

2013 Montana State University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

The Montana State University College of Agriculture (COA) and Montana Agricultural Experiment Station (MAES) is pleased to present the 2014 Annual Report of Accomplishments and Results. The report not only highlights annual accomplishments, it also represents the breadth and depth of MSU COA/MAES leadership and productivity in science, education and innovation. Leading Montana in cutting edge research and delivering timely information to stakeholders continues to serve the mission of the university. MSU/COA 2013 accomplishments and results represent modern day achievements in 151 years of honoring the legacy and commitment within the land grant tradition. Federal Hatch Act funding continues to allow MSU COA/MAES faculty scientists to meet the changing needs of Montana, explore unique solutions to pressing questions, and solve global problems in agriculture, and continues as the critical foundation for COA/MAES scientists to be successful in competition for complimentary national-level grant funding. The result of this work is an informed public and a strong agricultural economy that remains Montana's highest grossing industry.

This report highlights both long-term, traditional programs, as well as innovative programs that are early in their development. COA/MAES projects and investigations in pest management and plant breeding again allowed producers and stakeholders to remain competitive in national and world markets in 2013. COA/MAES research activities produced three patent applications in the fields of pest management and plant breeding. The patent applications are a direct result of research conducted in response to destructive diseases and pests in crop production that remain a regional threat. Additional 2013 development of new strategies in plant and pest resistance include: educational programs and materials, achievements in biological control agents, invasive mitigation methods, and new genetic resistance successes. Improved wheat cultivars with improved pest resistance and quality characteristics, provide Montana producers the ability to continue to thrive in global markets.

COA/MAES scientists also initiated new findings in animal health including significant advancements in forage intake, supplement consumption, delivery methods and vaccination research, all of which helped to enhance overall production. Additional 2013 achievements include thirty-two new registered products that range from new germplasms, to educational aids and curricula, videos and websites, nationally unique research models, and insect and plant collections numbering more than 26,000 species. COA/MAES investigators also provided quality in-depth trainings and presentations to more than 5,000 patrons, and strengthened partnerships with MSU Extension, and private stakeholders.

Montana again ranks 2nd in the U.S. in acres devoted to farms and ranches with annual crop and livestock cash receipts exceeding \$3 billion. The 2012 value of crop production increased to \$2.3 billion, an increase of \$325.1 million or 16 percent above 2011. The value of livestock increased in 2012 to 41.6 billion, up \$200.6 million from 2011. According to the "2013 Montana Agricultural Statistics," published by USDA, NASS and Montana Department of Agriculture offices, agriculture demonstrated a nine percent increase, up \$375.6 million from 2011. In 2011-2012, wheat production totaled 8.5 percent of the entire U.S. production.

Montana farmers saw an increase in the production of corn and sugar beets with production up 17 percent from 2011. Dry edible pea production, and canola were up as well, but hay production fell by 26 percent this year. In 2011-2012 the state ranked 1st in the production of lentils and dry edible peas; 2nd in spring wheat, barley, Austrian winter peas, and flaxseed; 3rd in the production of winter wheat, durum wheat, hay, safflower, and canola; 4th in garbanzo beans; 5th in sugar beets and canola; 6th in the production of all hay; and in the top 10 for pinto beans.

Montana is home to 12 tribal nations (Assiniboine, Blackfeet, Chippewa, Cree, Gros Ventres, Kootenai, Little Shell, Northern Cheyenne, Pend D'Orieille, Salish, Sioux) and seven reservations (Blackfeet, Crow, Flathead, Fort Belknap, Fort Peck, Northern Cheyenne, Rocky Boy's). The Little Shell Band is currently "landless" but is seeking federal recognition and to establish its own land base. The tribal nations govern their reservations which comprise nine percent of Montana's land base. Each tribal government has sovereignty and establishes services for its citizens. Recognition of American Indian cultural heritage (§ Mont. Code Annotated 20-1-501) is a constitutionally declared policy of Montana to recognize the distinct and unique cultural heritage of American Indians, and to be committed in its educational goals to the preservation of their cultural heritage. The Montana State Constitution binds every public educational agency, and all educational personnel, to work cooperatively with Montana tribes when providing instruction and implementing educational goals, and to include information specific to the cultural heritage and contemporary contributions of American Indians. Particular emphasis of such is placed on Montana Indian tribal groups and governments. Thus, at every turn, COA, MAES and MSU Extension cooperatively design and implement programs that best align with Montana's sovereign Indian Nations.

Due to increasing competition in federal funding, in conjunction with several faculty assignments having left for new institutions, the COA/MAES saw a decrease of 6.2 percent in FTE representation. However, since the calendar year began in January 2013, COA/MAES has hired three new faculty positions in Animal and Ranges Sciences, with more faculty appointments expected to be filled in coming months. Despite funding hardships, achievements made in 2013 continued to support and maintain agricultural crop production for the economic health of the state, region and country. COA/MAES has always maintained a close relationship with Montana State University Extension and worked extensively with them to create a new 2015 Combined Research and Extension Plan of Work. The opportunity to enhance this partnership and elevate agriculture in Montana is valued and represents a clear commitment to the heritage of the state.

As the goal statements and outcomes throughout this report attest, the agricultural challenges and opportunities in Montana are endless. Increasingly, the COA/MAES institution serves a growing, diverse constituency with limited, competitive resources.

In 2013, the Montana agricultural community worked together to reinforce the priorities for the College of Agriculture and the Montana Agricultural Experiment Station. Investigators and stakeholders facilitated focus groups and community meetings throughout the state ensuring the research priorities were current and valid for the target population. Following is a list of priorities:

- Add value to Montana's high quality crop and livestock systems
- 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

Programs reported on this report include:

1. Climate Change

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 as well as carbon sequestration. The changing climate has significantly impacted Montana insects which in turn impact the ecosystem. Researchers are studying the biology, distribution, and systematics of insects and their impact on Montana's agricultural producers.

2. Food Safety

Food safety and security have become important concerns for the beef industry at all production levels. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal. COA/MAES studies help ensure that Montana producers raise safe beef while improving the quality of the beef and ensure consumers are aware of the quality and health of their products through advancements in educational programs on beef quality assurance (BQA) practices, voluntary beef cattle marketing options, and ranch management issues throughout the state via meetings and interactive technologies. Food Safety also involves mycotoxins in grains and feeds.

3. Integrated Pest Management

COA/MAES reflect the global food security and hunger program in two areas. The first is integrated pest management, and the second key program is plant breeding, genetics, and genomics. 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 and 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. In Montana and throughout the U.S., maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policies.

4. Animal Health, Production and Products

Research programs at MSU COA and MAES focus on reproductive performance in animals, nutrition, genetic improvements for herds, and developing better animal management systems. NIFA defined sustainable agriculture as an integrated system of plant and animal production practices having a site-specific application that will over the long-term satisfy human food and fiber needs. It also discussed the importance of enhancing environmental quality and the natural resource base essential to the agricultural community. Researchers at MSU feel little plant/animal integrated systems level research has been done that addresses all of the factors outlined in the USDA definition of sustainable agriculture. In addition, organic certified vegetable, row crop, and animal production enterprises and research have not fully taken advantage of the potential benefits of plant/animal integration and suffer from issues ranging from animal health and finishing (particularly internal parasite control), and alternatives to confinement finishing) to residue and cover crop management, and soil health issues related to extensive tillage commonly used in organic farming programs. Thus, COA/MAES scientists have designed several research projects that will emphasize a combined animal and plant approach.

5. Plant Breeding, Genetics and Genomics

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. Continued productivity of breeding programs 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.

6. Sustainable Energy

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 these projects, providing administration and research expertise for product development, enterprise budgeting and marketing. Additional research is focusing on the use of native plants and grasses in the landscaping industry. Wheat producers need crop diversity to increase profitability and management options.

7. Childhood Obesity

MSU COA/MAES no longer manages the childhood obesity planned program. Rather, MSU's College of Education Health and Human Development conducts most research relating to obesity studies. Still, researchers at the COA are working on new crops that deliver specific value added products to consumers, often to specific health based consumer groups such as celiac disease sufferers. MSU COA/MAES is vested in the agricultural community through their extensive academic and research programs. Investigators are challenging themselves and their staff every day to discover new information, programs, and systems that will enhance quality and productivity, and allow Montana producers to remain key players in the national and global market.

While the program overview and highlights in this annual report reflect just a portion of the many accomplishments during 2013, it does adequately represent the dedicated and committed talent that collectively ensures Montana's agricultural and natural resource success. Researchers at Montana State University COA/MAES also continued learning as they focused on diversity and efficiency in agricultural operations and continued to optimize grower profitability. Because of a statewide network of private producers, stakeholder groups, supported by COA/MSU faculty and staff, it is possible for MSU COA/MES to remain committed to serving and enhancing citizen knowledge and production. On behalf of the Montana State University College of Agriculture and Montana Agricultural Experiment Station, we are pleased to present the 2013 Annual Report.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	311.5	0.0
Actual	0.0	0.0	268.0	0.0

II. Merit Review Process

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

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

2. Brief Explanation

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

III. Stakeholder Input

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

- Use of media to announce public meetings and listening sessions
- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Survey of traditional stakeholder groups
- Survey of traditional stakeholder individuals

- Survey specifically with non-traditional groups
- Other (Educational outreach programs)

Brief explanation.

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

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

1. Method to identify individuals and groups

- Use Advisory Committees
- Open Listening Sessions
- Other (Volunteers, membership on 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 Council meets three times each year to discuss program focus and direction, Montana legislative priorities, and productivity/impact. These meetings are open to the public. Administrators and faculty in the COA serve on agricultural association committees that annually direct and fund research activities. These committees use a variety of collection methods, but the most common are face-to-face meetings, telephone, and some video teleconferencing.

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

1. Methods for collecting Stakeholder Input

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

Brief explanation.

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

3. A statement of how the input will be considered

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

Brief explanation.

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

A state-of-the-art Animal Bioscience Building built in 2010

- Three new full-time faculty positions in Animal and Range Sciences
- New equipment

The new equipment includes a:

on Torrent Personal Genome Machine for profiling genetic information taken from livestock samples

- Illumina MiSeq which collects specific information from multiple DNA molecules helping scientists study microbial life in a sample
- Maxwell 16 (a machine which extracts nucleic acid and runs 16 DNA samples at a time)
- Polymerase chain reaction machine
- Refrigerated micro centrifuge
- Computer bio-analyzer which measures RNA and DNA samples
- Necropsy down-draft tables for laboratories complete with ceiling cameras

The Land Resources and Environmental Sciences department had a comprehensive external review and the College is actively working on the recommendations from the review with particular emphasis on reshaping the undergraduate curriculum to include core competencies, and exploring stakeholder interactions.

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

Brief Explanation of what you learned from your Stakeholders

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

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	2479498	0

2. Totaled Actual dollars from Planned Programs Inputs				
Extension			Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	2615279	0
Actual Matching	0	0	12637480	0
Actual All Other	0	0	10709357	0
Total Actual Expended	0	0	25962116	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover				
	0	0	2189879	0

V. Planned Program Table of Content

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

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Climate Change

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources			10%	
102	Soil, Plant, Water, Nutrient Relationships			13%	
111	Conservation and Efficient Use of Water			10%	
121	Management of Range Resources			16%	
122	Management and Control of Forest and Range Fires			5%	
132	Weather and Climate			5%	
136	Conservation of Biological Diversity			12%	
201	Plant Genome, Genetics, and Genetic Mechanisms			12%	
216	Integrated Pest Management Systems			12%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	55.6	0.0
Actual Paid Professional	0.0	0.0	69.1	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	778006	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	3749252	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2806312	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Develop new crops and cultivars suitable to a warmer and drier climate
- Explore the ecological impact of climate change on Montana wildlife habitats and grazing areas
- Study the impact of a changing climate on insects
- Develop and enhance pest management programs
- Continue investigating crops and management systems that rely on less water consumption
- Complete 10 year carbon sequestration research project

2. Brief description of the target audience

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

3. How was eXtension used?

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

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2500	5000	0	0

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

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	5	34	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2013	34

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of new drought tolerant crop recommendations (or changes) for Montana
2	Number of carbon sequestration technologies explored

Outcome #1

1. Outcome Measures

Number of new drought tolerant crop recommendations (or changes) for Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Climate change models suggest earlier and more rapid spring runoff in the middle and northern latitudes of Asia, Europe and North American by 2035. This translates into fewer riparian ecological services and diminished late season flows. Because these reductions competition among irrigators, municipalities and wildlife conservation for the remaining water will escalate. Damn construction will meet considerable resistance because of further loss of riparian ecological services.

What has been done

Found a clearer picture of the potential for possible impact from heavily stocked shrub stands on phreatic groundwater recovery following thinning of adjacent conifer stands, and establish a treatment target level of sagebrush stands that enhances groundwater recovery without sacrificing wildlife habitat productivity. Drafted supportive information for future development of a proposal to describe the impact of climate change on wood plant dominated ecosystems in Idaho, Montana, Nevada, Oregon, Washington and Wyoming.

Results

Quantified the amount of dietary quality of forbs and grasses in the pre-treatment drainages in a measurement of amount of forage produced in 2013. Produced planned reduction of 32% of the existing shrub canopy in four of the treatment drainages. This information can serve as a landscape management goal for wildlife biologists writing habitat recovery plans for the Greater Sage Grouse in southwestern Montana.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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102	Soil, Plant, Water, Nutrient Relationships
132	Weather and Climate
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Number of carbon sequestration technologies explored

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

The ultimate goal is to characterize carbon cycle science through global surface flux observations and model syntheses and land-atmosphere interaction. Project includes exploring the variation of soil processes at the landscape scale, using natural and human induced gradients to study atmospheric deposition to soils, disturbance effects on soil function, and the contribution of weathering processes to surface water chemistry in small catchments.

Results

Great progress has been made in documenting the quantity of soil carbon, including Montana, through federal programs such as the Rapid Carbon Assessment program. Understanding of the process that dominate soil carbon turnover has been improved recently. Progress made on this project focused on understanding a process-based understanding of dominant controls over soil carbon turnover rates, and developing plans for a synergistic and hands-on learning opportunities for students and community stakeholders.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
132	Weather and Climate
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

External factors which affected the outcomes included:

- A new faculty member added to the program within the last two years
- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- Lack of full-time staff and part time assistant
- Major interruptions in program development

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation studies were successful through the issuance and collection of surveys, published peer reviewed materials and securing peer reviewed grants. Notable evaluation results:

Researchers disseminated the results to the agricultural community at grower meetings, Certified Crop Adviser meetings, industry conferences, and MAES field days. They also shared the information with agricultural professionals at the American Society of Agronomy National meetings. The investigator developed a web site to keep growers, agricultural consultants, and other interested parties up-to-date on the progress of various studies.

Results of a long-term study on linking upland plant community structure and riparian processes resulted in a riparian rehabilitation guide for private and public land managers. Experts in the riparian processes distributed 700 of the guides in four Montana counties and hosted several workshops to explain how to rehabilitate degraded riparian

areas. A new website was developed and is used to forecast spring and winter wheat basis in various Montana locations and can be found at <http://wheatbasis.montana.edu>.

Key Items of Evaluation

MSU COA researchers advanced crop options for a warmer and drier climate:

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

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Food Safety

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			10%	
301	Reproductive Performance of Animals			5%	
302	Nutrient Utilization in Animals			10%	
303	Genetic Improvement of Animals			7%	
305	Animal Physiological Processes			5%	
306	Environmental Stress in Animals			5%	
307	Animal Management Systems			11%	
308	Improved Animal Products (Before Harvest)			5%	
311	Animal Diseases			15%	
315	Animal Welfare/Well-Being and Protection			7%	
503	Quality Maintenance in Storing and Marketing Food Products			5%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			5%	
902	Administration of Projects and Programs			5%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	73.2	0.0
Actual Paid Professional	0.0	0.0	56.3	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	395442	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2755296	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	3163703	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Create databases accessible to researchers and producers to share research results readily available
- Distribute papers and research results at state nutrition conferences, field days, county meetings, and state conventions
- Prepare research articles, fact sheets, and news releases for scientists and state media
- Hold strategic planning meetings with state agricultural groups
- Develop systems that ensure food safety and agricultural security
- Integrate, where possible, best practices for beef quality assurance in programs

2. Brief description of the target audience

- State agencies, animal health companies, and state commodity groups
- Ranchers, seedstock industry, colleagues, and related stakeholders
- Crop and livestock producers in Montana
- Participants in extension and commodity group meetings, conventions, conferences, and field days
- State of Montana
- Montana Department of Agriculture, BLM, USFS, and other government entities
- Montana Stockgrowers Association and the Montana Department of Livestock

3. How was eXtension used?

COA and MAES researchers worked closely with county extension agents and outreach coordinators to disseminate timely and accurate information regarding the evaluation and procurement of food safety.

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2000	4000	0	0

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

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	45	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2013	45

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 improvements to vaccines developed
4	Number of activities per year that prevent disease outbreaks or manage diseases of Montana livestock
5	Meetings that maintain or enhance Montana's presence in the production of quality meat products
6	Number of producers that participate in livestock tracking programs

Outcome #1

1. Outcome Measures

Identify critical infection and resistance processes

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Identifying critical infection and resistance processes is immensely important to Montana's food producers. Providing detection, treatment and resistance for a variety of illnesses and diseases ensures that Montana's food exports are safe and meet standards for the global market, while assuring producers and patrons of a healthy and economically viable food source. Infection and resistance studies also provide a deeper understanding of human illness and their correlation and behavior with that of animal diseases.

What has been done

Identified virulence factors and protective antigens among the cell surface proteins of horse pathogen Streptococcus, and identified new virulence factors among 13 uncharacterized cell wall proteins. Determined whether virulence factors identified in the primary objective are protective antigens, and the study expects to identify new projective antigens that can be included in a vaccine formulation for the development of an effective and safe strangles subunit vaccine.

Results

2013 research objectives included cloning DNA fragments on three target genes for inactivation of the target genes, successfully obtaining Streptococcus equi mutants for two of the three target genes, and have generated mutants for 12 of 13 target genes. The project compared virulence of four mutants with the parent strain using a mouse model of intranasal S. equi infection, and one of the mutant was significantly attenuated in virulence. Studying animal losses allows a deeper and active understanding of food safety.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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303	Genetic Improvement of Animals
305	Animal Physiological Processes
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
903	Communication, Education, and Information Delivery

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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

During legislative testimony producers repeatedly shared the impact COA/MAES research had on their operations and how new technologies were saving money and increasing agricultural product quality.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

Number of improvements to vaccines developed

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Research was conducted on the bovine gamma/delta T cells using functional, biochemical and molecular approaches, which clarified the general understanding of the bovine immune system and how it is similar and dissimilar to the immune system in rodents and humans. This information facilitates the development of new approaches to treat infectious diseases of cattle.

Results

The direct impact of this work is a general understanding of animal immune systems and their responsive health to new improvements to vaccine development. This discovery and research affects the fields of food animal production and food safety. Several producers expressed appreciation for the alert and pro-active action taken by MSU and the state livestock department.

4. Associated Knowledge Areas

KA Code	Knowledge Area
305	Animal Physiological Processes
307	Animal Management Systems
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Research centered on the use of forage nutrient analysis and the application of the analysis results as risk management for beef cattle producers, and understanding the quality of harvested forages is critical to building a cost-effective feeding plan.

Results

MSU researchers and Montana Department of Livestock researchers formed a taskforce to address this concern and develop strategies for vector mitigation. Through a series of conference calls, they developed recommendations and shared the information with Montana public.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
305	Animal Physiological Processes
307	Animal Management Systems
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
503	Quality Maintenance in Storing and Marketing Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

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
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

Two professors redesigned a university course in the Animal and Range Sciences Department to include social and video media. They incorporated agriculture and range science advocacy training into the course, which has allowed a broad audience to have access to advocacy materials.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
305	Animal Physiological Processes
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
503	Quality Maintenance in Storing and Marketing Food Products
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Number of producers that participate in livestock tracking programs

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

MSU researchers evaluated electronic identification tags and are now emphasizing DNA tracking in the sheep and cattle industry. MSU hired two faculty members in 2012 to enhance DNA and genetics management and a rumen micro-biologist. At the Northern Agricultural Research Center researchers evaluated 276 replacement heifers and developing bulls through the GrowSafe System. Reproduction, longevity and RFI are evaluated and the data will be used for long-term tracking and monitoring of the livestock.

Results

Through the use of EID tags producers are receiving carcass information and sometimes even feedlot information, allowing them to identify production characteristics for their herd and for individual bloodlines beyond typical ranch production traits. This information allows producers to position their production for the future and identify specific markets that fit their product.

4. Associated Knowledge Areas

KA Code	Knowledge Area
315	Animal Welfare/Well-Being and Protection
503	Quality Maintenance in Storing and Marketing Food Products
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

MSU COA and MAES experienced significant faculty movement impacting this planned program, and several programs with remaining research goals have migrated with the principal investigators and their respective projects, outlined in the 2012 and 2013 Plan of Work.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Montana has 2.5 times more cattle than people providing the foundation for the number one industry in the State - agriculture. It is in this context that researchers design, implement, and conduct research projects within the COA/MAES. Research in the Animal Health Program is critical to the industry in Montana and producers and consumers alike who count on the investigators to promote a healthy industry through their consistent research. Highlights for 2013 were:

- Advancements in knowledge of Staphylococcus Aureus in humans and livestock

- Hired new faculty members, two of which are core users of new molecular tools
- Evaluated 256 animals through the GrowSafe system and added new equipment to MSU research center doubling the capacity of researchers to evaluate residual feed intake
- Conducted webinars, workshops, and seminars to share up-to-date information on animal health and quality assurance reaching audiences in excess of 2,500

Key Items of Evaluation

The Animal Bioscience Building combined with state-of-the-art laboratory equipment assisted in the successful recruitment and hiring of three new faculty members in the Animal and Range Sciences Department for the College of Agriculture. The new faculty include a beef geneticist, a range ecologist, and a rumen microbiologist. The College also purchased an Illumina MiSeq and is using it to help members of the Crow Indian Reservation identify sources of antibacterial resistant E. Coli. A collection of biting flies (mosquitos and midges) have been collected for disease collection specifically for the knowledge for livestock producers. A model product was produced used for estimating environmental concentrations of insecticides used for adult mosquito management. Educational aids and curricula were produced on adding value to beef cattle, these materials were presented 23 times to a total of 1,261 constituents in the North West region of the United States. Presentations for this program included state and agricultural extension agents, financial advisors, local business leaders and beef cattle and forage producers. Finally, data and research material was produced on a study regarding the commonality of S. aureus in the anterior nares of horses.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Global Food Security and Hunger -- Integrated Pest Management

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
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: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	33.3	0.0
Actual Paid Professional	0.0	0.0	61.7	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	619903	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2645002	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1981868	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

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

2. Brief description of the target audience

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

3. How was eXtension used?

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

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	5000	7000	2000	1000

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

Patent Applications Submitted

Year: 2013

Actual: 2

Patents listed

- 1.) Bacillus Isolates and Methods of their use to protect against plant pathogens and virus
13/175,6148,524,222
- 2.) MNR - 180 Rust Resistant Mutant in Wheat 61/915,380

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	103	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2013	103

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Actual
2013	65

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

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

Outcome #1

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	241

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

Researchers explored new and improved methods to identify and control insects, weeds, and disease challenging Montana farmers. They then conducted face-to-face training sessions with members of the Montana agricultural community, conducted webinars for additional participants, and presented at public meetings and seminars. 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 awareness to incorporating targeted grazing into farming systems. Researchers with the targeted grazing program spoke at seven locations educating 241 participants as to the benefits of the program, and they shared information at field days. A total of 12 presentations, 6 workshops and several poster-presentations disseminated new research findings, recommendations and information.

Researchers held a pest management tour and visited five locations.

New online information programs are including more data to assist farmers and ranchers with weed and insect identification, including multiple trainings for the United States Forest Service and the Crow Reservation in Montana on identifying rush skeletonweed root moth, and the biological control of weeds and use of insect biocontrol agents. Many radio interviews were conducted regarding the emerging research of the wheat stem sawfly, and five private farm and ranch consultations were provided by faculty from our Western Triangle Research Center.

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, evaluated, or changed/altered

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Invasive plant species are recognized as a serious and threatening problem to Montana. Producers must continually improve pest management programs to increase productivity and profit. Consumers are demanding farmers use less chemical pesticides for food crops. Integrated pest management research also involves pest mitigation with researchers investigating both herbicides and biological control agents for insect and plant diseases. Invasive plant species are a serious economic and ecological problem for range and forested lands

What has been done

MSU COA researchers are exploring biological control agents several species of invasive weeds that a negative impact on the state's food production. Research projects contributed to the selection of potential new control agents and an increased understanding of how to use them. They continued exploring targeted sheep grazing as an economical and ecologically sustainable tool to manage lands with large infestations of invasive plants. Numerous biocontrol agents are currently being studied for the control of noxious pests, as many target weeds currently either are

without any form of biological control, or agents already established are not effective over the range of the production.

Results

Researchers released 20 gall wasps in 2009 and found an equal number of galls infesting the Russian knapweed. Since then the numbers have increased exponentially with thousands of galls present in 2013. Additionally, a cost-benefit ratio is being researched to provide information to growers about the use of biological based pesticides for the control of the wheat stem sawfly.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

Number of broad-ranging stewardship practices implemented

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

and suggestions for targeted grazing practices. Researchers also made significant advancements in wheat stem sawfly research. Advancements were also made toward integrating molecular research with applied entomology.

Results

New online information programs are including more data to assist farmers and ranchers with weed and insect identification, including multiple trainings for the United States Forest Service and the Crow Reservation in Montana on identifying rush skeletonweed root moth, and the biological control of weeds and use of insect biocontrol agents. Many radio interviews were conducted regarding the emerging research of the wheat stem sawfly, and five private farm and ranch consultations were provided by faculty from our Western Triangle Research Center. Map models were also created for public use regarding the probability of invasive plant distribution, for specific management areas. This models can be found at: <http://ippf.msu.montana.edu/>

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
2013	32

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

MSU Pesticide Education Program administered a website which included 250 private applicator programs this year. These programs are meticulously reviewed before awarding continuing education credits awarded based on meeting the core pesticide education categories: pesticide laws, integrated pest management, calibration, pesticides in the environment, the private applicator license, and pesticide safety. Without available credits private applicators may choose to spray pesticides without adequate training, or to not manage noxious weeds and insect pests through the use of pesticides. A hands-on workshop for 18 Crop Consultants and county extension agents on plant disease diagnosis and management included virus detection. The workshop provided 16 ACA credits and six Montana Private Applicator Credits.

Results

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

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

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

New products registered.

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Number of potential products/practices evaluated

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	19

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

MSU COA IPM experts traveled extensively to deliver educational outreach related to cropland entomology. They wrote more than 20 Ag Alerts and several articles in regional magazines, educated growers about current infestations and outbreaks, and posted educational modules on the extension webpage. They also coordinated and distributed 2000 copies of a Pulse Pest Calendar in Montana and North Dakota to growers and agricultural professionals. Additional products produced include: study guide for MSU students was produced, a new germplasm, survey instruments, models, data and research material, weed workshops, biological control workshops, a new collection of Montana insects numbering more than 26,000 specimens, a video on pine invasions from the Northern Hemisphere in New Zealand, and models for creating probability of invasive plant distribution maps for specific management areas.

4. Associated Knowledge Areas

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

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

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Investigators with the COA and MAES focused on identifying and managing weeds, insects, and diseases, so the agricultural community in Montana can better impact global food security. Field crops are an important foundation for the Montana agricultural industry and revenue exceeding \$2 billion in 2013. The most significant crop in Montana was wheat (5.4 million acres, \$1.4 billion) followed by barley (760,000 acres, \$143 million). The grain supports the livestock industry in Montana, and also the export market. A leading researcher shared that of the growers attending conferences on disease management and fungicide treatment options 65 percent could better identify diseases and had a clearer plan of how to treat them. Educating one field agronomist about stripe rust is estimated to have impacted 48,000 acres with an economic benefit to growers of \$4 million. A direct economic impact of recommendations from researchers at the MSU Schutter Diagnostic lab this year was approximately \$400,000 on 354,000 acres. Requests for assistance were lower, because it was a dry year with fewer disease outbreaks.

Researchers are investigating the sawfly's chemical ecology, and evaluating host plant resistance, pathogens, and cropping strategies. Researchers at MSU identified sex pheromones from hundreds of moth species and are using them to study and trap the insects and disrupt their mating by altering the odorant receptor proteins from male moth antenna. Additionally, studies were aimed at developing microbial pesticides as practical tools for the wheat stem sawfly.

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

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

ecology and economics of Montana agriculture. This year two studies focused on cheatgrass and how to control it as well as revegetation methodologies. Information was shared through workshops and field days with private and public land managers to improve rangeland health.

Key Items of Evaluation

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

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

An important finding in 2013 was the confirmation of glyphosate-resistant kochia populations in Montana. Kochia is especially troublesome in wheat-fallow cropping systems, because it spreads quickly. Researchers are working with farmers in Montana to educate them on herbicide-resistant kochia management.

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

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

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

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			15%	
202	Plant Genetic Resources			35%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			15%	
205	Plant Management Systems			10%	
502	New and Improved Food Products			5%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			5%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	40.6	0.0
Actual Paid Professional	0.0	0.0	37.3	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	393062	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1558818	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1186656	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Communication of information on plant breeding and genomics advances through classroom activities, field days, cultivar trials, news releases, presentations at county and state meetings, and conventions
 - Release germplasm, new cultivars, and new genomics tools and techniques
 - Strategic planning with state agricultural groups
 - Technical and non-technical publications
 - Develop value-added, agriculturally based end-use products
 - Establish biobased product and food science education and research programs
 - Enhance partnerships among faculty across the Montana university system, producers, agricultural industry, and other educational institutions across the region
 - Provide ways to enhance agricultural production practices to enhance product quality
 - Develop research summaries and fact sheets

2. Brief description of the target audience

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

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1000	2000	0	0

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

Patent Applications Submitted

Year: 2013
 Actual: 1

Patents listed

PVP App. 201300357 Application filing date: 8/01/2013 Title: Wheat, common 'SY Clearstone 2CL'

61/915,380 12/12/2014 MNR-180 Rust Resistant Mutant in Wheat

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	42	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of foreign trade teams in Montana

Year	Actual
2013	18

Output #2

Output Measure

- Number of foreign trade teams at MSU

Year	Actual
2013	4

Output #3

Output Measure

- Number of research citations

Year	Actual
2013	42

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	Integration of new molecular techniques into breeding projects to improve outcomes
3	Average per bushel yield increase of Montana grains while maintaining product quality
4	Number of elite lines of wheat and barley screened for agronomic and quality characteristics
5	Number of improved cultivar recommendations by districts across Montana
6	Planted acreage percentage increase per year of new MSU-released small grains in Montana
7	Number of programs established to enhance global food biosecurity
8	Number of new food products created from Montana crops

Outcome #1

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	38

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

Producers are using the tools and researchers are sharing information about how to best use them prior to crop selection. Information is posted on the sites regarding current analysis of new cultivars and crops along with the most current information on disease and insect resistant strains. The sites provide comprehensive information about new crop recommendations by district. These tools also provide timely completion of wheat quality evaluations on breeder's samples is a priority, which leads to the timely identification of varieties suitable for desired end product quality, and for recommendations for growers to produce.

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

Integration of new molecular techniques into breeding projects to improve outcomes

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Advancements in technology allow scientists to discover new genotypes and breed for favorable traits while eliminating undesirable characteristics. In particular, genetically engineered wheat varieties at MSU are geared specifically toward higher yield potential and be desirable to wheat buyers. These research goals and achievements keep Montana's producers and the Montana agricultural production economy a top priority.

What has been done

Field selection, augmented by the use of molecular markers during the traditional plant breeding process of crossing and selection, was privileged by researchers in 2013. Several trials were conducted to identify new genes for incorporation into the breeding program, which contains experimental lines at all stages of development, from initial crosses to highly selected individual crosses made in previous years.

Results

Two new varieties underwent seed increase and purification in 2013, and they are under consideration for potential release. Dissemination of varieties has been accomplished through the established seed growers program and over one million acres were evaluated and tested. New crosses are made every year, and after several years of selection, a small subset of lines from the best crosses is ready for testing in statewide yield trails. Extensive testing for agronomic traits and end-use quality in the statewide trails provides data for the Montana Agricultural Experiment Station to consider potential release of an experimental line as a new variety.

4. Associated Knowledge Areas

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

Outcome #3

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

Durum, spring, and winter wheat yields dropped in 2012, and 2013 yield statistics have not been published. "Yellowstone," "Genou," and "Rampart" comprised more than half of the total winter wheat planted in 2012. Seeded acres of barley increased by 200,000 but yield dropped due to drought. Total wheat yields for 2012 totaled 34.8 bu/acre for 2011-2012. In 2012, wheat acreage planted totaled 5,800 and the price per bushel rose 8.51, up a 6 percent increase from 2011.

2012 all wheat value of production totaled 1.6 million. Montana remains the second largest spring wheat producer in the country, according to the USDA NASS, Montana Field Office. "Vida," "Choteau," "Reeder," and "Corbin" accounted for more than 55 percent of Montana's 2012 spring wheat acreage and two of them were developed by the MAES.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #4

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	270

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 determined the agronomic and economic impact of various crop sequences in dryland crop production in Montana and screened for key agronomic and horticultural traits such as general adaptation, phenology and growth potential. Two new varieties underwent seed increase and purification in 2013 and they are under consideration for potential release. These include CAP400 and MT1172. Data from the Northwestern Agricultural Research Center has shown superior performance of CAP400 for yield, grain protein, OWBM resistance and stripe rust resistance. MT1172 showed very high yield potential and modest grain protein levels.

Results

Researchers planted the intrastate yield trial at eight locations with yields averaging 58 bu/acre. Seven hollow-stem, one solid-stem, and one "Clearfield" experimental lines were selected for further testing and seed stock purification. Twenty lines were selected for additional testing, and a 49 entry yield trial was planted and harvested and twelve solid stem lines were retained in upper level sawfly trials. 856 lines were evaluated for agronomic potential, 99 harvested, with 60 then selected for preliminary yield testing. These included four hard white and three two-gene "Clearfield" lines. They also screened for reliable grain yield and the plants ability to retain green leaves after heading. Winter wheat investigators added 284 crosses to the germplasm base, emphasizing disease resistance and adaptation traits. Extensive testing for agronomic traits and end-use quality in the statewide trails provides data for the Montana Agricultural Experiment Station to consider potential release of an experimental line as a new variety.

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

Number of improved cultivar recommendations by districts across Montana

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	40

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

varieties that will grow under dryer and warmer conditions. There are several biotic and abiotic stresses that hinder wheat production in Montana, thus, improved cultivar recommendations are immensely important to Montana producers.

What has been done

In 2013, recommendations were made and released from the breeding program: Warhorse, a solid-stem HRW wheat resistant to wheat stem sawfly, Colter, a high-yielding HRW with strong stripe rust resistance, and WB33768, a high-yielding hard white winter wheat line was licensed to Monsanto. Leading cultivars in the state included Yellowstone (23.5%, released in 2005), Genou (14.4%, released in 2004) and Decade (6.0%, released in 2010.) Judee and Bearpaw solid stem, semi-dwarf cultivars have now entered commercial production and are expected to replace Genou. Variety performance information was disseminated to producers via internet, traditional extension bulletins, popular press articles and field day presentations.

Results

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

4. Associated Knowledge Areas

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

Outcome #6

1. Outcome Measures

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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
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3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

MAES and the COA released "Silver Durum," and two Clearfield hard red winter wheat varieties, "War Horse" and "Colter." In 2011 they released "Hockett" barley, three hard red winter wheat varieties ("Judee," "Bearpaw," and "Decade"), and a new red spring wheat named "Duclair." All of them were recommended in 2013 to districts throughout Montana.

Results

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

4. Associated Knowledge Areas

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

Outcome #7

1. Outcome Measures

Number of programs established to enhance global food biosecurity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Discovering new ways to use products increases global food security and keeps consumers engaged. Consumers continue to want more local food options, and they are more interested in how and where it was grown. COA/MAES researchers prioritize providing the most accurate and reliable data to Montana breeders, to ensure breeders will continue using the best lines. The COA/MAES breeding and genetics programs develop and releases crop and plant varieties that are more profitable for Montana growers. The programs identify genes and genetic mechanisms that promote improved plant productivity and plant health, and ultimately provide more profit and confidence for Montana producers.

What has been done

MSU researchers processed samples submitted by the wheat and barely breeding programs in a timely mannner to allow the breeding programs to continue their selection programs without incurring delays. MSU researchers also conducted studies on genes important to cereal grain quality and agronomic traits. In 2013, they completed five refereed journal articles with three appearing online and in press. These manuscripts covered three main topics: plant productivity, grain hardness, and starch quality.

Results

The primary output of MSU research breeding programs is the completion of crop quality evaluations on breeders samples, and the results of which continue to be featured in journals and publications throughout Montana and beyond enhancing knowledge for producers and consumers alike. This then leads to the identification of varieties for desired end product quality and to recommend for growers to produce.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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 #8

1. Outcome Measures

Number of new food products created from Montana crops

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

MSU researchers conducted studies on genes important to cereal grain quality and agronomic traits. In 2012, three new germplasms were released; WB9879CLP, MSUPBLB10-10, and another on behalf of faculty member Michael Grioux. In 2013, gene tagging and identification efforts was focused specifically on three pea varieties, as the gene originally proposed to investigate was identified by others. Dry peas, following a newly released food product, are demonstrative of a crop well suited to the agricultural practices common in Montana and neighboring states. Dry peas are an economically viable alternative to wheat, barely and canola, and the crop also helps to condition the soil through its ability to add nitrogen, low water use, and alternate pests, weeds and diseases.

Results

A new product type, a new germplasm, was released in 2013: MSUPBLB10-10, a yellow, high-amylose dry pea suitable for conditions on the northern Great Plains. This is new product registry provides a new food product tailored for the economic gain and surrounding bio region for a large percentage of Montana producers. A second new germplasm that included the variety WB9879CLP, was also released. The germplasm is resistant to the imidazolinone herbicides and has solid stems for wheat stem sawfly resistance. A set of near-isogenic lines with all combinations of the R genes were developed and submitted to the National Small Grains Collection. Montana received 462 germplasm accessions during 2012. Of those accessions 384 (75%) were Triticum species. Seventeen individuals received germplasm during 2012, and eight were associated with Montana State University.

4. Associated Knowledge Areas

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

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

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

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The development of improved winter wheat lines and cultivars continues with improvements in yield, disease resistance, and tolerance advances, combined with improved stem solidness to combat sawfly. New challenges arrive, or former pests mutate to circumvent the remedies developed to thwart their damage and renew their attack on wheat and other crop species.

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

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

"Yellowstone" and "Genou" (cultivars developed by the MSU research program) are the top two planted cultivars in Montana, accounting for about one million acres in 2012.

Adoption of these cultivars by Montana wheat growers has resulted in harvest of an additional 21.5 million bushels of winter wheat over the past six crop years (2007-2012) based on production acreage and estimated yield gains over previously deployed cultivars.

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

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

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

Key Items of Evaluation

- A new germplasm, "MSUPBLB 101-10", a yellow, high-amylose dry pea suitable for conditions found on the northern Great Plains was released
- An organized collection of more than 9,000 photographs of plants, including more than 2,000 photos of grasses are maintained at www.flickr.com/photos/plant_diversity/collections. All photographs are georeferenced and tagged with taxonomic, ecological, and morphological information for ease of retrieval and use as primarily an educational tool and secondarily to document study sites
- Three winter wheat cultivars were released: Warhorse, Colter HRW wheat, WB3768 HWW wheat
- Several new low glycemic lines of potato, one low glycemic line of naked oats, and one low glucosinolate *Camelina sativa* line for microgreens were developed
- A set of guidelines for dryland crop rotation for Montana producers is currently being developed
 - "Yellowstone" and "Genou" (cultivars developed by MSU) continued to be the top two planted cultivars in Montana, accounting for about 0.934 million acres in 2012. Adoption of these cultivars by Montana wheat growers has resulted in harvest of an additional 21.5 million bushels of winter wheat over the past six crop years (2007-2012) based on production acreage and estimated yield gains over previously deployed cultivars.
 - Completed complex field research experiments with nearly 1,000 experimental lines of dryland and irrigated barley.
 - MAES researchers developed and reported a new high throughput molecular marker for leaf rust resistance breeding and a new strategy for studying genes in wheat seed development.
 - Researchers demonstrated two important mechanisms in plant triacylglycerol biosynthesis pathway that were published.
 - Spring wheat varieties developed by the COA/MAES program were grown on more than one million acres. The two most widely grown varieties in the state, "Vida" and "Choteau," were developed at MSU. In addition, two varieties developed by marker-assisted selection were marketed for the first time in 2012.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Sustainable Energy

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			10%	
202	Plant Genetic Resources			15%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			10%	
205	Plant Management Systems			15%	
511	New and Improved Non-Food Products and Processes			25%	
605	Natural Resource and Environmental Economics			10%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	40.3	0.0
Actual Paid Professional	0.0	0.0	25.2	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	229176	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	975677	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	840367	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conduct outreach activities related to biobased products
- Develop value-added, agriculturally based end-use products
- Enhance partnerships among faculty across the Montana university system, producers, the agricultural industry, and other educational institutions across the region
- Develop 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

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	30	1000	0	0

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

Year: 2013
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	5	7	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- New business partnerships created

Year	Actual
2013	0

Output #2

Output Measure

- Number of research citations

Year	Actual
2013	7

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of new crop options with research trials as biofuels in Montana

Outcome #1

1. Outcome Measures

Number of new crop options with research trials as biofuels in Montana

Not Reporting on this Outcome Measure

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

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

V(I). Planned Program (Evaluation Studies)

Evaluation Results

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

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Global Food Security and Hunger: Animal Health, Production, and Products

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
301	Reproductive Performance of Animals			15%	
302	Nutrient Utilization in Animals			12%	
303	Genetic Improvement of Animals			12%	
304	Animal Genome			12%	
305	Animal Physiological Processes			12%	
306	Environmental Stress in Animals			10%	
307	Animal Management Systems			12%	
308	Improved Animal Products (Before Harvest)			15%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	63.0	0.0
Actual Paid Professional	0.0	0.0	12.7	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	164664	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	806521	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	157882	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conduct research regarding livestock reproduction and fertility rates and share results timely with producers
- Enhance the value of animal products, primarily sheep and beef cattle
- Explore the nutritional managements systems for livestock and winter grazing
- Continue advanced research for targeted grazing management
- Maintain research on residual feed intake and feed to grain conversion

2. Brief description of the target audience

- State agencies, animal health companies, and state commodity groups
- Ranchers, seedstock industry, colleagues, and related stakeholders
- Crop and livestock producers in Montana

3. How was eXtension used?

COA and MAES researchers worked closely with county extension agents and outreach coordinators to disseminate timely and accurate information about animal health, production and products.

V(E). Planned Program (Outputs)

1. Standard output measures

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

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	19	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2013	19

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of off-campus educational programs offered

Outcome #1

1. Outcome Measures

Number of off-campus educational programs offered

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Animal health, production and products are of significant concern to Montana producers, as animal health is a field that directly impacts the state's economy. Livestock production on Montana farms and ranches provided \$ 1.6 billion of gross income to the United States Economy, and of that amount, \$1.2 billion of the value-added was in beef. Montana producers rely heavily on current information and studies within the animal health field.

What has been done

Interactions between the levels of supplement consumption, supplement delivery methods, and forage intakes by beef and cows were evaluated. The intent of this research is to determine how the basic processes controlling forage intake and utilization by ruminants can be manipulated by supplementation.

Results

Sixty mature ewes were used to determine if a feeding method of pea-barely forage had an effect on individual ewe mineral consumption. In this study, both swath grazing ewes and ewes in confinement consumed more mineral than recommended by the mineral manufacturer and the NRC indicating that more research is needed to develop a better understanding of the factors that regulate and impact mineral intake. This data was presented at the 2012 Montana Nutrition Conference and the Western Section of the 2012 American Society of Animal Health. Additionally, two journal articles on the study were published.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals

303	Genetic Improvement of Animals
304	Animal Genome
305	Animal Physiological Processes
306	Environmental Stress in Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)

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

MSU COA and MAES experienced significant faculty movement impacting this planned program. Previous projects highlighted in the 2013 Plan of Work included extensive research into brucellosis and prion diseases. The principal investigators in these projects were recruited to larger institutions with significant salary increases, and these projects were terminated.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Montana has 2.5 times more cattle than people providing the foundation for the number one industry in the State - agriculture. It is in this context that researchers design, implement, and conduct research projects within the COA/MAES. Research in the Animal Health Program is critical to the industry in Montana and producers and consumers alike who count on the investigators to promote a healthy industry through their consistent research. Highlights for 2013 were:

- Advancements in knowledge of Staphylococcus Aureus in humans and livestock
- Hired new faculty members, two of which are core users of new molecular tools
- Evaluated 256 animals through the GrowSafe system and added new equipment to MSU research center doubling the capacity of researchers to evaluate residual feed intake
- Conducted webinars, workshops, and seminars to share up-to-date information on animal health and quality assurance reaching audiences in excess of 1,500

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Childhood Obesity

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
701	Nutrient Composition of Food			15%	
702	Requirements and Function of Nutrients and Other Food Components			50%	
703	Nutrition Education and Behavior			25%	
723	Hazards to Human Health and Safety			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	5.6	0.0
Actual Paid Professional	0.0	0.0	6.2	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	35026	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	146914	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	572569	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conduct research experiments
- Partner with the Extension and other MSU colleges to develop recipes using new grain products
- Publish findings of research involving diseases that might be impacted by nutrition
- Conduct experiments and analyze, evaluate data for studies within the genetic, metabolic and systemic physiological processes that underline Fatty Liver Disease

2. Brief description of the target audience

- Specific health based consumer groups
- Domestic and foreign buyers of quality grains
- Farmers, colleagues, and stakeholders
- Grain associations, Montana Department of Agriculture, Montana Wheat and Barley Committee, grain elevators, and state commodity groups
 - 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

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

Patent Applications Submitted

Year: 2013
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	6	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

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

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	New crops identified with options for specific health-need based consumers
2	Relationship between high fat diet and liver-cell turnover

Outcome #1

1. Outcome Measures

New crops identified with options for specific health-need based consumers

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Consumers are increasingly demanding specific health-based markets, and the development of new grains for production. Nutritional needs and activity from the gluten free community and celiac sufferers is leading to increased sales in health markets, in turn, this creates an increased demand in acreage for the development of new grains. Ultimately, the goal is to expand the number of value-added crops.

What has been done

Development of camelina, timtana, proatina and montina, was continued and the process of expanding their marketability and profitability to growers was investigated. Research involving a consumer base with needs that are not being met by current crops is also ongoing.

Results

New germplasm in potatoes and oats were screened for better nutritional traits. Several low glycemic lines are in the advanced stages of testing for nutritional and agronomic tests. A new germplasm was created, which and several new low glycemic lines of potato and one low glycemic line of naked oats and one low glucosinolate Camelina sativa line for microgreens.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
703	Nutrition Education and Behavior

Outcome #2

1. Outcome Measures

Relationship between high fat diet and liver-cell turnover

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Tens of millions of Americans suffer from fatty liver disease (FLD) and an estimated eight-million of these people will progress to liver cirrhosis. Most cases of FLD are caused by excessive consumption of either calories or alcohol, so the attempts at treatment of this disease are solely behavioral. The enormous prevalence of FLD indicates that behavioral approaches are not adequately effective. Because of such, a deeper understanding of the genetic, metabolic and systemic physiological processes that underline FLD provide a better understanding of genetic predispositions to the disease. Examining the nation's food supply or reviewing USDA's nutritional recommendations may also be effective in reducing national rates of FLD.

What has been done

Using a set of three novel mouse models that have been developed within the project, each model has been manipulated to host genetic predispositions to FLD. The models allow the opportunity to distinguish the metabolic pathways underlying FLD, and allow assessment in the dietary/supplement/food-quality evaluations. The evaluation of genetic susceptibility to environmental FLD on the effects of dietary fat on animals (mouse models), have provided a deeper understanding of the relationship between some forms of genetic or metabolic susceptibility to FLD.

Results

Several novel mouse models have been developed and two papers have been published regarding work with the models. One of these mouse models has been accepted for public distribution by Jackson Laboratories as stock #023035. Several educational aids have been produced and several activities and experiments have been conducted in analyzing data for general mouse studies with FLD. The mouse models have been incorporated into two senior-level courses on functional genomics, the PI was invited as a keynote speaker and presenter on Redox Biology at the University of Nebraska, Lincoln.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
702	Requirements and Function of Nutrients and Other Food Components

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
- Competing Programmatic Challenges

Brief Explanation

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

V(I). Planned Program (Evaluation Studies)

Evaluation Results

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

Key Items of Evaluation

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