

2011 Montana State University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

The Montana Agricultural Experiment Station (MAES) and the Montana State University College of Agriculture (COA) remained highly engaged with the agricultural and natural resource communities in many innovative ways. Investigators explored new and enhanced varieties of spring and winter wheat, delved into pest management and continued with leading research in animal health, food safety, and food security. Researchers published their findings in traditional formats and took advantage of breakthroughs in technology and the internet making them a key component in the advancement of agriculture techniques and productivity throughout the world.

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 975,000 people inhabiting 93 million acres which equates to less than 7 people per square mile. Although the population is small, the state's commitment to agriculture is clear with approximately 29,000 farms and ranches comprising more than 66% of Montana lands. Montana prides itself on its agricultural roots and its commitment to leading researchers in the agricultural community. In 1893 the Agricultural College of the State of Montana boasted eight students all of which were male. Now in 2011 the Montana State University College of Agriculture has approximately 1,000 students and half are women. The college also experienced its fifth consecutive year of increased enrollment with student numbers not seen since the early 1980s.

Agriculture experts at MSU have the globe as their classroom through technology and direct participation in diverse overseas experiences. Given the opportunity to extend their learning outside the classroom students and faculty teach and learn in labs, 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 ranks 2nd in the U.S. in acres devoted to agricultural enterprises with annual crop and livestock cash receipts exceeding \$3 billion. Although Montana suffered a cold wet growing season throughout much of the region in 2011 the field crop revenue totaled \$2.4 billion. Wheat was the most significant crop at 5.4 million acres totaling \$1.4 billion in revenue. This was followed by barley with 760,000 acres and revenue of \$159 million. Montana ranks 3rd in the United States for the number of acres devoted to wheat production. The grain supports both the livestock industry in Montana and the export market. Farmers saw an increase in the production of garbanzo beans, potatoes, and canola in 2011. The state ranked 1st in the production of Austrian winter peas; 2nd in lentils, dry edible peas, flaxseed, and safflower; 3rd in the production of barley; 5th in sugar beets, canola, and garbanzo bean; 6th in the production of all hay; and in the top 10 for all dry beans and pinto beans.

Montana is among the top ten producers of beef cows and sheep in the nation and excels in honey production and wool. The value of Montana's livestock exports increased in 2010 to \$1.0 billion, a 14% increase from 2009. Cattle and calves represented 35.6% of the cash receipts in 2010 and was the highest of the livestock products.

Montana plays a key geographical role as the headwaters for the Missouri, Yellowstone, and

Columbia Rivers. While Montana remains committed to agriculture it is also keenly tied to tourism and the recreational activities centered on the waterways. Researchers in Montana work to balance the needs of agriculture and value-added activities with conservation, recreation and environmental issues so there will be enough water for everyone's needs. The State also plays host to two national parks which provide excellent research opportunities in the areas of climate change and food security.

Native Americans represent the largest group of potentially underserved citizens in Montana and comprise 6.4% of the state's population. MSU works with tribal councils, colleges in the Rocky Mountain region, and educators providing programs and educational opportunities for this group of Montana citizens. Cooperative efforts with MAES provide resources and training to Native Americans in the areas of livestock management, certification, childhood obesity, nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification, and social skill building. American Indian students enrolled in the College of Agriculture comprise about 7% of an increasing number of Native American students earning degrees at MSU.

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

Priorities of 2011: The Montana agricultural community worked together to reinforce ongoing priorities for 2011. 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 the 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

Several priorities overlap as investigators in various departments collaborate and share results to ensure 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 Plant 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 Western Triangle Advisory Committee. Members of these committees

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

Funding: Several sources fund MAES faculty research. They include: BIA, BLM, Canadian provinces, conservation and wildlife groups, Montana crop and animal agricultural groups, Montana Department of Agriculture, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, Montana Department of Transportation, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, NASA, NIH, NRCS, 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 agriculture 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 development and consumption, food security, safety, and hunger. Investigators in Montana are 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 so students will be marketable in traditional and emerging job markets. Outreach programs linked researchers with educators, stakeholders, producers, and consumers through face-to-face communication, print media, and electronic methods. Information technology specialists successfully completed a project linking all of the experiment stations throughout Montana with video conferencing capabilities. This allows the experiment stations 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.

Each of the seven agricultural research centers scattered throughout Montana hosted a field day 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 Animal Health

Situation: Animal health is economically essential to livestock producers who work diligently producing high quality, high profit stock. Promoting and maintaining animal health has led to advances in genetics and reproductive science and improved animal performance. Montana prides itself on being home to some of the greatest cattle and sheep operations in the United States, and also as a State with more wildlife than people. This brings about unique research opportunities as scientists balance health concerns of livestock, wildlife and consumers.

Investigators at Montana State University COA studied animal health and its impact on food safety through numerous studies exploring all aspects of livestock management from genetics research projects, disease identification and prevention, to animal breeding practices, reproductive sciences, and nutrition.

Studying infectious diseases is important to Montana researchers because of both the economic losses for producers and food safety concerns. Immunology and Infectious Diseases (ImID) focused on animal health, and particularly infectious cattle diseases. ImID and the Animal and Range Sciences department worked together on several research projects developing new drugs, vaccines, and diagnostic tools for fighting infectious diseases of livestock, humans, and wildlife, as well as zoonotic diseases that can be transmitted to humans.

Priorities of Research for Animal Health and Food Safety

- Develop effective livestock disease control methods
- Expand research on agricultural and natural resource interactions
- Improve beef production practices and evaluate genetics to improve herds
- Identify and mitigate the transmission of diseases between livestock and wildlife
- Increase traceability of livestock at minimal expense
- Implement targeted grazing strategies
- Nutritional impact of grazing on sheep and cattle

Input: Stakeholders provided input for the strategic planning process and offer valuable input. Stakeholders include the Northern Agricultural Research Center, the Montana Beef Council, Montana Wool Growers, Montana Stockgrowers, USDA-ARS, and other regional research programs.

Research Activities: Scientists with ImID utilize state-of-the-art molecular approaches to address basic and applied problems in infectious disease research. Richard Bessen is investigating agent-host interactions in prion diseases which are fatal neurodegenerative diseases. Prion diseases such as bovine spongiform encephalopathy in cattle, scrapies in sheep, and chronic wasting disease in deer and elk breakdown the central nervous system resulting in death. Researchers want to define the pathway of prion agent infection of skeletal muscle following oral prion infection, so they can better understand how the prion agent spreads within a host.

Montana researchers face the continued challenge of ensuring livestock and wildlife do not pass diseases such as brucellosis between each other. *Brucella abortus* remains a threat to the health and well-being of livestock in states bordering the Greater Yellowstone Area (GYA). Cohabitation of infected wildlife with cattle has jeopardized Idaho's and Wyoming's brucellosis-free status and now has compromised Montana's brucellosis status. Infected wildlife, including bison and elk, will serve as a reservoir for *B. abortus* unless wildlife and livestock experts can adequately manage the disease. David Pascual, a leading researcher at ImID, is studying a new vaccine that protected 75% of the treated animals. Previous livestock *B. abortus* vaccines have only been approximately 60% effective in cattle and wildlife. During the past year researchers continued improving the vaccines and formulating ideal dosages.

Sheep production is a valuable component of Montana agriculture and investigators made great strides in residual feed intake and genetics research. Producers gleaned important information from researchers regarding nutritional strategies to improve lamb production. The research compared low cost common feeds with higher cost options and found the low cost feeds were as beneficial as the more expensive options. Investigators also studied the differences in nutritional needs for ewe lambs during the first two years. They concluded the feed efficiency differences were more relevant for the lambs during active growth and for the yearlings during their maintenance stage. Researchers have also worked with area ranchers to better track the genetics of their herds. This tracking led to the Miles City Ram Sale being the top sale in the United States.

MAES investigators also made significant advancements in the traceability of livestock this year. John Paterson, lead investigator, provides a systems approach to help beef producers document "best

management" practices in raising and marketing calves. This program provides beef quality assurance certification, implements and documents bio-security plans on ranches, and provides educational outreach on topics such as disease management and cow/calf nutrition.

Dr. Patterson's electronic identification tags resulted in approximately \$12 per head more income for producers enrolled in the program. The average cost of participating in a source and age verification program was \$3 per head resulting in a \$9.83 per head profit.

Program #2 Climate Change

Situation: Montana, known for its rugged beauty and wide open ranges, also frequently makes national news because of its harsh and sometimes unpredictable climate. The Continental Divide runs north to south through the State and the rugged mountains often impact weather patterns resulting in very different conditions between the eastern and western parts of Montana. The average frost free zones vary throughout the state from 30 days to 125 days based on location and altitude. This alone plays a key role in crop selection and production in Montana.

Priorities: The agricultural community in Montana wants to add value to Montana's high quality crop and livestock systems as ongoing adaptations to climate change. Leaders in the agricultural community have prioritized research exploring new and alternative crop varieties and high yielding cultivars. Researchers are also studying how the climate is affecting native plants, insects, and wildlife.

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

Research Activities: Knowing that changes in the climate will impact agriculture, researchers at MSU COA and MAES are exploring new varieties of crops. Researchers made significant progress introducing new varieties of barley and wheat. Investigators expect barley, one of the most durable cereal crops, to perform exceedingly well in a drier, warmer climate. They continued exploring the vegetation and microbes growing in the thermal pools of the Yellowstone ecosystem. By studying the mechanisms of growth to native plants in geothermal-modified soils they gain a better understanding of limitations and opportunities increasing temperatures may present in agricultural production.

The changing climate has significantly impacted Montana insects which in turn impact the ecosystem. Researchers studied the biology, distribution, and systematics of insects this year. They trapped wood boring insects and found a large number of new specimens. While field researchers were collecting and identifying the new specimens, researchers at the Montana State University Entomology program processed 25 loans, accessioned new specimens, and installed new equipment as part of a project updating the entomology collection. Visiting scientists, researchers, extension personnel and students used the new collection to further knowledge and research.

The Montana landscape is changing along with the climate, and Montana scientists are concerned about the loss of sagebrush habitat due to conifer encroachment. Researchers collected data from three different areas in southwest Montana to determine the relationship between conifer and sagebrush. "Restoration Ecology" accepted the result for publication. Investigator Molly Runyon completed another range ecology study regarding beaver reintroduction. Researchers concluded beavers stimulated aspen growth, but ungulate herbivores prevented aspen recovery.

Program #3 Global Food Security and Hunger

Situation: The MSU COA and MAES looks outward with a keen awareness on global food security and a desire to stimulate research in the agricultural industry through dynamic and comprehensive rural leadership programs, technological advancements, and proven scientific and educational practices.

The College understands the need for research, education and extension to boost U.S. agricultural production and improve the global capacity to meet the growing food demand. In the 2012 Plan of Work MSU highlighted Global Food Security in two areas: Plant Breeding, Genetics and Genomics; and Integrated Pest Management. Research also focused on animal health which is critical to global food security and hunger.

Priorities: COA researchers in the Department of Plant Sciences and Plant Pathology at MSU explore the biology, genetics and biochemistry of diseases of small grains, along with fungal products, and the biological control of weeds and pathogens. These researchers studied plant breeding at a traditional level and at a molecular level paying close attention to both molecular biology and molecular genetics. Livestock researchers helped producers breed and raise the healthiest animal products, and they provided systems to better track the livestock from conception to consumer.

Input: Focus Groups, Montana Wheat and Barley Committee, multistate research committees, consumers in the food industry

Research Activities: Investigators made great progress in the exploration and development of new grain crops, and they gained significant advancements in pest management, and disease control. Researchers in the Animal and Range Sciences Department worked to develop systems that increased the traceability of sheep and cattle products so consumers would know more about the product they were buying. The College is reporting the specifics of research activities in the areas of integrated pest management and plant breeding in programs #4 and #5.

Program #4 Global Food Security and Hunger: Integrated Pest Management

Situation: An increase in public concern about food safety, quality, cost, biodiversity, and the sustainability of natural resources such as soil, air, and water quality is pushing scientists to rely less on pesticides and look for more environmentally friendly options. Researchers explored new and improved methods to identify and control insects, weeds, and diseases challenging Montana farmers. MSU investigators studied biological controls as low impact pest control options to promote sustainable practices. Producers and researchers are evaluating these new integrated pest management (IPM) methodologies so they can maintain a competitive position in U.S. and world markets while helping alleviate global hunger.

Priorities: IPM programs optimize grower profitability and natural resource sustainability through the development, selection, and implementation of economically sound and environmentally acceptable pest management strategies. MSU researchers explored less chemically dependent systems and are addressing the economic feasibility and environmental impact of biological controls and growth of organic systems. The COA and MAES taught growers more about crop rotation systems, crop production methods, and water management issues that help produce high quality crops and mitigate pest problems. Researchers are working with the Forest Service studying the impact of ecological and climate changes to pest management. By understanding ecological relationships researchers will implement more biological controls and science-based systems for pest management.

Inputs: Summaries of survey information from the Montana weed coordinators identified research needs in the management of invasive plants on private, public, and agency lands. This led to new state funding, research, and educational initiatives aligned with the multi-agency and citizen-supported Montana Weed Management Plan. Funding sources 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. Researchers collected stakeholder input in county and reservation sponsored meetings, listening

sessions during pesticide applicator education programs, and during 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: Research focused on how to control troublesome weeds and insects more effectively. Montana sheep researchers studied the impact of targeted grazing on noxious weeds throughout the region. Targeted sheep grazing is an economical and ecologically sustainable tool to manage lands with large infestations of invasive plants such as Dalmatian Toadflax. Investigators with COA and MAES worked with 1,000 private landowners, county weed supervisors, and public agencies to develop new sheep grazing protocols and projects.

While sheep grazing is effective, invasive plant species remain a serious problem on Montana's range and forested lands. Noxious weeds impact productivity and compromise the ecological integrity of all Montana's land. Researchers are investigating the use of biological control for the management of noxious weeds and especially the use of insects. Researchers are introducing natural enemies into the environment in an attempt to control the weeds. The USDA Animal Plant Health Inspection Service approved a specific gall wasp and a gall midge for field release, and investigators released gall midges in Montana and Wyoming. They are currently analyzing the data and rearing more insects for further releases.

Investigators studied insects helpful to agriculture as well as the community's greatest pests. They enhanced their understanding of the diversity, distribution and activities of pollinators, and also made significant advancements in handling troublesome moths and wheat stem sawflies.

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

Situation: As the third leading producer of wheat products in the United States, Montana, through MAES and COA investigators continued researching new and better varieties of wheat cultivars and made significant advances in both the spring and winter wheat breeding programs. The value of Montana's 2011 all wheat crop was down 2% from 2010 to \$1.3 billion, according to national agricultural statistics. But according to leading investigators with the COA, the yield of winter wheat improved an average of 0.73 bushels per acre per cycle from 2002 to 2011 resulting in improved yield potential of 7.3 bushels per acre since 2002. Researchers will continue developing new cultivars of small grains that are marketed globally.

Priorities: Researchers investigated high yielding crop varieties resistant to insects and diseases and that will perform well in the Northwest Region. The agricultural community and allied industries depend on new cultivars to remain competitive in the world marketplace. Primary breeding objectives include increasing yield potential, improving winter hardiness, enhancing wheat stem sawfly resistance, and improving dual-purpose end-use quality grains. MSU's intensive genomic research will help Montana producers stay competitive and provide improved cultivars adapted to Montana's climatic conditions and cropping systems. An increased understanding of the molecular biology and biochemistry of cereal grains will lead to the development of products more suited to the requirements of a competitive world market and help alleviate world hunger. Continued productivity of the breeding program will improve the understanding of the genetics from key traits and allow the development of new selection tools. The broader impacts of the work are a larger and higher quality food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat.

Input: Foreign trade teams, international trade missions, faculty, staff, and students establish funding recommendations and priorities. Farmers cooperate by providing dryland and irrigated fields for cultivar trials and by providing associated inputs. The Montana Wheat and Barley Committee competitively awards research proposals. The COA and MAES routinely apply for PVP Title V status on all released wheat and barley cultivars, which then increases revenues for research.

Research Activities: Investigators researched several types of winter wheat in 2011. For the fifth consecutive year, farmers planted more "Genou" wheat than any other variety, but it continues to be susceptible to stripe rust and the wheat stem sawfly. Researchers made excellent progress this year selecting more stripe rust resistant lines of wheat. "Yellowstone" yielded the most winter wheat ever in Montana according to lead investigator Dr. Bruckner who also oversaw the planting of "Judee" and "Bearpaw," both solid-stem semi-dwarf cultivars, in the fall of 2011.

Researchers advanced malting barley lines in 2011 and improved feed, hay, and food barley varieties. The hay barley project successfully developed high yielding high straw soluble carbohydrate lines, and researchers purified six lines from each of 30 families in 2011. Researchers have almost completed their food barley breeding effort. With the support of a major U.S. food company they developed several populations of hullless barley using "Prowashonupana" and several land race accessions from USDA's barley collection as donors of the high protein, high grain beta-glucan content trait. In 2011 Dr. Blake and a team of investigators advanced the best of these lines to statewide trials and conducted a large replicated yield trial consisting of 80 lines at the Bozeman Plant Growth Center.

Program #6 Sustainable Agriculture

Situation: Montana farmers and ranchers were "green" long before the phrase became part of America's vernacular. They have historically practiced sustainable production methods because of the difficult semi-arid and harsh climate throughout the state. Montana sustainable agriculture methods focus on pest control options, tillage programs, and crop diversity. Researchers are postured to identify and meet the needs of a global market in the food and fiber industry.

Priorities: Research conducted in sustainable agricultural projects support developing competitive, sustainable, and viable plant and animal systems for Montanans. To decrease Montana's primary dependence on small grains and forage crops, researchers explored the feasibility of growing a variety of crops including pulse crops (peas, lentils, chickpeas, and soybeans), herbs, mustard, safflower, sunflower, canola, turf grass, and specialty grains. Increasing crop diversity will improve the economic well-being of dryland agricultural producers in Montana and the Northern Plains. MSU research provides technology that improves plant and animal production systems while adding value and enhancing food security for stakeholders. Initiatives will provide new insights into food safety and risk assessment.

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 Advisory Committee, Montana Wheat and Barley Committee, Organic Certification Association of Montana, and state agricultural advisory committees. MAES and the COA will continue to host meetings, interviews, and focus groups to gather information from stakeholders, they will also use computer modeling and surveys to gather and compile data. The agricultural industry, faculty, and other regional institutions have created partnerships among producers that provide outreach activities related to bio-based products. Investigators use input from focus groups and stakeholders to identify strategies for marketing safe agricultural commodities and consumer products.

Research Activities: Maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policy. Montana agriculture scientists are vigilant about guarding limited resources, focusing on water issues, and developing crop and livestock systems that improve sustainability. Studies focus on how to produce the high yielding crops with minimal production costs and reduced environmental impact. Researchers in plant sciences continue to investigate crop rotations with winter and spring peas, canola, corn, lentils, mustard, sunflower, triticale, and chickpeas. Oilseed crops represent important new sources of income for farmers and provide opportunities for increasing crop diversity.

Montana livestock producers are using more targeted grazing and making advancements in the sustainable beef supply (SBS). Beef producers are more consumer-oriented with greater emphasis on documented management practices such as electronic identification.

Sheep producers made great advances in the fiber industry through advancing their sorting abilities for fiber width and marketing the finer wool to online manufacturers. The Objective Fiber Diameter Analyzer 2000 allows producers to sort fleeces at sheering. They can now immediately measure the wool fiber in microns and give the consumer the product they desire. Using the OFDA 2000 to sort the wool increases the marketing efficiency and international competitiveness of U.S. wool. Sheep ranchers are also using target grazing for weed control and fire mitigation. Research indicates that the sheep are helping restore the ecological balance in much of the state's rangelands.

Program #7 Sustainable Energy

Situation: Corn grain is the major feedstock for fuel ethanol production in the U.S., yet little corn grain is produced in Montana. Therefore 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 bio-based products. Researchers at MSU focused on how to do more in the agricultural industry with less impact on limited resources. Fuel costs are high throughout the U.S. and due to the geographical dispersion of population centers in Montana, agricultural producers here must develop the most fuel efficient operations. They also are trying to balance the use of chemicals with environmental needs, and focusing on water consumption, a key factor in the semi-arid Rocky Mountain climate.

Priorities: Researchers want 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. By increasing productivity in a bio-based economy, there is a positive effect on manufacturing, product development, rural development, job opportunities, and farm and ranch incomes. MSU COA and MAES are leading this project, providing administration and research expertise for product development, enterprise budgeting and marketing.

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

Research Activities: Researchers continued exploring new and diverse varieties of barley. Dr. Blake, a leading researcher at Montana State University, stated barley is primarily a public sector crop, because of the limited investment opportunities in the private sector in barley variety development. While barley seed sales typically generate little revenue, it is important to create and identify barley varieties that better utilize Montana's agricultural resources. As mentioned earlier, as climate changes the need for new varieties of crops will increase. Barley, the most durable and adaptable of the cereals, will likely see increased production in a warmer, drier world. The barley varieties the MAES produce are selected to be more productive and to produce higher quality grain in a drier climate.

Water is a valuable resource and with Montana serving as a "Headwaters" state it is essential conservation efforts begin here. As researchers explore drought resistant varieties of barley they strive to find the balance between rain fed and irrigated crop production systems in Montana, Idaho and North Dakota. The U.S. malting industry invested heavily in new malting plants in Montana and Idaho, and the industry demands barley of superb quality. Water is a limiting resource in the Northern Plains, and the plants use a lot of barley produced under rain fed conditions. Montana State University's collaborative program is increasing the reliability of rain fed quality barley production by producing varieties that better withstand drought stress. Researchers developed barley varieties with genes that tolerate stress during

grain fill and winter barley varieties that avoid late-season drought.

New agronomic practices that enhance the survival of winter barley varieties and evaluations of the pest and pathogen resistance of these potential varieties also helps MAES release new, improved varieties of barley. In 2009 MSU COA identified and characterized two barley genotypes that produce straw high in fructan, a water-soluble carbohydrate easily digested and fermented by the yeast, *Kluyveromyces marxiana*. Researchers constructed a pilot plant and are developing straw fermentation technology to determine its potential for on-farm fuel ethanol production.

"Hockett" barley is the most rapidly growing barley variety in Montana and the Northern Plains. This variety provides barley producers with lowered risk of rejection by malt barley buyers through its enhanced tolerance to moisture stress. Producers in southern Idaho are growing more winter barley varieties of "Charles" and "Endeavour." Collaborative winter and spring barley testing expanded, and trials of high straw soluble carbohydrate barley varieties permitted development of an estimate of the economic feasibility of on-farm fuel ethanol production utilizing the technology and germplasm developed in this program.

Additional research in 2011 focused on the use of native plants and grasses in the landscaping industry. Researchers identified and promoted native plants to consumers for landscaping. This practice promotes a natural ecosystem and requires less water than some of the more common domestic landscape options.

Researchers in the COA and MAES selected projects that would ultimately increase the profitability of Montana agriculture, reduce our reliance on non-renewable energy sources, and help ensure food safety and security in a growing world market. The primary research objective is to develop value-added, agriculturally-based end-use products suitable for production in rural Montana. Researchers here continue to develop products with a competitive edge, and enhance agricultural production approaches through bio-based product education and research, and by conducting outreach activities for producers and agribusiness.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	240.5	0.0
Actual	0.0	0.0	0.0	0.0

II. Merit Review Process

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

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

2. Brief Explanation

Department heads at 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 can have 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 every six months 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.

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

1. Method to identify individuals and groups

- Use Advisory Committees
- Open Listening Sessions
- Other (Volunteers, membership on ag. assoc. boards)

Brief explanation.

The seven agricultural research centers have local advisory groups that meet multiple times per year. In addition, a State Advisory Committee meets three times each year to discuss program focus and direction, 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 conferencing.

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 set 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.

Brief Explanation of what you learned from your Stakeholders

Stakeholders continue to 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.

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	2706731	0

2. Totaled Actual dollars from Planned Programs Inputs				
Extension			Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	1817813	0
Actual Matching	0	0	9074076	0
Actual All Other	0	0	18669914	0
Total Actual Expended	0	0	29561803	0

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

V. Planned Program Table of Content

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

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Animal Health

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			12%	
301	Reproductive Performance of Animals			5%	
302	Nutrient Utilization in Animals			11%	
303	Genetic Improvement of Animals			7%	
305	Animal Physiological Processes			4%	
306	Environmental Stress in Animals			2%	
307	Animal Management Systems			11%	
308	Improved Animal Products (Before Harvest)			12%	
311	Animal Diseases			21%	
312	External Parasites and Pests of Animals			1%	
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals			1%	
315	Animal Welfare/Well-Being and Protection			7%	
503	Quality Maintenance in Storing and Marketing Food Products			1%	
701	Nutrient Composition of Food			1%	
702	Requirements and Function of Nutrients and Other Food Components			1%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			1%	
902	Administration of Projects and Programs			1%	
903	Communication, Education, and Information Delivery			1%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Extension	Research
------------------	-----------------

Year: 2011	1862	1890	1862	1890
	Plan	0.0	0.0	82.5
Actual Paid Professional	0.0	0.0	112.5	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	454611	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2265977	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	9898787	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Developed and fielded databases for researchers and producers
- Distributed papers and research results at state conferences, field days, county meetings and state conventions
- Prepared research articles, fact sheets and news releases for scientists and state media

2. Brief description of the target audience

- Montana Department of Agriculture
- Animal health companies and state commodity groups
- Montana Stock Growers Association
- Montana Department of Livestock
- Montana Wool Growers Association
- Montana ranchers, seedstock industry, colleagues, and related stakeholders
- Wildlife management agencies

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2011	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	850	1300	0	0

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

Patent Applications Submitted

Year: 2011

Actual: 3

Patents listed

Allen Harmsen: US Provisional Patent Application, November 2011. No:61/556,647 "Protection Against Lung and Gastrointestinal Infections by Administration of Protein Cages Nasally, Orally, or Parenterally"
 David Pascual, Patent Number 7,910,113 issued March 27, 2011 "Tolerating Agents: Protein Sigma 1"
 Mark Quinn, Provisional Patent Application No.: 61/541,681 "Use of Acai Derived Polysaccharides to Counter Infection"

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	23	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations
 Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Building built through donations
 Not reporting on this Output for this Annual Report

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.

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
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

There is on-going concern about infectious diseases in livestock. In addition, there is also a global concern for the health of honeybees critical to the food supply and economy.

What has been done

The COA laboratory conducted experiments related to the interaction of *Nosema ceranae* and a previously unidentified DNA virus, identified by the Army's proteomics screen. Researchers used live honey bees to study the interaction between *Nosema ceranae* and the DNA virus and its impact on honey bee mortality.

Results

The study is offering new knowledge related to infectious agents influencing honey bee health. Researchers provided *Nosema* and honey bee virus handling training and honey bee inoculation training to other university students and beekeepers in the State. The target audience for this research includes national and international beekeepers, and the general public.

4. Associated Knowledge Areas

KA Code	Knowledge Area
308	Improved Animal Products (Before Harvest)
311	Animal Diseases

Outcome #2

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2011	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.

What has been done

Investigators education and research programs allowed producers to document "best management" practices raising and marketing calves. The program provides quality assurance certification, implements and documents bio-security plans on ranches, and provides informational outreach. Investigators at MSU also evaluated electronic identification tags. Sheep and wool producers continued to use targeted grazing to increase the competitiveness of Montana lamb and wool in the world market.

Results

The electronic identification tags resulted in approximately \$12 per head more income for producers enrolled in the MBN program.

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
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana researchers face the continued challenge of ensuring livestock and wildlife do not pass diseases between each other. *Brucella abortus* remains a threat to the health and well-being of livestock in states bordering the Greater Yellowstone Area (GYA). Cohabitation of infected wildlife with cattle has jeopardized Idaho's and Wyoming's brucellosis-free status and now has compromised Montana's brucellosis status. Infected wildlife, including bison and elk, will continue serving as a reservoir for *B. abortus* unless wildlife and livestock experts can better manage the disease. This increases livestock producer costs.

What has been done

Dr. David Pascual, a leading researcher at ImID, is focusing on a new vaccine that reflected a 75% protection rate in treated animals. Previous livestock *B. abortus* vaccines have only been approximately 60% effective in cattle and wildlife.

Results

During the past year researchers continued to improve the vaccines and formulate ideal dosages.

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.

Not Reporting on this Outcome Measure

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
2011	10

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 enhances food safety awareness and increases the quality of meat products produced and processed in Montana.

What has been done

Dr. Jane Anne Boles conducted onsite training at all 8 meat processing plants in the State. As the Processing Authority she trained 60 pork producers about different variables that impact food quality and conversion of muscle to meat. Dr. Boles also offered an online barbeque training session and taught at 4-H Congress with the Extension Service.

Results

Meat producers have a better understanding of what can affect the quality of their products in the processing plant. The meat processors in Montana saved more than 200 pounds of bacon as a direct result of the training they received from Dr. Boles.

4. Associated Knowledge Areas

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

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

Investigators at MSU COA and MAES continued progressing in the field of animal health research. They furthered their research into prion diseases and brucellosis.

Researchers worked closely with sheep and wool producers and gleaned critical information regarding residual feed intake and targeted grazing.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Infected wildlife, including bison and elk, will continue to serve as a reservoir for *B. abortus* unless wildlife and livestock experts can adequately manage the disease. Dr. David Pascual, a leading researcher at IMID, is focusing on a new vaccine that reflected a 75% protection rate in treated animals. Previous livestock *B. abortus* vaccines have only been approximately 60% effective in cattle and wildlife.

Dr. Richard Bessen is investigating agent-host interactions in prion diseases which are fatal neurodegenerative diseases. Prion diseases such as bovine spongiform encephalopathy in cattle, scrapie in sheep, and chronic wasting disease in deer and elk breakdown the central nervous system resulting in death. The goal is to define the pathway of prion agent infection of skeletal muscle following oral prion infection to better understand how the prion agent spreads within a host.

Investigators made great strides in studying residual feed intake and genetics in sheep. Research compared low cost common feeds with higher cost options and found the low cost feeds were as beneficial as the more expensive options. Investigators also studied the differences in nutritional needs for ewe lambs during the first two years. They concluded the feed efficiency differences were more relevant for lambs during active growth and during the maintenance stage for yearlings.

Key Items of Evaluation

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Climate Change

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			7%	
102	Soil, Plant, Water, Nutrient Relationships			22%	
104	Protect Soil from Harmful Effects of Natural Elements			2%	
111	Conservation and Efficient Use of Water			12%	
112	Watershed Protection and Management			9%	
121	Management of Range Resources			16%	
122	Management and Control of Forest and Range Fires			2%	
124	Urban Forestry			3%	
125	Agroforestry			2%	
131	Alternative Uses of Land			3%	
133	Pollution Prevention and Mitigation			7%	
135	Aquatic and Terrestrial Wildlife			3%	
136	Conservation of Biological Diversity			12%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	3.7	0.0
Actual Paid Professional	0.0	0.0	52.3	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	333291	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1830482	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2716666	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Researchers in Montana centered investigations on developing new crops and cultivars suitable to a warmer and drier climate as well as exploring the ecological impact of climate change on natural wildlife habitats in Montana and grazing areas.

The warmer climate in Montana is also impacting insects, so investigators are identifying and curating them. This year researchers curated the MSU Entomology Collection. Investigators identified new wood boring insects attacking the forest lands in the state.

Water remains a key concern in Montana and researchers continue investigating crops and management systems that rely on less water consumption.

2. Brief description of the target audience

- Crop and livestock producers in Montana
- State agricultural advisory committees
- State of Montana
- Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities
- Participants in extension and commodity group meetings, conferences, and field days

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2011	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	550	7500	147	0

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

Patent Applications Submitted

Year: 2011

Actual: 1

Patents listed

William Inskeep, No. 61/505,653 "Acidophilic Fusarium Oxysporum Strains, Methods of their Production and Methods of their Use." Filed July 8, 2011

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	7	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations
Not reporting on this Output for this Annual Report

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
2011	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Scientists are studying new crop varieties that can thrive under warmer and dryer growing conditions.

What has been done

MSU researchers screened 50 elite lines of barley in 2011, and the MSU Variety Release Committee recommended "Hockett" for production as malting barley under both dryland and irrigated conditions in all regions of Montana.

Results

Barley and wheat production were all down in 2011. Field crop revenue for Montana in 2011 totaled \$2.4 billion with wheat the most significant at 5.4 million acres totaling \$1.4 billion in revenue. This was followed by barley where producers planted 760k acres totaling \$159 million.

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

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
2011	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Carbon dioxide has been identified as a leading contributor to climate change. Scientists in Montana are working to sequester carbon out of the atmosphere and return it to the soil where it is beneficial to the soil and enhances crop productivity.

What has been done

Scientists are conducting two carbon sequestration research projects. In north-central Montana they are testing five 80 acre sites. They planted a variety of crops: wheat, peas, canola, lentils, native grasses and flax. Researchers are measuring soil carbon levels under reduced-till versus no-till conditions and also studying cropping intensity, fallow versus continual cropping. They are conducting similar tests in the Gallatin Valley.

Results

Carbon is a cumulative measurement and often changes are not measurable for six years. Scientist are completing both studies in the fall of 2012. They are optimistic about the results and have identified significant changes in the carbon levels in the Gallatin Valley test sites.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
131	Alternative Uses of Land

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

Extreme weather throughout the State impacted test crops and carbon measurements often take a long time to show significant changes.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Researchers shared results of conifer encroachment with federal and state land managers in meetings and some have changed their approach to conifer management. Information was also shared with National Park Service; USFS; BLM; NRCS; Tribal land managers; and Montana Fish, Wildlife and Parks, and the scientific community (Society for Range Management and The Wildlife Society).

Investigators at the Eastern Research Center explored high-value and alternative crops for Eastern Montana. The sugarbeet industry contributes greatly to the economy of the Mondak region in Montana. Potatoes, safflower, dry edible beans, sunflowers and soybeans are good rotational crops with sugarbeets and small grains.

Key Items of Evaluation

V(A). Planned Program (Summary)**Program # 3****1. Name of the Planned Program**

Global Food Security and Hunger

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			13%	
202	Plant Genetic Resources			14%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			15%	
205	Plant Management Systems			17%	
502	New and Improved Food Products			5%	
602	Business Management, Finance, and Taxation			2%	
603	Market Economics			2%	
604	Marketing and Distribution Practices			2%	
608	Community Resource Planning and Development			2%	
609	Economic Theory and Methods			1%	
610	Domestic Policy Analysis			1%	
611	Foreign Policy and Programs			2%	
701	Nutrient Composition of Food			1%	
703	Nutrition Education and Behavior			1%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			1%	
721	Insects and Other Pests Affecting Humans			3%	
722	Zoonotic Diseases and Parasites Affecting Humans			2%	
802	Human Development and Family Well-Being			5%	
903	Communication, Education, and Information Delivery			1%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	21.3	0.0
Actual Paid Professional	0.0	0.0	35.9	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	233699	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1330268	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1431917	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Developed livestock traceability system to increase food safety and agricultural security
- Developed value-added, agriculturally based end-use products
- Established bio-based 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
 - Provided ways to enhance agricultural production practices and product quality
 - Developed research summaries and fact sheets
 - Conducted training in cooperation with Beef Quality Assurance standards and the SBS program

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, and conferences, and field days
 - State of Montana
 - Montana Department of Agriculture, BLM, 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

2011	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: 2011

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	10	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2011	179

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of programs established to enhance global food biosecurity
2	Number of new food products created from Montana crops
3	Number of producers that participate in livestock tracking programs

Outcome #1

1. Outcome Measures

Number of programs established to enhance global food biosecurity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Researchers are concerned with proper grain storage as the world market increases its demand for quality grains. Researchers are investigating ways to maintain the highest quality grains during processing, shipping, and handling and mitigate insect problems, especially the wheat Stem Sawfly (in-season). Researchers at MSU are also concerned about discovering environmentally friendly ways to control weeds and pests.

What has been done

Investigators shared their extensive research with the peer scientific community and grain producers at more than ten conventions throughout Montana and North Dakota. They conducted training sessions on trap cropping, host plant resistance, and conservation biocontrol for wheat stem sawfly management.

Results

Grower practices are being modified to favor conservation of wheat stem sawfly parasitoids. Combining non-preference host plant resistance with antibiosis in trap crop scenarios is also being adopted by an increasing number of growers. Grower appreciation of the value of antixenotic host plant resistance is evident in the increasing number of acres planted to these varieties.

4. Associated Knowledge Areas

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

502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
722	Zoonotic Diseases and Parasites Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #2

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
2011	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Producers are developing ways to maximize crop yield through new practices and new products. Growers are inspired by increased global sales to produce crops with global marketability, such as grains that produce a higher quality asian noodle and those that require less water and adapt to a warmer growing season. There is also an increased demand for hull-less barley for malting purposes.

What has been done

Researchers advanced malting barley lines improving feed, hay and food varieties. MSU's food barley breeding effort is nearing completion. MSU and a major U.S. food company investigators developed several populations of hull-less barley using both "Prowashonupana" and several land race accessions from USDAs barley collection as donors of the high protein, high grain glucan content trait. In 2011 they advanced the best of these lines to statewide trials and conducted a large replicated yield trail consisting of 80 of these lines at Bozeman.

Results

Investigators purified six lines of malting barley from each of 30 families in 2011.

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
502	New and Improved Food Products
701	Nutrient Composition of Food
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Number of producers that participate in livestock tracking programs

Not Reporting on this Outcome Measure

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

Brief Explanation

Growing conditions differed from the norm throughout much of Montana in 2011. Much of the State received excessive moisture in May which caused some flooding and saturated soil conditions for much of the month. Winter wheat benefited from the extra moisture, but many spring crops were planted late and did not produce as well as previous years.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Researchers at MSU COA and MAES are leading the way in the development of new spring and winter wheat varieties. The barley program is showing good results and the wheat programs are showing exceptional results. The livestock community is producing healthier livestock that can be easily tracked as desired or warranted for increased food security.

Key Items of Evaluation

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Global Food Security and Hunger: Integrated Pest Management

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
211	Insects, Mites, and Other Arthropods Affecting Plants			27%	
212	Pathogens and Nematodes Affecting Plants			25%	
213	Weeds Affecting Plants			20%	
215	Biological Control of Pests Affecting Plants			10%	
216	Integrated Pest Management Systems			18%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	37.0	0.0
Actual Paid Professional	0.0	0.0	52.5	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	317945	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1476181	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2278600	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Researchers shared their study results online, in print, and curated the Entomology Collection
- Published information on targeted grazing efforts
- Continued investigating the use of biological control agents for the management of noxious weeds raising and releasing a stem galling cynipid wasp (*Aulacidea Acroptilonica*) and a gall midge (*Jaapiella Ivannikovi*)
 - Developed a quick and accurate electronic field identification system for weed management
 - Made significant progress in development of new and improved disease management tools for sugarbeet and potato growers in Montana.

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?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2011	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	500	0	0	0

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

Patent Applications Submitted

Year: 2011

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	41	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations
Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Actual
2011	179

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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

Outcome #1

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2011	88

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

An increase in public concern about food safety, quality, cost, biodiversity, and sustainability of soil, air, and water quality is pushing scientists to rely less on pesticides and look toward more environmentally friendly options.

What has been done

Researchers explored new and improved methods to identify and control insects, weeds, and diseases challenging Montana farmers. They then conducted 88 training sessions for nearly 3,000 members of the Montana agricultural community. 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. 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
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 #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
2011	1

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 also demanding farmers use less chemical pesticides for food crops.

What has been done

Researchers have extensively studied insect damage to crops and have developed plants that are increasingly resistant to insect damage. Investigators also identified sex pheromone receptors from different species within the model corn borer system. During 2011 this *Xenopus oocyte* (unfertilized frog eggs) assay became fully functional and has been used for mutagenesis studies of the receptors. Establishing a robust functional assay was a significant achievement.

Results

This *Xenopus oocyte* assay represents the application of new technology (insect molecular biology and receptor function) towards traditional IPM research designed to manage insect pests. This particular instrument that MSU acquired is an automated robotics system that allows faster data collection and provides a competitive advantage in research.

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
2011	249

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 crops.

What has been done

MSU has focused 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. The MSU Pesticide Education program sponsored 249 integrated pest management programs in 2011.

Results

New online information programs are available to assist farmers and ranchers with weed and insect identification. Scientists are quickly sharing new advances in pesticide applications with producers and using all the tools available to combat noxious weeds and insects affecting crops and rangelands. More producers are also turning to targeted sheep grazing as a viable option.

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
2011	90

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Pesticide application training is important for the safety of producers and consumers. The COA and the Extension Service work closely offering training and application licenses throughout the State.

What has been done

Users can attend the class when offered in their communities or they may attend the course at the College.

Results

All of the participants who attended the class in 2011 were licensed. Statewide the passing rate was 85%. MSU COA licensed 33 applicators in 2011 and had 30 operators which was a 70% increase from 2010.

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
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Dr. David Weaver is primarily focused on developing new techniques and tools for wheat stem sawfly management. This insect is the most economically important pest of wheat in Montana, with annual losses exceeding \$100 million. Insecticides are not a viable option for control of this insect, and current management of sawfly is driven by the planting of solid-stem wheat, which is resistant to stem lodging and causes variable mortality in the immature stages.

What has been done

Scientists are investigating insect and host plant chemical ecology, biological control, pathogens, and new sources of host plant resistance to incorporate in a non-insecticide, integrated pest management program (IPM) for this insect, which will be framed around the existing use of solid-stem varieties.

Results

Crop rotation including non-host plants such as canola has helped reduce infestations if there are no barley or wheat crops nearby. Sawflies are now emerging nearly a month earlier than previously, so they are present when the winter wheat is susceptible. Late planted spring wheat fields now frequently avoid attack.

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

{No Data Entered}

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. They are also developing and sharing quality stewardship programs to identify and mitigate noxious weeds and harmful insects. Field crops are an important foundation for the Montana agricultural industry and revenue totaled \$2.4 billion in 2011. The most significant crop in Montana was wheat (5.4 million acres, \$1.4 billion) followed by barley (760k acres, \$159 million). The grain supports the livestock industry in Montana, and also the export market. A leading researcher, Dr. Burrows, shared that of the growers attending conferences on disease management and fungicide treatment options 65% could better identify diseases and had a clearer plan of how to treat them. Montana farmers spent approximately \$15 million on fungicide applications in 2011. Although yield benefits/detriments from spraying a fungicide are difficult to estimate, most respondents estimated a 0-20% yield increase. Not spraying resistant varieties of grain saved \$12 million. Stripe rust cost growers \$48 million in 2011. Fungicide application saved growers \$30 million. If the estimated worth of the wheat crop in MT is \$1.6 billion, they saved 2% of the crop. Susceptible varieties sprayed in a timely manner saved approximately \$90 million. Savings due to herbicide and seed costs on 2000 acres of winter wheat totaled approximately \$60,000 and yields of winter wheat averaged approximately 40 bu/A, totaling \$480,000 (est. \$6/bu) in farm revenue.

In 2011 investigators also 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.

Researchers continued studying insects within the State including the wheat stem sawfly (*Cephus cinctus*) and Lepidoptera insects. Producers have not managed the fly with conventional tools or agricultural practices, so 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.

Producers must manage and control insects to preserve grain quality during storage. A multistate partnership focused on insecticidal and non-insecticidal approaches in laboratory and large-scale field trials. Investigators focused entomological research on reducing storage losses at a lower cost than conventional chemical methods with less reliance on chemical intervention.

Weed management requires rapid and accurate identification of plants. Investigators published a quick field guide and are intensely studying the molecular processes that allow weeds to withstand herbicides. Researchers are also using the enhanced MSU Entomology Collection to identify and study insects affecting crops and finding those that might help control weeds.

Key Items of Evaluation

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

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

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			17%	
202	Plant Genetic Resources			18%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			14%	
204	Plant Product Quality and Utility (Preharvest)			20%	
205	Plant Management Systems			23%	
502	New and Improved Food Products			6%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			1%	
903	Communication, Education, and Information Delivery			1%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	33.1	0.0
Actual Paid Professional	0.0	0.0	25.8	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	145008	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	850996	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1131150	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Share information on plant breeding and genomics advances through classroom activities, field days, cultivar trials, news releases, and presentations at county and state meetings and conventions
- Released germplasm, new cultivars, and new genomics tools and techniques
- Hosted strategic planning sessions with state agricultural groups
- Published findings in technical and non-technical publications

2. Brief description of the target audience

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

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2011	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2000	500	0	0

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

Year: 2011
 Actual: 1

Patents listed

Plant Variety Protection Certificate No. 201100096, Common Wheat "Decade." Issued 2/25/2011

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	35	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Actual
2011	15

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Actual
2011	4

Output #3

Output Measure

- Number of research citations

Year	Actual
2011	119

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.

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
2011	0

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.

Results

Producers are using the tool and researchers are sharing information about how to best use it prior to crop selection. Information is also posted on the site regarding current analysis of new cultivars and crops along with the most current information on disease and insect resistant strains. The site provides comprehensive information about the 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.

Not Reporting on this Outcome Measure

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
2011	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana ranks third in the United States for number of acres of wheat, behind Kansas and North Dakota and has a significant export market. Barley has increased in popularity with Montana producers as the price paid per bushel increased for feed and malt barley.

What has been done

Investigators continued developing wheat varieties for Montana farmers and the wheat milling and baking industry. In 2011 MT farmers planted nearly 2.7 million acres of hard red spring wheat. The top two winter cultivars were "Genou" and "Yellowstone" totaling about 1.1 million acres. Using these cultivars wheat growers harvested an additional 18 million bushels of winter wheat over the past five crop years based on production acreage and estimated yield gains over previously deployed cultivars.

Results

Durum, spring and winter wheat yields were down in 2011: Durum was down 6 bushels/acre, spring wheat dropped 7 bu/acre, and winter wheat was down 7 bu/acre. "Genou" was the most planted wheat cultivar for the fifth straight year, but remained susceptible to stripe rust and wheat

stem sawfly. Winter wheat yields were up an average of 0.73 bu/acre/cycle over 10 breeding cycles (2002-2011) an increase yield potential of 7.3 bu/acre since 2002. "Yellowstone" is the highest yielding winter wheat ever in MT. MSU released "Judee" and "Bearpaw", solid-stem semi-dwarf cultivars, in 2011. Both should positively impact winter wheat production. Investigators made excellent progress selecting lines with stripe rust resistance in 2011.

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
502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

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
2011	0

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

Researchers screened 50 elite barley lines and 100 spring wheat landraces at 2 high population sawfly sites and identified specific interest areas of the wheat chromosomes. The researchers will use molecular markers to identify types resistant to the stem sawfly. They also screened for reliable grain yield and how well the plant retains green leaves after heading. Winter wheat investigators added 284 crosses to the germplasm base, emphasizing disease resistance and adaptation traits. MAES planted the intrastate yield trial at 8 locations and harvested 7.

Results

Researchers advanced malting barley lines improving feed, hay and food barley varieties. The hay barley project successfully developed high yielding high straw soluble carbohydrate lines. Researchers purified 6 lines from each of 30 families in 2011. The spring wheat program will release "Duclair" for 2012. In the winter wheat program the top yielding lines all exhibited excellent strip rust resistance. "Yellowstone" had the highest statewide yield average in 6 of 9 years and averaged 66.1 bu/a over 186 trials during that period.

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
502	New and Improved Food Products
903	Communication, Education, and Information Delivery

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
2011	5

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 drier and warmer conditions.

What has been done

The MSU Variety Release Committee is recommending "Hockett" for production as malting barley under both dryland and irrigated conditions in all regions of Montana. The committee also recommended "Decade," a hard red winter wheat, for the cropping districts in the north, central and eastern regions of Montana. They recommended "Judee" and "Bearpaw", both solid-stem hard winter wheat varieties, for all but the north-eastern district of Montana. They recommended "Duclair" as a hard red spring wheat.

Results

Barley and wheat production were all down in 2011. Montana producers seeded 2.20 million acres of winter wheat last fall for the 2012 crop year, down 50,000 acres or 2% below the 2011 winter wheat planting of 2.25 million acres.

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
502	New and Improved Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

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
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montanans place a lot of trust in Montana State University as a global leader in agriculture and economics and nowhere is it more evident than in the Cereal Quality Laboratory and the small grain breeding and genetics programs. 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 "Hockett" barley, three hard red winter wheat varieties ("Judee," "Bearpaw," and "Decade"), and a new red spring wheat named "Duclair."

Results

Field crop revenue for Montana in 2011 totaled \$2.4 billion with wheat the most significant at 5.4 million acres totaling \$1.4 billion in revenue. This was followed by barley (760k acres, \$159 million). Producers seeded 2.25 million acres of winter wheat, up 10% from 2010, and harvested 2.19 million acres, up 240k acres from last year. Winter wheat yield was down 7 bushels/acre. Spring wheat producers seeded and harvested less due in part to wet conditions. Barley producers seeded 60,000 acres less of barley, but harvested the same 620,000 acres as in 2010 with an average 12 bu/acre less.

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
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Montana experienced a much wetter growing season in 2011 with more than 19 inches of growing season precipitation from September 2010 through August 2011.

Rainfall in May caused some flooding and saturated soil conditions for a significant part of the State. While researchers agree winter wheat benefited from the extra moisture, spring crops did not because they were planted late.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MAES investigators worked on exploring plant breeding, genetics and genomics programs. 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. With the winter wheat breeding program researchers continue increasing winter hardiness while maintaining superior end-use quality for bread and noodle markets. The 16 member Variety Release and Recommendation Committee recommended three new varieties of winter wheat this year for planting. On a state basis 2011 was a good winter wheat year. Harvested winter wheat acreage for 2011 was 2.19 million acres averaging approximately 41 bu/acres. Producers used fungicides effectively to manage stripe rust on susceptible cultivars. Leading cultivars were "Genou," "Yellowstone," "CDC Falcon," "Rampart," "Ledger" and "AP503C12." The release committee also recommended "Hockett" barley and "Duclair" spring wheat.

Other researchers focused efforts on sugar beet and potato production and discovered biocontrol agents for different disease affecting these crops. Sugar beet producers in Montana planted 45,000 acres in 2011, up 2,400 acres from 2010 and harvested 43,000 acres. While this was an increase of 500 acres from 2010 the yield decreased 3.7 tons per acre.

The COA and MAES will continue to research and publish their 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

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Sustainable Agriculture

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			12%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			12%	
204	Plant Product Quality and Utility (Preharvest)			17%	
205	Plant Management Systems			20%	
206	Basic Plant Biology			10%	
213	Weeds Affecting Plants			16%	
215	Biological Control of Pests Affecting Plants			8%	
601	Economics of Agricultural Production and Farm Management			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	57.3	0.0
Actual Paid Professional	0.0	0.0	35.5	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	312047	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1235029	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1077655	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Communicated research results through field days, news releases, fact sheets, research summaries, and presentations at county and state meetings and conventions
 - Distributed results of research via the internet
 - Held strategic planning discussions with state agricultural groups including ag associations and federal and state land management agencies

2. Brief description of the target audience

- Alternative energy groups and state agricultural advisory committees
- Crop and livestock producers in Montana
- Montana wheat and barley committees, companies, fertilizer advisory committees, conservation tillage equipment companies
 - State of Montana
 - Montana Department of Agriculture, BLM, USFS, and other government entities
 - Participants in outreach 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

2011	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: 2011
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	5	5	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2011	234

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
2011	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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 can help develop research programs that reflect stakeholder needs. In addition, resolutions are passed in numerous associations and approved by voting members providing direction to MAES.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants

204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
213	Weeds Affecting Plants

Outcome #2

1. Outcome Measures

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

Not Reporting on this Outcome Measure

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
2011	6

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

Oilseeds (including *Camelina sativa*, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of oils. Barley varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Additional initiatives will provide new insights into food safety and risk assessment, including the development of new wheat varieties.

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
205	Plant Management Systems
206	Basic Plant Biology
601	Economics of Agricultural Production and Farm Management

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
2011	22

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

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

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

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

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

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

Not Reporting on this Outcome Measure

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
2011	3500

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The seed lab processed more than 3,500 seed samples in 2011. The lab verifies the seeds are viable, pure, and disease free. About 1/3 of the samples are labeled certified and 2/3 of them are common seed. The lab is also a key line of defense against noxious weeds.

What has been done

The MSU seed lab tested 3,500 seed samples and verified they were free of noxious and common weed seed. They also tested animal pellets to make sure they did not have weed seed in them that would possibly contaminate forest lands.

Results

Montana seed is tested and labeled for consumer protection.

4. Associated Knowledge Areas

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The agricultural community in Montana is committed to sustainable agriculture. Crop producers continue to manage insects, weeds, and diseases and are exploring new crop varieties and practices each year.

Scientists are working throughout industry and government to develop sustainable agricultural practices that work with the issues associated with wilderness areas and harsh climates.

Key Items of Evaluation

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Sustainable Energy

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			62%	
605	Natural Resource and Environmental Economics			25%	
903	Communication, Education, and Information Delivery			13%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	5.6	0.0
Actual Paid Professional	0.0	0.0	2.9	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	21212	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	85143	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	135139	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conducted outreach activities related to bio-based 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
- Continued researching 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, BLM, 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

2011	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: 2011

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	10	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Actual
2011	0

Output #2

Output Measure

- Number of research citations
Not reporting on this Output for this Annual Report

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
2011	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

Researchers in Montana have been studying camelina crops in an attempt to increase the oil content through technology and modify the quality of the oil in the seeds for fuel and lubricants.

Results

Better crops have led to better oils and increased the yield per acre planted. In 2009 Montana farmers planted 20,800 acres of camelina, harvested 19,500 acres and produced nearly 12 million pounds of seed which equated to 615 pounds per acre. In 2010 they planted less than half the acres, (9,900 acres), but increased their yield to 1,010 pounds per acre.

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
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Crop exploration is important to the Montana agricultural community. Researchers are searching for dryland crops that are economical and sustainable and that will impact biofuel projects throughout the North America.

What has been done

Montana farmers planted new pulse crops that added significant value to crop diversification, organic agriculture, soil carbon sequestration, and agricultural adaptation to climate change. Researchers expanded testing of winter and spring barley varieties to conduct trials of high straw soluble carbohydrate barley to estimate the economic feasibility of using it for on-farm fuel ethanol production.

Results

In 2009 MSU COA identified and characterized two barley genotypes that produce straw high in fructan, a water-soluble carbohydrate easily digested and fermented by the yeast, *Kluyveromyces marxiana*. Researchers constructed a pilot plant and steps are being taken to further develop straw fermentation technology to determine its potential for on-farm fuel ethanol production.

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

MSU researchers continue to explore alternative energy sources and are developing crops that can serve as replacement options for petroleum. Scientists are working closely together monitoring plant genetics and genomics, studying carbon sequestration in soils, and discovering better crop management systems -- all in an attempt to sustain agricultural practices in Montana and support national priorities. Montana farmers and ranchers serve as premier examples of sustainable living as they do more with less. They are seeking alternative energy sources that will lower production costs and enhance performance. While immediate results are difficult to measure or quantify, researchers will continue to support the agricultural community by discovering, producing, and teaching them how to use alternative energy sources.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MSU researchers continue to explore alternative energy sources and are developing crops that can serve as replacement options for petroleum. Scientists are working closely together monitoring plant genetics and genomics, studying carbon sequestration in soils, and discovering better crop management systems all in an attempt to sustain agricultural practices in Montana. Montana farmers and ranchers serve as premier examples of sustainable living - doing more with less. They are looking for alternative energy sources that will lower production costs and enhance performance. While immediate results are difficult to measure or quantify, researchers will continue to support the agricultural community in discovering, producing, and using alternative energy sources.

Key Items of Evaluation