researchers at the COA are working on crops that deliver specific value-added products to consumers, often to specific health-based consumer groups such as celiac disease sufferers and this will be reported on in the upcoming Annual Reports.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	339.1	0.0
Actual	0.0	0.0	311.5	0.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- Internal University Panel
- External Non-University Panel
- Other (Dept. Head External to PI's Dept.)

2. Brief Explanation

Department heads with the MAES and COA review Hatch Projects at the department level. A committee of peers then reviews the project and passes it to the director for final approval. The MAES director's office ensures this process is done as efficiently as possible. The peer review committee, selected by the director after consultation with COA department heads, includes the principle investigator's (PI) department head, MAES administrator, one department peer reviewer and two additional faculty external to the PI's department. Researchers present seminars to the review committee and interested stakeholders, including faculty, staff, students, and constituents. The director requires researchers to propose new projects for a three year period, while researchers with favorably reviewed ongoing projects continue for five years. Because there are not any Montana Agricultural Experiment funds allocated outside of the COA, external expert reviews occur with Montana State University faculty external to the COA, as a requirement of the review process. Presenters announce all seminars ensuring broader attendance and input potential. Reviewers provide written recommendations on the following: relevance and importance of the project; relationship of the project to previous research; objectives; approach and methods; scientific and technical quality; resources; environmental, economic, and/or social impacts. The MAES administrator and department head share the responses with the PI. If the projects do not meet expectations the director will not approve them and will defer them until the researcher meets the key elements satisfactorily. Ultimately, the office staff submits the director-approved projects to USDA-NIFA for final approval.

III. Stakeholder Input

1. Actions taken to seek stakeholder input that encouraged their participation

- Use of media to announce public meetings and listening sessions
- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Other (Educational outreach programs)

Brief explanation.

The Montana Agricultural Experiment Station (MAES) and COA obtain stakeholder input on research priorities and programs. Stakeholder committees include the sustainable agriculture focus group, MAES State Advisory Council, Ag Coalition and other state and local groups. MAES scientists routinely participate with this group and NRCS to provide training and expertise in the geospatial sciences. The Ag Coalition consists of representation from the Agricultural Business Association, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, Montana Water Users, Montana Wool Growers, Seed Growers, and the Seed Trade. It meets periodically with the dean and director to review program priorities, new initiatives, fundraising efforts, and legislative activities. The College advertises the meetings via news releases, newsletters, individual letters, and announcements at group meetings. Extension agents use county profile information to ensure those invited to the sessions reflect the diversity of the area. The MAES responds to stakeholder inputs by considering their proposals at research planning meetings with scientists, advisory groups, and administrators. Administrators solicit stakeholder input at the strategic planning process and as programs are developed, implemented, and sometimes redesigned. Local advisory committees to the research centers also provide annual and long-term guidance to the College and MAES.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Open Listening Sessions
- Other (Volunteers, membership on agriculture association boards)

Brief explanation.

The seven agricultural research centers have local advisory groups that meet multiple times per year. In addition, a State Advisory Council meets three times each year to discuss program focus and direction, Montana legislative priorities, and productivity/impact. These meetings are open to the public. Administrators and faculty in the COA serve on agricultural association committees that annually direct and fund research activities. These committees use a variety of collection methods, but the most common are face-to-face meetings, telephone, and some video teleconferencing.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Meeting with the general public (open meeting advertised to all)
- Survey specifically with non-traditional groups

Brief explanation.

Through direct participation with agricultural stakeholder groups, broad participation in committees, and directed meetings, MAES listens to and considers defined problems or questions that the research programs can address. The director targets selective meetings with non-traditional groups. Montana has an open meeting law. Therefore, all meetings are open to the public and the organizer must publish an agenda.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Research Programs
- In the Staff Hiring Process
- To Set Priorities

Brief explanation.

As a Land Grant Institution Montana State University has a solid foundation of past and future program activities that allow stakeholder input and strong interactive dialogue, and the COA and MAES clearly sets the tone for this interactive environment. The College and the research centers serve as the primary conduit for connection and delivery of education and new knowledge in agriculturally-related activities throughout rural Montana. Advancements in the Animal and Range Sciences Department provide an example of how stakeholder input resulted in specific actions. Stakeholder requests for a more comprehensive beef, cattle, and genomics program resulted in:

- A state-of-the-art Animal Bioscience Building built in 2010
 - Three new full-time faculty positions in Animal and Range Sciences
 - New equipment
 - The new equipment includes a:
 - Ion Torrent Personal Genome Machine for profiling genetic information taken from livestock samples
 - Illumina MiSeq which collects specific information from multiple DNA molecules helping scientists study microbial life in a sample
 - Maxwell 16 (a machine which extracts nucleic acid and runs 16 DNA samples at a time)
 - Polymerase chain reaction machine
 - Refrigerated micro centrifuge
 - Computer bio-analyzer which measures RNA and DNA samples
 - Necropsy down-draft tables for laboratories complete with ceiling cameras
- The Land Resources and Environmental Sciences department had a comprehensive external review and the College is actively working on the recommendations from the review with particular emphasis on reshaping the undergraduate curriculum to include core competencies, and exploring stakeholder interactions.

COA researchers launched a stakeholder driven project studying Tall Buttercup, a newly listed noxious weed in Montana that is posing problems for producers in western and southwestern Montana. Found primarily in wet hay meadows, there is little information about tall buttercup currently available, but producers are concerned because it is toxic and appears to reduce forage production. The Madison County Weed District and local producers approached the COA/MAES about helping them manage the buttercup problem.

Brief Explanation of what you learned from your Stakeholders

Stakeholders play a key role in our programs, and they are pleased with the direction the College of Agriculture and the Montana Agricultural Experiment Stations are going. During recent legislative hearings key stakeholders repeatedly testified about the College and MAES research accomplishments from integrated pest management and the wheat breeding program, to the excitement generated with the application of latest molecular technologies towards agricultural and natural resource systems.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	2701835	0

2. Totaled Actual dollars from Planned Programs Inputs				
Extension			Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	2102204	0
Actual Matching	0	0	12534085	0
Actual All Other	0	0	16411931	0
Total Actual Expended	0	0	31048220	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	0	0	1570619	0

V. Planned Program Table of Content

S. No.	PROGRAM NAME
1	Climate Change and Environment
2	Food Safety -- Animal Health
3	Food Safety -- Sustainable Agriculture
4	Global Food Security and Hunger -- Integrated Pest Management
5	Global Food Security and Hunger -- Plant Breeding, Genetics and Genomics
6	Sustainable Energy
7	Childhood Obesity

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Climate Change and Environment

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources			5%	
102	Soil, Plant, Water, Nutrient Relationships			15%	
111	Conservation and Efficient Use of Water			10%	
112	Watershed Protection and Management			10%	
121	Management of Range Resources			10%	
122	Management and Control of Forest and Range Fires			5%	
132	Weather and Climate			5%	
133	Pollution Prevention and Mitigation			5%	
136	Conservation of Biological Diversity			10%	
201	Plant Genome, Genetics, and Genetic Mechanisms			10%	
216	Integrated Pest Management Systems			10%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	9.7	0.0
Actual Paid Professional	0.0	0.0	53.3	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	360281	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2494244	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2464503	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research included looking at carbon sequestration in rangelands and croplands, the movement of energy and materials through agro ecosystems, and microbial ecosystems.

Researchers evaluated new crops and cultivars suitable for a warmer and drier climate and continued investigating practical approaches to carbon sequestration. Micro meteorological tools are providing accurate measurements of ammonia gas losses from the soil. This study includes field trials at six different sites. A new website was developed to measure and share information regarding the potential of soil to sequester carbon in response to changes in cropping systems. Two investigators are working on the Big Sky Regional Carbon Sequestration Partnership - Phase III Terrestrial Group. The grant was awarded fall 2012 and they are facilitating farmer interaction and field records, biomass measurement, and sample location. This is also the first year of a grant to use cover crop mixtures to improve soil health in low rainfall areas in the Northern Plains.

Research on the microbial mat communities in YNP continue to reveal enormous diversity of highly adapted microorganisms in natural thermal systems and their biotechnological potential. In 2012 researchers focused on a bar-code analyses that provided a robust demarcation of species populations and their distribution and responses to environmental change. Observations will help scientists understand the basis for efficient light utilization and CO₂ sequestration in the microbial community. This will then help the research program outcomes with bioenergy development.

An investigator in the Animal and Range Sciences department created a riparian rehabilitation guide for private and public land managers and distributed 700 in four counties in Montana. The investigator then hosted several workshops to explain how to rehabilitate degraded riparian areas.

As the demand for water increases and resources decline, researchers are designing forecast and water management models for watershed and runoff controls. COA scientists focused on three activities: (1) the development and assessment of new hydrologic models for mountain headwater catchments; (2) developing methods for model calibration and Bayesian inference for hydrologic models; and (3) implementing methods for predictions and quantification of uncertainties in ungauged catchments.

2. Brief description of the target audience

- Montana agricultural community
- Private landowners
- Crop and livestock producers in Montana

- Fertilizer dealers
- State agricultural advisory committees
- State of Montana, Montana Department of Agriculture, Montana Department of Natural Resources
- Bureau of Land Management, US Forest Service, Natural Resources Conservation Service
- Montana Fish, Wildlife and Parks
- Non-government conservation groups
- Participants in extension and commodity group meetings, conferences, and field days

3. How was eXtension used?

Information generated from research resulted in a riparian rehabilitation guide for private and public land managers. Seven hundred copies were distributed to Cooperative Extension Agents and Conservation District Coordinators in Blaine, Hill, Phillips and Valley Counties. Distribution was followed with three workshops to introduce the guide and explain its use in rehabilitating degraded riparian areas. Completion of a second study has supplied foundational material for the revision of the USDA NRCS Technical Guide TR 1737-15 1998. Proposed revisions were submitted to the regional review team.

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1730	8000	25	0

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

Patent Applications Submitted

Year: 2012
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	5	25	30

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2012	42

Output #2

Output Measure

- MSU researchers shared their expertise on radio and television programs such as NOVA, NPR, Montana Ag Live TV, and other PBS programs increasing awareness and knowledge of critical research programs in this planned program.

Year	Actual
2012	10

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of new drought tolerant crop recommendations for Montana
2	Number of carbon sequestration technologies introduced

Outcome #1

1. Outcome Measures

Number of new drought tolerant crop recommendations for Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Scientists in Montana continue studying new crop varieties that can thrive under warmer and drier growing conditions. MSU breeders developed "Vida" as a drought resistant variety of spring wheat, and it was the top choice of growers in 2011 and 2012. Barley is expected to grow well in warmer and drier climates, and breeders are advancing new lines in field tests.

What has been done

MSU wheat and barley breeders completed a second year of a five-year study exploring how to improve wheat and barley in a changing climate. They introduced two new lines of spring wheat and explored approximately 50 elite lines of barley.

Results

Two new spring wheat were released "WB9879CLP" and "Silver" durum, as was a hard red winter wheat named "SY Clearstone." Although Montana experienced droughts throughout much of the state and struggled through a brutal fire season, the agriculture revenue for 2012 reflected a 14 percent increase from 2010. According to the 2012 Montana Agricultural Statistics the 2011 value of crop production increased to \$2.1 billion (19 percent above 2010).

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
132	Weather and Climate
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #2

1. Outcome Measures

Number of carbon sequestration technologies introduced

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

MSU researchers are interested in learning more about nutrient management and cycling in Montana soils and the potential of soils to sequester carbon in response to changes in cropping system practices. As no till cropping systems increase many growers no longer use intensive tillage practices to control weeds during fallow phases. The potential impacts of this research may become critical to Montana's agricultural community should trading of C credits become mandatory for carbon dioxide emitting industries in the United States.

What has been done

Researchers evaluated new crops and cultivars suitable for a warmer and drier climate and continued investigating practical approaches to carbon sequestration. Micro meteorological tools are providing accurate measurements of ammonia gas losses from the soil. This study includes field trials at six different sites. A new website was developed to measure and share information regarding the potential of soil to sequester carbon in response to changes in cropping systems.

Results

Two investigators are working on the Big Sky Regional Carbon Sequestration Partnership Phase III Terrestrial Group. The grant was awarded fall 2012 and they are facilitating farmer interaction and field records, biomass measurement, and locations to take samples. This is also the first year of a grant to use cover crop mixtures to improve soil health in low rainfall areas in the Northern Plains.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources

102	Soil, Plant, Water, Nutrient Relationships
112	Watershed Protection and Management
132	Weather and Climate
133	Pollution Prevention and Mitigation
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- Lack of full-time staff and part time assistants
- Major interruptions in program development

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Researchers quantified ammonia volatilization losses associated with surface-applied urea to no till winter wheat during cold weather months using a micrometeorological system to measure gas losses from the soil at six Montana farms. Findings show volatility is closely linked to surface moisture conditions at the time of fertilization and the amount of precipitation after fertilization. Adding at least 1/2 inch of water after fertilizing minimized ammonia volatilization. Researchers also concluded cold soil temperatures did not provide protection against large ammonia losses.

Adding the inhibitor Agrotain® to urea always reduced ammonia loss by approximately 66 percent compared to untreated areas. Total cumulative loss from Agrotain® treated urea averaged six percent of the applied nitrogen rate, a 64 percent reduction in volatilization compared with untreated urea. The cost of treating urea with Agrotain® was approximately \$55 per ton of fertilizer, an approximate 10 percent price premium to urea fertilizer, which was less than the potential savings of lost nitrogen.

Researchers disseminated the results to the agricultural community at grower meetings, Certified Crop Adviser meetings, industry conferences, and MAES field days. They also shared the information with agricultural professionals at the American Society of Agronomy National meetings. The investigator developed a web site to keep growers, agricultural consultants, and other interested parties up-to-date on the progress of the study. It is available at <http://landresources.montana.edu/ureavolatilization/>.

Results of a long-term study on linking upland plant community structure and riparian processes resulted in a riparian rehabilitation guide for private and public land managers. Experts in the riparian processes distributed 700 of the guides in four Montana counties and hosted several workshops to explain how to rehabilitate degraded riparian areas. Completion of a second study supplied foundational material for the revision of the USDA NRCS Technical Guide TR 1737-15, 1998.

Key Items of Evaluation

- MSU COA researchers advanced crop options for a warmer and drier climate:
 - Developed two new spring wheats varieties called "WB9879CLP" and "Silver" durum
 - A winter wheat, "SY Clearstone"
 - Increased planting of "Vida," a drought resistant variety of spring wheat which was the top choice for growers in 2011 and 2012
- Researchers developed and shared new knowledge about carbon sequestration
- Created a riparian rehabilitation guide
- Furthered research helping forests and rangelands with emphasis on whitebark pine and sage

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Food Safety -- Animal Health

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			10%	
301	Reproductive Performance of Animals			5%	
302	Nutrient Utilization in Animals			6%	
303	Genetic Improvement of Animals			5%	
305	Animal Physiological Processes			5%	
307	Animal Management Systems			10%	
308	Improved Animal Products (Before Harvest)			5%	
311	Animal Diseases			20%	
315	Animal Welfare/Well-Being and Protection			5%	
503	Quality Maintenance in Storing and Marketing Food Products			5%	
702	Requirements and Function of Nutrients and Other Food Components			5%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			5%	
802	Human Development and Family Well-Being			3%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities			3%	
804	Human Environmental Issues Concerning Apparel, Textiles, and Residential and Commercial Structures			3%	
902	Administration of Projects and Programs			2%	
903	Communication, Education, and Information Delivery			3%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	124.7	0.0
Actual Paid Professional	0.0	0.0	98.1	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	422998	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2941650	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	8283077	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Created easily accessible databases for researchers and producers making research results available
- Distributed research results at state conferences, field days, county meetings, and conventions
- Prepared research articles, fact sheets, and news releases for scientists and state media
- Held strategic planning meetings with state agricultural groups
- Developed systems enhancing food safety and agricultural security

2. Brief description of the target audience

- Crop and livestock producers in Montana
- State agricultural advisory committees
- Economic development groups
- Participants in extension and commodity group meetings, conventions, conferences, and field days
- State of Montana
- Montana Department of Agriculture, BLM, USFS, and other government entities
- Ranchers, seedstock industry, colleagues, and related stakeholders
- Montana Stockgrowers Association and the Montana Department of Livestock

3. How was eXtension used?

- In-State Extension
- Multistate Extension
- Integrated Research and Extension

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	689	81	201	0

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

Patent Applications Submitted

Year: 2012

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	0	55	105

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2012	7

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Identify critical infection and resistance processes
2	Number of ranches per year adopting enterprise management of animal health issues
3	Number of novel vaccines developed per year
4	Number of activities per year that prevent disease outbreaks or manage diseases of Montana livestock
5	Meetings that maintain or enhance Montana's presence in the production of quality meat products
6	Number of producers that participate in livestock tracking programs

Outcome #1

1. Outcome Measures

Identify critical infection and resistance processes

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

A leading scientist with Immunology and Infectious Diseases (ImID) stated digestive and respiratory diseases account for more than 50 percent of non-predator deaths in calves. Researchers must learn more about bovine specific immunity, so they can improve the effectiveness of vaccines. Current knowledge of protective immune responses is primarily based on work done in rodents and humans. While there are similarities with bovine immune responses, there are also clear differences. A key difference is in the immune cells: cattle have far more of a unique T cell called gamma/delta than humans and rodents.

What has been done

Researchers at ImID are studying these special cells which comprise a large percent of the infection fighting cells in cattle and play a vital role in immunology. Researchers are exploring both the compounds and the delivery methods. They want to develop products and procedures that are safe, simple, low cost, and will stimulate immunity in cattle. Researchers also studied the molecular interactions of rotavirus, and they are investigating the incidence and characteristics of Staphylococcus aureus cattle. This year they isolated a chemokine CCL28 that appears to play an important role in mammary immunity.

Results

Scientists are currently testing a compound, Amphotericin B, (AMB) in cattle. AMB is currently used to fight fungal infections in humans. Researchers are testing AMB in calves and dairy cows using different delivery methods like strips that dissolve on the tongue.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

301	Reproductive Performance of Animals
303	Genetic Improvement of Animals
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #2

1. Outcome Measures

Number of ranches per year adopting enterprise management of animal health issues

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Consumers are increasingly demanding more information about their food products, especially meat. Producers are therefore working to track their livestock from conception to consumption. Producers are focusing on genetics, disease identification and prevention, and better feed management systems. MSU studies help ensure Montana producers raise safe beef while improving the quality.

What has been done

MSU investigators education and research programs allowed producers to document best management practices for raising and marketing calves. The program provides quality assurance certification, implements and documents bio-security plans on ranches, and provides informational outreach. Sheep and wool producers continued using targeted grazing to increase the competitiveness of Montana lamb and wool in the world market.

Results

While difficult to quantify the number of ranches adopting enterprise management practices, we can report the number of inquiries just to one MSU beef cattle specialist. A researcher reached nearly 800 producers, industry participants and youth and addressed more than 90 inquiries from county agents and producers via phone and email on topics ranging from ration balancing to water quality and young cow reproductive performance. During legislative testimony producers repeatedly shared the impact COA/MAES research had on their operations and how new technologies were saving money and increasing agricultural product quality.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

Number of novel vaccines developed per year

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

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

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Animal losses due to environmental stresses, disease, and death create the need for an improved understanding of factors affecting Montana livestock. Infectious disease continues to cause considerable losses to livestock producers by reducing production and by reduced sales because of food safety concerns. Disease outbreaks are closely monitored in Montana to ensure quality and disease-free animals are shipped to other states.

What has been done

This year evaluations of insecticide products applied to sheep to suppress vector blood feeding (biting midges and mosquitoes) resulted in two effective synthetic chemical products that can be deployed in the event biological and climatological conditions suggest a high risk of an epizootic.

Results

The 2012 summer weather patterns were similar to 2007 when epizootics of West Nile virus and bluetongue occurred in the state. Based on surveillance collections, biting midges (bluetongue vector) and mosquitoes (West Nile virus vector) were increasing. MSU researchers and Montana Department of Livestock researchers formed a taskforce to address this concern and develop strategies for vector mitigation. Through a series of conference calls, they developed recommendations and shared the information with participants expected to attend the 2012 ram sale. Fortunately, bluetongue transmission was not detected, but several producers expressed appreciation for the alert and pro-active action taken by MSU and the state livestock department.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)

- 311 Animal Diseases
- 315 Animal Welfare/Well-Being and Protection

Outcome #5

1. Outcome Measures

Meetings that maintain or enhance Montana's presence in the production of quality meat products

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Quality meat production is critical for producers, processors, and consumers. Educational programs geared toward specific audiences enhance food safety awareness and increases the quality of meat products produced and processed in Montana.

What has been done

An MSU professor and beef cattle specialist administered the Steer of Merit program, providing feedback on youth beef cattle projects for youth, parents, beef cattle producers, and county agents. The state Steer of Merit Committee meets annually to set industry-reflective standards for the following fair season.

Results

In 2012, 890 carcasses were submitted to the state Steer of Merit program. Experts awarded SOM certificates to eligible carcasses and presented the top 5 awards in carcass and ultrasound divisions at the Montana Stockgrowers Convention in December 2012.

Two professors redesigned a university course in the Animal and Range Sciences Department to include social and video media. They incorporated agriculture and range science advocacy training into the course and as a result one of the three students is actively blogging in advocacy of beef cattle ranching and her blogs have been distributed to a wide audience. The blogs for the course can be seen at <http://msugradstudents.wordpress.com>.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
503	Quality Maintenance in Storing and Marketing Food Products
702	Requirements and Function of Nutrients and Other Food Components
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Number of producers that participate in livestock tracking programs

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

USDA has encouraged livestock tracking programs for producers as a national effort to mitigate transmission of disease and track animals if there is a disease outbreak.

What has been done

MSU researchers evaluated electronic identification tags and are now emphasizing DNA tracking in the sheep and cattle industry. MSU hired two faculty members in 2012 to enhance DNA and genetics management and a rumen micro-biologist. At the Northern Agricultural Research Center researchers evaluated 276 replacement heifers and developing bulls through the GrowSafe

System. Reproduction, longevity and RFI are evaluated and the data will be used for long-term tracking and monitoring of the livestock.

Results

The electronic identification tags resulted in approximately \$12 per head more income for producers in Montana. Through the use of EID tags producers are receiving carcass information and sometimes even feedlot information, allowing them to identify production characteristics for their herd and for individual bloodlines beyond typical ranch production traits. This information allows producers to position their production for the future and identify specific markets that fit their product.

4. Associated Knowledge Areas

KA Code	Knowledge Area
503	Quality Maintenance in Storing and Marketing Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

MSU COA and MAES experienced significant faculty movement impacting this planned program. Previous projects highlighted in the 2012 Plan of Work included extensive research into brucellosis and prion diseases. The principal investigators in these projects were recruited to larger institutions with significant salary increases, and these projects were terminated.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Montana has 2.5 times more cattle than people providing the foundation for the number one industry in the State - agriculture. It is in this context that researchers design, implement, and conduct research projects within the COA/MAES. Research in the Animal Health Program is critical to the industry in Montana and producers and consumers alike who count on the investigators to promote a healthy industry through their consistent research. Highlights for 2012 were:

- Advancements in knowledge of Staphylococcus Aureus in humans and livestock
- Hired new faculty members, two of which are core users of new molecular tools
- Evaluated 256 animals through the GrowSafe system and added new equipment to MSU research center doubling the capacity of researchers to evaluate residual feed intake
- Conducted webinars, workshops, and seminars to share up-to-date information on

animal health and quality assurance reaching audiences in excess of 1,500

Key Items of Evaluation

The Animal Bioscience Building combined with state-of-the-art laboratory equipment assisted in the successful recruitment and hiring of three new faculty members in the Animal and Range Sciences Department for the College of Agriculture. The new faculty include a beef geneticist, a range ecologist, and a rumen microbiologist. The College also purchased an Illumina MiSeq and is using it to help members of the Crow Indian Reservation identify sources of antibacterial resistant E. Coli.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Food Safety -- Sustainable Agriculture

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships			20%	
121	Management of Range Resources			10%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			5%	
211	Insects, Mites, and Other Arthropods Affecting Plants			15%	
212	Pathogens and Nematodes Affecting Plants			15%	
213	Weeds Affecting Plants			10%	
215	Biological Control of Pests Affecting Plants			5%	
216	Integrated Pest Management Systems			11%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			2%	
721	Insects and Other Pests Affecting Humans			2%	
722	Zoonotic Diseases and Parasites Affecting Humans			3%	
903	Communication, Education, and Information Delivery			2%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	83.6	0.0
Actual Paid Professional	0.0	0.0	80.9	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	579168	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	3072624	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	3077838	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Communicate research results through field days, news releases, fact sheets, research summaries, and presentations at county and state meetings and conventions
- Distribute results of research via the internet
- Hold strategic planning discussions with state agricultural groups including ag associations and federal and state land management agencies
- Conduct research experiments
- Provide training
- Maintain healthy partnership with College of Education, Health, and Human Development for Sustainable Agriculture Degree

2. Brief description of the target audience

- Alternative energy groups and state agricultural advisory committees
- Crop and livestock producers in Montana
- Montana Wheat and Barley Committee, companies, fertilizer advisory committees, equipment companies
- State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities
- Participants in extension and commodity group meetings, conferences, and field days

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1627	0	900	0

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

Year: 2012
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	3	13	16

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2012	21

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of interactive meetings with state groups and agencies
2	Number of producers per year implementing new farm management and budgeting practices
3	Increased number of new crops adapted to Montana through percent acres increased
4	Number of field days, news releases and presentations at conventions
5	Number of new producers per year adopting measures to improve agricultural efficiency (e.g. better seed quality, higher numbers of fields with soil tested, optimization of fertilizer use)
6	Increase in acres of non-traditional crops planted in Montana.
7	Number of routine field crop and forage samples processed by the MSU Seed Laboratory per year

Outcome #1

1. Outcome Measures

Number of interactive meetings with state groups and agencies

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

It is important to meet regularly with crop and livestock producers, wheat and barley committee, crop protection companies, fertilizer advisory committee, equipment companies, alternative energy groups, and state agricultural advisory committees to identify research and outreach needs for MSU COA/MAES.

What has been done

Producers, commodity groups, advisory boards, and industry hold annual meetings to present research results and to plan future research and outreach activities. Organizers conduct surveys so they develop research program that reflect stakeholder needs. In addition, resolutions are passed in numerous associations and approved by voting members providing direction to MAES.

Results

MSU researchers provide new small grain varieties and alternative crops to meet Montana producers needs. Researching new crops and finding new markets for existing crops are potential ways to enhance growth in sustainable agriculture. As technology advances and producers rely more on computer-aided information, the role of MSU research and outreach continues to grow in value and impact. MAES leaders use stakeholder feedback and input to refine and redirect research programs while providing realistic time frames for outputs.

As testimony to the support the Montana agriculture community offers and the value they place on MAES research, the Montana Farm Bureau passed a resolution recommending the Montana Legislature make a long-term commitment to adequately fund the Montana Agricultural Experiment Station and Extension Service. This is but one example of how sharing information with state groups and agencies increases sustainability support of Montana agriculture through research and education.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
121	Management of Range Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
721	Insects and Other Pests Affecting Humans
722	Zoonotic Diseases and Parasites Affecting Humans

Outcome #2

1. Outcome Measures

Number of producers per year implementing new farm management and budgeting practices

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Dryland wheat production characterizes a key agro ecosystem of the northern Great Plains (NGP) that is dependent on nitrogen (N) fertilizer. Future farming in this region under energy-constrained scenarios must focus on increasing the net gain associated with N inputs. A new class of crops, the pulses (annual grain legumes), are poised to play a major role in diversifying cropping systems in the NGP, due to their inherent profit potential, and due to farmer perceptions of meaningful N contributions to their wheat crops.

What has been done

The dominant variable energy input to crop production in the northern Great Plains is N fertilizer. This has raised a new awareness of soil N dynamics among wheat growers and led to an increase in legume crop production. Pea and lentil acreage has risen to nearly 500,000 acres in Montana from 2010 to 2012. Conclusions from an on-farm energy audit showed the largest energy effects from N fixing pulse crops are in the form of a 40 percent increase in wheat yields and a 15 percent decrease in N fertilizer requirements or need.

Results

Area devoted to pea and lentil crops increased in the NGP over the past decade and may increase further. There are two key limitations to using pulse crops to offset N fertilizer: 1) N contributions from pulse crops are difficult to estimate accurately, especially in the short term. It will be important to investigate pulse crop effects over time to better understand their role in conditioning cropping system energy budgets and changes in soil, and 2) perhaps more important, some areas within the NGP do not receive enough rainfall to permit annual cropping, and are reliant on fallow wheat systems. There may be an unmet opportunity to green fallow in a more sustainable fashion, with the use of annual legume green manures.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	1349000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

MSU researchers continue to develop and register new crops for Montana producers. The best measurement of success is in the number of acres devoted to new crops. Another measure is the

number of producers selecting plant varieties developed through the MSU breeding programs. Our spring and winter wheat breeding programs are prime examples of how new crops are regularly introduced to area producers.

What has been done

Montana farmers planted 2.2 million acres of winter wheat in 2012, ranking fifth in the United States for the number of acres planted. Three of the top four varieties planted in Montana this year were developed by the MSU Winter Wheat Breeding Program. "Yellowstone," "Genou," and "Rampart" made up more than half of the total winter wheat planted bringing in about \$600 million in revenue each year to Montana and maintaining an adequate supply require a high quality, outcome-based breeding program.

Results

Montana farmers selected several Montana varieties of wheat and barley. Following are a few significant crops developed through COA/MAES reflecting an increase in seeded acres from 2011 to 2012.

"Yellowstone" winter wheat increased from 380.9 (000)acres to 500.5 acres

"Vida", a spring wheat, increased from 553.7 to 559.2 acres

"Choteau", another MSU spring wheat, increased from 443.3 to 447.8

"Hockett" barley increased from 235.1 acres to 240.4.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

Outcome #4

1. Outcome Measures

Number of field days, news releases and presentations at conventions

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	22

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Sharing information is a critical function of the College and Montana Agricultural Experiment Station and one of the most popular ways to interact with stakeholders is through the annual field days. Additionally researchers have established a professional relationship with local, national and international media outlets and their valuable research has contributed to professional conferences around the globe.

What has been done

Critical information is shared on a regular basis with stakeholders through key events such as the annual field days in each of the research centers as well as regular press releases regarding critical information that must be disseminated in a timely manner. Examples of this are the confirmation of glyphosate resistant Kochia and concerns over a potential bluetongue outbreak. Media around the state are quick to assist researchers in sharing critical information.

Results

Researchers share expertise in a variety of ways including National Public Radio, weekly participation in a local PBS program called Montana Ag Live (spring and fall seasons) reaching nearly 10,000 viewers weekly, more than 19 international presentations, 7 videos for range management courses, and weekly articles in newspapers throughout Montana. Research projects were also shared with global audiences through the New York Times and Fox News.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
121	Management of Range Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
213	Weeds Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
721	Insects and Other Pests Affecting Humans
722	Zoonotic Diseases and Parasites Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Number of new producers per year adopting measures to improve agricultural efficiency (e.g. better seed quality, higher numbers of fields with soil tested, optimization of fertilizer use)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers are faced with ever increasing costs including seed, land, and fertilizer and chemical inputs. Maximizing efficiency is paramount for producers to remain in business and address consumer preferences. According to leading researchers with the Agricultural Economics and Economics Department nitrogen fertilizer prices continued to be exceptionally high and producers used more than 700,000 tons in 2011 and the expense to Montana producers went from \$158 million to \$347 million.

What has been done

Several researchers are investigating optimal use of fertilizer, tillage and crop rotation effect on N, and the impact it has on weed control and the final crop. MSU agronomists made hundreds of off-campus presentations focusing on new crop varieties, nutrient management concepts and pest management methodologies. Information was shared via formal presentations to growers, seed companies, and industry representatives as well as through field days, local fair booths, farmers markets, classroom instruction, and a variety of media outlets including new websites and online tools.

Results

Montana Agricultural Research Centers are sharing research advancements through traditional field days, while also using the latest computer technologies. Researchers at the Southern Agricultural Research Center developed a new online tool for producers to use when selecting herbicides. The agronomy decision tool helps producers select fertilizer, herbicides, and develop an irrigation schedule. The interactive table allows farmers to enter current crop data and the next planned crop along with a time schedule. By selecting specific weeds present in the fields, the program compiles data and offers users appropriate herbicide options. The intent is not to rank or recommend any particular herbicide, but filter out chemicals that don't fit the crop, rotation interval, or the weed spectrum.

4. Associated Knowledge Areas

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

Outcome #6

1. Outcome Measures

Increase in acres of non-traditional crops planted in Montana.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Researchers at the Central Agricultural Research Center continued improving crop lines for both food and forage uses. The superintendent summarized progress in four areas: peas and lentils, hooded barley, spineless safflower, and winter triticale. Researchers successfully planted Austrian winter, green, and yellow peas during fall planting with several consecutive successful harvests. Researchers encourage growers in Central Montana to try these fall plantings.

Results

Investigators selected improved hooded hull-less barley lines for forage and grain production with higher levels of beta-glucan, a soluble fiber. Developing shorter season safflower offers another rotational crop producers can market as bird seed, cattle forage and upland game bird habitat. In spite of safflowers coarse appearance, cattle find it palatable and it is highly digestible minimizing calf scours. Progress was also made with the winter triticale study. Triticale, a cross between rye and wheat, offers producers an alternative forage crop that also has good potential for food as it is often found in seven grain breads and grows well in Central Montana.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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{No Data} null

Outcome #7

1. Outcome Measures

Number of routine field crop and forage samples processed by the MSU Seed Laboratory per year

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	3718

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The MSU Seed Laboratory processed 3,178 samples in 2012.

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Successful pulse crop options encouraged producers to continue increasing their crop diversity.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MAES and COA investigators are participating in a myriad of studies aimed at finding optimal fertilizer and nutrient levels for soils and crops.

Researchers focused on pulse crops, mustard, safflower, sunflower, canola, turf grasses, and specialty grains. In 2011 and 2012, Montana was number one in the nation for pulse crop production with nearly 80 percent of the pulse crop acreage in Northeastern Montana where producers are planting on acreage that was previously left fallow for a growing season. An estimate from the Montana Department of Agriculture identifies the economic benefits attributable to the 2010 pulse crop at \$102 million including the money received from the pulse crop instead of fallow acres, and an estimate of the economic benefit the pulse crop had on the following wheat crop in terms of increasing yield and improving wheat protein levels.

Eighteen safflower varieties were released in the previous five years. Up to 100 high oleic oil safflower advanced lines and 100 high linoleic oil safflower advanced lines were grown annually in replicated dryland and irrigated tests. Approximately 1,000 safflower genetic lines were grown in summer nurseries at Sidney, Montana for evaluation of fatty acid composition, meal fiber content, meal protein content, disease resistance, biodiesel, bio-lubricant, cosmetic, high-end livestock nutritional supplement, and other value-added oil and plant characteristics.

Oilseed crops continue to represent new sources of income for farmers and provide opportunities for increasing crop diversity. Oilseed production was up again this year and researchers advanced projects looking toward using plant oils for industrial applications. Researchers identified genes responsible for directing polyunsaturated fatty acids into triacylglycerols in oilseeds.

Research information on water utilization and management in the Northern Rockies is limited, but investigators are evaluating riparian protection as a tool to protect and promote water quality.

Targeted grazing (TG) continues to increase the competitiveness of Montana lamb and wool in world markets. Montana ranks number eight in the nation for both wool and lamb production and produced nearly two million pounds of wool in 2012.

The Mother Nature Network selected the new MSU Bachelor of Science degree in sustainable food and bioenergy systems as one of the top ten best college environmental programs in the United States. Enrollment is currently at 174 and the program saw its first twelve graduates in 2012.

Key Items of Evaluation

Rapid changes in technology and globalization in the agricultural industry mean producers must have a greater understanding of technology, new farming practices, and a strong grasp of economics and budget practices. Researchers at MSU continue to support the needs of area producers through high quality research and constant interaction between investigators and growers.

Investigators are advancing knowledge in crop and livestock production through studies designed to measure inputs and outputs. Feed, fertilizers, crop selections and rotations, and integrated pest management; all enhancing sustainable agriculture which remains the number one industry in Montana.

Montana producers showed support of COA/MAES agronomists by selecting crop varieties developed through the MSU breeding program.

- Seeded acres (000) of "Yellowstone" winter wheat increased from 381 acres in 2011 to 500 acres in 2012.
 - Seeded acres of "Vida," a spring wheat, increased from 554 to 559 acres
 - "Choteau," another MSU spring wheat, increased from 443 to 448
 - "Hockett" barley increased from 235 acres to 240.
- Pulse crops hit a new high with nearly 500,000 acres making Montana the top pulse crop producer in the U.S.

Researchers shared their expertise with 925 elementary school kids in the Gallatin Valley alone and to nearly 400 students at two schools on Native American Reservations.

The B.S. degree in sustainable food and bioenergy was selected as one of the top ten best college environmental programs in the U.S. with 12 graduates this year and 174 current students.

MSU COA professors developed new teaching programs including a new online master's degree program in environmental sciences; a landscape design laboratory focusing on native plants and xeriscaping; expansion of hops and grape nurseries; flipped classrooms where students read the material and view an online lecture prior to attending class, so class time is devoted to student /faculty interaction; international and abroad studies focused on agricultural sustainability; and a new outreach program linking horticulture students to senior citizens interested in gardening and fresh produce.

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Global Food Security and Hunger -- Integrated Pest Management

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
136	Conservation of Biological Diversity			48%	
211	Insects, Mites, and Other Arthropods Affecting Plants			5%	
212	Pathogens and Nematodes Affecting Plants			5%	
213	Weeds Affecting Plants			5%	
215	Biological Control of Pests Affecting Plants			10%	
216	Integrated Pest Management Systems			20%	
312	External Parasites and Pests of Animals			7%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	54.2	0.0
Actual Paid Professional	0.0	0.0	3.8	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	57955	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	228174	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	39634	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Wrote and disseminated pest control recommendations
- Produced regional management guides
- Communicated research results through pesticide workshops and field days
- Used research results to support FIFRA Section 18c product labeling requests
- Updated pesticide applicator training materials
- Updated training materials for private and commercial pesticide applicators

2. Brief description of the target audience

- Crop producers, dealers, distributors, and crop protection company representatives
- Crop protection companies registration and research personnel
- Montana crop advisory boards
- Private and commercial pesticide applicators
- State of Montana, Montana Department of Agriculture, BLM, USFS, and other government entities

3. How was eXtension used?

COA and MAES researchers worked closely with county extension agents and outreach coordinators to disseminate timely and accurate information about integrated pest management topics and issues.

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1553	70000	400	0

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

Year: 2012
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	12	64	76

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2012	58

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Actual
2012	62

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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

Outcome #1

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	59

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

An increase in public concern about food safety, quality, cost, biodiversity, and sustainability and quality of soil, air, and water resources is pushing scientists away from pesticides.

What has been done

Researchers explored new and improved methods to identify and control insects, weeds, and disease challenging Montana farmers. They then conducted 37 face-to-face training sessions for nearly 3,000 members of the Montana agricultural community and 7 webinars for an additional 287 participants. MSU investigators shared low impact pest control options that promote sustainable practices utilizing biological controls.

Results

The MSU research, teaching, and extension team is bringing a real awareness to incorporating targeted grazing into farming systems. Researchers with the targeted grazing program spoke at seven locations educating 241 participants as to the benefits of the program, and they shared information at field days.

Researchers held a pest management tour and visited five locations accompanied by 225 producers.

The IPM instructors shared sustainable ag practices that will better manage diseases, insects, weeds and rodents. The training also focused on the safest and most effective ways to use pesticides.

4. Associated Knowledge Areas

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

Outcome #2

1. Outcome Measures

New IPM options discovered and evaluated per year

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers must continually improve pest management programs to increase productivity and profit. Consumers are demanding farmers use less chemical pesticides for food crops. Integrated pest management research also involves weed mitigation with researchers investigating both herbicides and biological control agents.

What has been done

MSU COA researchers are exploring biological control agents for Russian knapweed, hoary cress, invasive hawkweeds, and rush skeleton weed. Invasive plant species are a serious economic and ecological problem for range and forested lands. Research projects contributed to the selection of potential new control agents and an increased understanding of how to use them. They continued exploring targeted sheep grazing as an economical and ecologically sustainable tool to manage lands with large infestations of invasive plants.

Results

Scientists introduced three new insects into Montana for controlling Russian knapweed and orange hawkweed. Researchers released 20 gall wasps in 2009 and found an equal number of galls infesting the Russian knapweed. Since then the numbers have increased exponentially with

thousands of galls present in 2012.

Researchers confirmed glyphosate resistant kochia populations in Montana. Researchers are working with farmers in Montana to educate them on herbicide-resistant kochia management.

Research findings suggest August is the optimal time to prescribe targeted sheep grazing for spotted knapweed.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

Number of broad-ranging stewardship practices implemented

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Weed and insect control is critical to sustainable agriculture in Montana. As the climate changes, Montana is dealing with an increase in noxious weeds, rodents, and harmful insects that impact rangeland and cropland.

What has been done

Investigators focus on broad-ranging stewardship practices and emphasized quality educational programs for farmers and ranchers and other key stakeholders. Weed and insect experts traveled throughout the State offering courses on insect and weed identification, proper pesticide usage, and suggestions for targeted grazing practices. Researchers also made significant advancements

in sex pheromone receptor and wheat stem sawfly research. Advancements were also made toward integrating molecular research with applied entomology.

Results

New online information programs are including more data to assist farmers and ranchers with weed and insect identification. Researchers at MSU identified the molecular basis for evolving ligand specificity of a sex pheromone receptor. This data assisted in advancing the research toward better attacking the wheat stem sawfly.

4. Associated Knowledge Areas

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

Outcome #4

1. Outcome Measures

Passing rate percentage for pesticide application licenses

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Pesticide application training is important for disseminating new data and guidelines. The COA and the Extension Service work closely offering training and application licenses throughout Montana.

What has been done

MSU Pesticide Education Program administered a website which included 250 private applicator programs this year. These programs are meticulously reviewed before awarding continuing education credits awarded based on meeting the core pesticide education categories: pesticide

laws, integrated pest management, calibration, pesticides in the environment, the private applicator license, and pesticide safety. Without available credits private applicators may choose to spray pesticides without adequate training, or to not manage noxious weeds and insect pests through the use of pesticides.

Results

A total of 55 pesticide education presentations were delivered to 2,000 certified applicators across Montana at 42 locations. Presentations included topics of pesticides in the environment, IPM, calibration, pesticide safety, restricted use recordkeeping, mixing and handling, alfalfa weevil IPM, and pesticide poisonings. Fumigant education training targeted 150 applicators with an intense six hours of training. Two train-the-trainer programs targeted 50 local pesticide education trainers. There are approximately 6,600 private applicators this year in Montana.

Thirty-two applicators indicated they would change their behaviors as a result of the education. Changes included applicators protecting themselves and calibrating more often.

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

New products registered.

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Number of potential products/practices evaluated

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers and researchers are evaluating new integrated pest management (IPM) methodologies for controlling pests so they can maintain a competitive position in U.S. and world markets while helping to alleviate global hunger. It is important to develop new strategies in order for the pests to not develop resistance.

What has been done

Investigators evaluated biological control agents like *Muscodor albus*, a plant-swelling fungus, to treat diseases in potato and sugar beet crops. This biological control agent has the potential to replace harmful and toxic biocides currently used in agriculture. Continued evaluating targeted grazing and explored other biological control agents.

Results

This year a COA IPM specialist is credited with educating a field agronomist about stripe rust that was estimated to have impacted 48,000 acres. The advice and education has a predicted economic benefit to growers of \$4 million.

In Meagher County in 2012, a confirmed ID of cutworms in the area allowed a grower to receive a \$179,000 indemnity check, treat the problem, and replant a crop within 72 hours. In addition, the grower harvested an 80 bushels/A barley crop.

MSU COA IPM experts traveled extensively to deliver educational outreach related to cropland entomology. They wrote more than 25 Ag Alerts and several articles in regional magazines, educated growers about current grasshopper outbreaks, and posted four educational modules on the extension webpage. Coordinated and distributed 2000 copies of a Pulse Pest Calendar in Montana and North Dakota to growers and agricultural professionals.

Directly addressed 1,553 people in 21 presentations; 7 appearances on Montana Ag Live with an estimated 10,000 viewers/appearance.

4. Associated Knowledge Areas

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

The demands of producers who grow crops organically require innovative pest and fertility solutions often requiring biocontrols and alternative nitrogen sources. Organic farming and the introduction of non-traditional crops create a need for MSU researchers to delve into new approaches to crop management.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Investigators with the COA and MAES focused on identifying and managing weeds, insects, and diseases, so the agricultural community in Montana can better impact global food security. Field crops are an important foundation for the Montana agricultural industry and revenue exceeding \$2 billion in 2012. The most significant crop in Montana was wheat (5.4 million acres, \$1.4 billion) followed by barley (760,000 acres, \$143 million). The grain supports the livestock industry in Montana, and also the export market. A leading researcher shared that of the growers attending conferences on disease management and fungicide treatment options 65 percent could better identify diseases and had a clearer plan of how to treat them. Educating one field agronomist about stripe rust is estimated to have impacted 48,000 acres with an economic benefit to growers of \$4 million. A direct economic impact of recommendations from researchers at the MSU Schutter Diagnostic lab this year was approximately \$400,000 on 354,000 acres. Requests for assistance were lower, because it was a dry year with fewer disease outbreaks.

Researchers are investigating the sawfly's chemical ecology, and evaluating host plant resistance, pathogens, and cropping strategies. Researchers at MSU identified sex pheromones from hundreds of moth species and are using them to study and trap the insects and disrupt their mating by altering the odorant receptor proteins from male moth antenna.

Researchers are better understanding the diversity, distribution, and activities of pollinators (including alfalfa leafcutter bees) in natural and agricultural ecosystems. The goal is to better understand the value of pollinators and predatory insects in agricultural and natural ecosystems, the effect of land management practices on these insects, and their basic biology.

Integrated management of rangeland invasive plants is also critical. Economically, weeds impact rangeland more than all other pests combined, including billions of dollars spent on control and reduction in livestock and wildlife carrying capacity. Containing existing populations and restoring rangeland severely degraded by weeds is critical for the ecology and economics of Montana agriculture. This year two studies focused on

cheatgrass and how to control it as well as revegetation methodologies. Information was shared through workshops and field days with private and public land managers to improve rangeland health.

Key Items of Evaluation

Scientists introduced three new insects into Montana for controlling Russian knapweed and orange hawkweed: *Jappiella ivannikovi* (a gall midge) and two stem galling wasps. Researchers released 20 gall wasps in 2009 and found an equal number of galls infesting the Russian knapweed. Since then the numbers have increased exponentially with thousands of galls present in 2012.

Researchers at MSU identified the molecular basis for evolving ligand specificity of a sex pheromone receptor. This data assisted in advancing the research toward better attacking the wheat stem sawfly with odor traps and other devices.

An important finding in 2012 was the confirmation of glyphosate-resistant kochia populations in Montana. Kochia is especially troublesome in wheat-fallow cropping systems, because it spreads quickly. Researchers are working with farmers in Montana to educate them on herbicide-resistant kochia management.

Research findings this year supported the suggestion that August is the optimal time to prescribe sheep grazing for spotted knapweed. The increased consumption of the knapweed in August versus July suggested either the knapweed was preferred in August or the ewes were becoming adapted to it.

Researchers spoke to more than 70 participants in a post fire weed control workshop at the conclusion of a fire season in Montana that burned more than 700,000 acres.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Global Food Security and Hunger -- Plant Breeding, Genetics and Genomics

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			10%	
202	Plant Genetic Resources			15%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			15%	
205	Plant Management Systems			20%	
206	Basic Plant Biology			10%	
502	New and Improved Food Products			5%	
601	Economics of Agricultural Production and Farm Management			5%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			5%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	60.3	0.0
Actual Paid Professional	0.0	0.0	71.2	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	611800	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	3550796	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2456267	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Communicated information on plant breeding and genomics advances through classroom activities, field days, cultivar trials, news releases, presentations at county and state meetings, and conventions
- Released germplasm, new cultivars, and new genomics tools and techniques
- Conducted strategic planning with state agricultural groups
- Wrote technical and non-technical publications
- Established biobased product and food science education and research programs
- Enhanced partnerships among faculty across the Montana university system, producers, agricultural industry, and other educational institutions across the region
- Developed research summaries and fact sheets

2. Brief description of the target audience

- Domestic and foreign buyers of quality wheat
- Farmers, colleagues, and stakeholders
- Grain associations, Montana Department of Agriculture, Montana Wheat and Barley Committee, grain elevators, and state commodity groups
- Seed companies
- Crop and livestock producers in Montana
- State agricultural advisory committees
- Economic development groups
- Participants in extension and commodity group meetings, conventions, and conferences, and field days
- State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2200	50000	150	0

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

Patent Applications Submitted

Year: 2012

Actual: 2

Patents listed

A provisional patent, Production of high quality durum wheat having increased amylose content, submitted 9/24/2012, modified 11/29/2012

Provisional Patent: Creation of high molecular weight gluten in alleles with unique dough properties, submitted 10/1/2012

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	0	47	47

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Actual
2012	17

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Actual
2012	4

Output #3

Output Measure

- Number of research citations

Year	Actual
2012	123

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets
2	The number of new molecular techniques used to enhance breeding results
3	Average per bushel yield increase of Montana grains while maintaining product quality
4	Number of elite lines of wheat and barley screened for agronomic and quality characteristics
5	Number of improved cultivar recommendations by districts across Montana
6	Planted acreage percentage increase per year of new MSU-released small grains in Montana
7	Number of programs established to enhance global food biosecurity
8	Number of new food products created from Montana crops

Outcome #1

1. Outcome Measures

Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	37

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Grain producers in Montana rely heavily on MSU research results for the development of new genetics and cultivars adapted to Montana's climate. New disease and insect resistant wheat and barley cultivars with value-added traits are critical to producers in Montana. Disseminating timely and accurate information about crop selection and results is important in this time sensitive industry.

What has been done

Researchers at MSU developed an online interactive tool to assist growers in selecting proper crops by district. Producers have several input options and the computer assisted program will help them select the best crops for their region. Another new agronomy decision tool assists producers in fertilizer and herbicide selection as well as proposing appropriate irrigation schedules.

Results

Producers are using the tools and researchers are sharing information about how to best use them prior to crop selection. Information is posted on the sites regarding current analysis of new cultivars and crops along with the most current information on disease and insect resistant strains. The sites provide comprehensive information about new crop recommendations by district.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources

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

Outcome #2

1. Outcome Measures

The number of new molecular techniques used to enhance breeding results

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Advancements in technology allow scientists to discover new genotypes and breed for favorable traits while eliminating undesirable characteristics.

What has been done

Investigators completed complex field research experiments done with nearly 1,000 experimental lines of dryland and irrigated barley. Other researchers investigated molecular advancements in wheat and leaf rust resistance, and another identified a chromosome in wheat that affected green leaf duration after heading which may be important under drought conditions.

Results

The barley experiments have been genotyped using a specific marker system, and researchers will utilize the data from the barley experiments to determine how well genome wide selection works compared to phenotypic and marker-assisted selection. Researchers also developed a new through-put molecular marker for leaf rust resistance breeding and a strategy for studying genes in wheat seed development. They published numerous journal articles.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

Average per bushel yield increase of Montana grains while maintaining product quality

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana ranks first in the production of certified organic wheat and third in the U.S. for wheat and barley production. The grain supports the livestock industry in Montana and the export market. Barley has increased in popularity with Montana producers as the cost per bushel increased for feed and malt barley. Montana produced nearly 20 percent of the barley in the U.S.

What has been done

Investigators with the COA and MAES continued developing hard red spring wheat varieties for farmers and the wheat milling and baking industry. Montana producers planted 2.2 million acres of winter wheat in 2012, ranking fifth in the U.S. for the number of acres planted. Three of the top four varieties planted were developed by the MSU breeding program. Producers planted approximately 2.9 million acres of spring wheat in Montana in 2012.

Results

Durum, spring, and winter wheat yields dropped in 2011, and 2012 yield statistics have not been published. "Yellowstone," "Genou," and "Rampart" comprised more than half of the total winter wheat planted in 2012. Seeded acres of barley increased by 200,000 but yield dropped due to drought. Winter wheat yields were up an average of 0.73 bu/acre/cycle over 10 breeding cycles (2002-2011). Montana remains the second largest spring wheat producer in the country, according to the USDA NASS, Montana Field Office. "Vida," "Choteau," "Reeder," and "Corbin" accounted for more than 55 percent of Montana's 2012 spring wheat acreage and two of them were developed by the MAES.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	278

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The need for high quality grains increases as the world population grows, and global buyers are looking to Montana as an international leader in the development of new small grain cultivars. Global traders want high quality wheat to enhance food production in breads and noodles, and they are looking for disease and insect resistant plants with high yield potential.

What has been done

Spring wheat researchers screened 64 elite lines under dryland and irrigated conditions. Entries included new solid stem and stay-green lines, and lines with resistance to the orange wheat blossom midge, and hard white wheat lines. Winter wheat program researchers added 214 crosses with emphasis on disease resistance and adaptation traits. There are several new hay barley lines that have one more year of forage yield trials prior to release. "MT 103022" performed well in its first year of testing in the intrastate barley trial.

Results

Researchers planted the intrastate yield trial at eight locations with yields averaging 58 bu/acre. Seven hollow-stem, one solid-stem, and one "Clearfield" experimental lines were selected for further testing and seed stock purification. Twenty lines were selected for additional testing, and a 49 entry yield trial was planted and harvested and twelve solid stem lines were retained in upper level sawfly trials. 856 lines were evaluated for agronomic potential, 99 harvested, with 60 then selected for preliminary yield testing. These included four hard white and three two-gene "Clearfield" lines. They also screened for reliable grain yield and the plants ability to retain green leaves after heading. Winter wheat investigators added 284 crosses to the germplasm base,

emphasizing disease resistance and adaptation traits.

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

Number of improved cultivar recommendations by districts across Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	39

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana crop producers want products suitable to domestic and export markets. They want wheat varieties that can thrive under harsh growing conditions and are more insect and disease resistant. As the barley industry grows researchers at MAES and the COA are introducing new varieties that will grow under dryer and warmer conditions.

What has been done

The MSU Variety Release Committee released three hard red winter wheat varieties in 2012, "MT 03012" durum wheat, and a high amylose yellow dry pea. They recommended "W.B. Quake" a hard red winter wheat throughout Montana, "Imicht 97" and "Duclair" in dryland areas of Montana, and "Brennan" except in the north-east where it is recommended only under irrigation. "SY Tyra" was also added to the recommended list.

Results

A variety is eligible for recommendation when a minimum of 16 location-years of performance data is obtained from the MAES statewide performance trials. Test results must indicate the variety is equal to or superior in overall merit to specified check cultivars and has end-use quality equal to or exceeding currently recommended varieties. Recommendations are considered on a case by case basis. Yield performance is important, but also considered are test weight, grain protein content, disease and pest resistance and end-use quality data. In general, yield needs to be at least equal to currently recommended varieties in a particular district, unless the variety is being recommended for a specific purpose; such as, sawfly resistance.

4. Associated Knowledge Areas

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

Outcome #6

1. Outcome Measures

Planted acreage percentage increase per year of new MSU-released small grains in Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montanans place a lot of trust in Montana State University as a leader in small grain agriculture, and nowhere is it more evident than in seed selection. Producers each year request the latest information and seed options available, so they remain competitive in a tough global grain market.

What has been done

MAES and the COA released "Silver Durum," and two Clearfield hard red winter wheat varieties, "War Horse" and "Colter." In 2011 they released "Hockett" barley, three hard red winter wheat varieties ("Judee," "Bearpaw," and "Decade"), and a new red spring wheat named "Duclair." All of them were recommended in 2012 to districts throughout Montana.

Results

Field crop revenue for Montana in 2012 totaled \$2.1 billion with wheat the most significant. Montana producers seeded 2.1 million acres of winter wheat last fall for the 2013 crop year, down 200,000 acres or nine percent below the 2012 winter wheat planting of 2.3 million acres. The MSU variety "Yellowstone" continues as the highest yielding winter wheat line ever developed at MSU. "Judee" and "Bearpaw" solid stem semi-dwarf cultivars were released in the fall of 2011 and are expected to soon replace "Genou." "Genou" and "Yellowstone" have increased their yield per acres by 2.8 bu/acre and 6.7 bu/acre since 2007. Spring and durum wheat production were both up as was barley.

4. Associated Knowledge Areas

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

Outcome #7

1. Outcome Measures

Number of programs established to enhance global food biosecurity

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

Number of new food products created from Montana crops

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Discovering new ways to use products increases global food security and keeps consumers engaged. Consumers continue to want more local food options, and they are more interested in how and where it was grown.

What has been done

MSU researchers conducted studies on genes important to cereal grain quality and agronomic traits. In 2012, they completed five refereed journal articles with three appearing online and in press. Two others are in press and will be published this year. These manuscripts covered three main topics: plant productivity, grain hardness, and starch quality.

Results

MSU research continues to be featured in journals and publications throughout Montana and beyond enhancing knowledge for producers and consumers alike.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
502	New and Improved Food Products
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Montana experienced one of the driest growing seasons on record in much of Southern Montana, but overall had a successful year with the value of all wheat crops up 24 percent from 2011 to \$1.7 billion, according to USDA NASS, Montana Field Office. The all wheat season average price increased \$0.77 per bushel to \$8.45 per bushel.

MSU COA is not reporting on the number of programs established in 2012 to enhance global food biosecurity as accurate data is not available.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The development of improved winter wheat lines and cultivars continues with improvements in yield, disease resistance, and tolerance advances, combined with

improved stem solidness to combat sawfly. New challenges arrive, or former pests mutate to circumvent the remedies developed to thwart their damage and renew their attack on wheat and other crop species.

Montana's spring wheat acreage during the past five years has ranged from 44 to 55 percent of the total wheat acreage planted. In 2012, spring wheat accounted for 48 percent and durum 7.8 percent of the total wheat acreages. In 2012, Montana ranked second among the wheat and durum producing states. The wheat stem sawfly, wheat rust diseases and leaf diseases including Septoria, remain threats to wheat growers in areas across Montana, and require the planting of resistant varieties.

Hard red spring wheat is grown in all areas of the state, with more than 97 percent of the acreage on dryland. The largest concentration of acreage is east of the Continental Divide along the northern tier of counties. The highest producing counties in 2012 were Roosevelt, Valley, and Toole. More than 98 percent of durum wheat is also grown on dryland, and in 2012 the highest producing counties were Sheridan, Daniels, and Roosevelt in northeastern Montana.

"Yellowstone" and "Genou" (cultivars developed by the MSU research program) are the top two planted cultivars in Montana, accounting for about one million acres in 2012. Adoption of these cultivars by Montana wheat growers has resulted in harvest of an additional 21.5 million bushels of winter wheat over the past six crop years (2007-2012) based on production acreage and estimated yield gains over previously deployed cultivars.

Scientists developed improved winter wheat cultivars adapted to Montana cropping systems and climatic conditions. Through molecular and genetic research they discovered plants more resistant to the wheat stem sawfly and made significant strides toward introducing new rust resistant genes into Montana cultivars.

Researchers focused efforts on sugar beet and potato production and discovered biocontrol agents for different disease affecting these crops. The value of the canola crops and safflower increased significantly and producers ranked number one in the U.S. for the production of pulse crops.

The COA and MAES will continue to research and publish results for the agricultural community. New online tools provide immediate information regarding crop and seed recommendations, and researchers are working relentlessly to improve production and profitability of Montana crops.

Key Items of Evaluation

- "Yellowstone" and "Genou" (cultivars developed by MSU) were the top two planted cultivars in Montana, accounting for about 0.934 million acres in 2012. Adoption of these cultivars by Montana wheat growers has resulted in harvest of an additional 21.5 million bushels of winter wheat over the past six crop years (2007-2012) based on production acreage and estimated yield gains over previously deployed cultivars.
- Completed complex field research experiments with nearly 1,000 experimental lines of dryland and irrigated barley.
- MAES researchers developed and reported a new high throughput molecular marker for leaf rust resistance breeding and a new strategy for studying genes in wheat seed development.

- Researchers demonstrated two important mechanisms in plant triacylglycerol biosynthesis pathway that were published.
- Spring wheat varieties developed by the COA/MAES program were grown on more than one million acres. The two most widely grown varieties in the state, "Vida" and Choteau," were developed at MSU. In addition, two varieties developed by marker-assisted selection were marketed for the first time in 2012.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Sustainable Energy

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
511	New and Improved Non-Food Products and Processes			40%	
605	Natural Resource and Environmental Economics			40%	
903	Communication, Education, and Information Delivery			20%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	6.6	0.0
Actual Paid Professional	0.0	0.0	4.1	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	70002	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	246597	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	90612	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conducted outreach activities related to biobased products
- Developed value-added, agriculturally based end-use products
- Enhanced partnerships among faculty across the Montana university system, producers, the agricultural industry, and other educational institutions across the region
- Explored sustainable fuels from crops grown in Montana

2. Brief description of the target audience

- Alternative energy groups and state agricultural advisory committees
- Crop and livestock producers in Montana
- Economic development groups
- Participants in extension and commodity group meetings, conventions, and conferences
- State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	30	10000	0	0

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

Patent Applications Submitted

Year: 2012

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	5	5	10

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Actual
2012	1

Output #2

Output Measure

- Number of research citations

Year	Actual
2012	11

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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

Outcome #1

1. Outcome Measures

Number of biofuels developed from existing crops in Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Bioenergy alternatives will help reduce dependence on fossil fuels. Crops designated for biodiesel production include canola, camelina, and mustard. Scientists are studying new oilseed crops and cropping systems as viable options for biodiesel production. Research has shown camelina to be a promising dryland crop for use in biodiesel and other bioproducts.

What has been done

A researcher in the Central Agricultural Research Center is part of a multi-state project, "The Science and Engineering for a Biobased Industry and Economy." The Montana participants are interested in characterizing oilseed feedstocks for biodiesel production and utilizing co-products and/or by-products. Montana researchers studied camelina crops as a rotational crop with winter wheat and participated in a nitrogen input and harvest management study on CRP land investigating biomass yield and quality affected by N.

Results

Camelina has been identified as an oilseed energy crop for feedstock, but production systems need to be developed or optimized for economical and sustainable production of this crop. This study investigated the impact of camelina on winter wheat yield and system profitability while using camelina as a rotation crop for winter wheat. The study will answer the question if camelina can be grown as a rotation crop without an adverse effect on food crop production, which is the major concern for bioenergy feedstock production. Preliminary results have been presented at several conferences. CRP land has the potential to be used for biomass feedstock production. However, N management and harvest timing have not been studied. Results from this project will provide information of biomass productivity on CRP land in central Montana. Some results have been published in scientific journals and were presented at the Sun Grant Initiative National Conference.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Number of new crop options introduced for biofuels in Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

MAES did not have any new crop options introduced this year for biofuels.

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Research in sustainable energy is now conducted through non-MAES entities. MAES energy research will be incorporated into Climate Change and Environment, and Global Food Security: Plant Improvements, Genomics, and Products. We will not maintain sustainable energy as a planned program.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MAES and COA researchers will continue to grow oilseed crops, but their efforts will focus primarily on feedstock energy.

Key Items of Evaluation

Research in sustainable energy is now conducted through non-MAES entities. MAES energy research will be incorporated into Climate Change and Environment, and Global Food Security: Plant Improvements, Genomics, and Products. We will not maintain sustainable energy as a planned program.

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Childhood Obesity

- Reporting on this Program

Reason for not reporting

There were no planned activities in this area. The work on childhood obesity was primarily conducted by the MSU College of Education, Health, and Human Development whom do not have MAES support.

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
607	Consumer Economics			100%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	0.0	0.0
Actual Paid Professional	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
Actual Volunteer	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
1862 Matching	1890 Matching	1862 Matching	1890 Matching
{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
1862 All Other	1890 All Other	1862 All Other	1890 All Other
{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}

V(D). Planned Program (Activity)

1. Brief description of the Activity

N/A

2. Brief description of the target audience

N/A

3. How was eXtension used?

{No Data Entered}

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	0	0	0

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

Patent Applications Submitted

Year: 2012

Actual: {No Data Entered}

Patents listed

{No Data Entered}

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	0	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- {No Data Entered}

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

Outcome #1

1. Outcome Measures

{No Data Entered}

V(H). Planned Program (External Factors)

External factors which affected outcomes

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

{No Data Entered}

Key Items of Evaluation

{No Data Entered}