

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	Diseases 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: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	63.6	0.0
Actual Paid	0.0	0.0	76.8	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

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

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	617369	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2940694	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2682245	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The importance of integrated pest and disease management remains a consistently critical field as invasive pest and disease species continue to threaten Montana's agricultural industry as well as the global safety of the state's food exports, and general health of the state's myriad natural resources essential to agriculture production. Pests and diseases, in all of their forms (plants, soils, animals, food storage, water), will continue to represent a colossal economic threat to Montana producers in pre and post-harvest production systems. Dwindling water resources, vulnerable natural resources and a changing climate have only exacerbated the demand for research funding and applied research as it relates to supporting and protecting Montana's agriculture industry. In 2014, producers and researchers continued to evaluate new integrated pest and disease management methodologies so they could maintain a competitive position in U.S. and world markets while helping alleviate global hunger.

The program area of integrated pest management explored new and improved methods to identify and control insects, weeds and diseases in large and small-scale cropping and agricultural productions. An increase in public concern about food safety, quality, cost, biodiversity, and the sustainability of natural resources such as soil, air, and water quality encouraged scientists to rely less on pesticides and look for more environmentally friendly options. Studying biological controls as low-impact pest control options, promote sustainable practices. 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.

Research areas continued to privilege; insects, mites and other arthropods affecting plants, pathogens and nematodes affecting plants, weeds affecting plants, biological control of pests affecting plants and overall integrated pest management systems. Faculty scientists continued quality in-depth training programs for continuing education on integrated pest and disease management and discover, evaluate, or change new integrated pest priorities and projects. Additional outcomes included new products registered, the passing rate percentage for pesticide application licenses and a number of new broad-ranging stewardship practices that were implemented. Research also focused on stopping food-borne illness (preharvest for food and animal consumption). Diversification and innovative and integrated cropping systems have helped with disease and weed control while reducing dependence on fertilizer. Most land managers agree the spread of invasive plants and pests are the primary environmental threats to western wildlands and rangelands. Noxious weed invasion reduces the ecological integrity of land and water, alters ecosystems, impacts wildlife habitat and threatens survival of native plants. MSU Extension manages the Private Pesticide Applicator Training Program for the Montana Department of Agriculture. Both Extension and COA/MAES actively participated in research projects on the subject and interacted with producers, landowners and property managers to share the latest information.

Investigators with the COA and MAES focused on identifying and managing weeds, insects, and diseases, so the agricultural community in Montana can better impact global food security. They also developed and shared quality stewardship programs to identify and mitigate noxious weeds and harmful insects. Field crops are an important foundation for the Montana agricultural industry and revenue exceeded \$2 billion in exported goods in 2014. The most significant crop in Montana was wheat (5.4 million acres, \$1.4 billion) followed by barley (760,000 acres, \$143 million). Montana farmers spent approximately \$15 million on fungicide applications in 2011, but the number was much less in 2012, because of drier conditions. Although yield benefits/detriments from spraying a fungicide are difficult to estimate, most respondents estimated a 0-20 percent yield increase. Not spraying resistant varieties of grain saved \$12 million. Stripe rust cost growers \$48 million in 2011. Fungicide application saved growers \$30 million. If the estimated worth of the wheat crop in Montana is \$1.6 billion, they saved 2 percent of the crop. Susceptible varieties

sprayed in a timely manner saved approximately \$90 million. Savings due to herbicide and seed costs on 2,000 acres of winter wheat totaled approximately \$60,000 and yields of winter wheat averaged approximately 40 bu/acre, totaling \$480,000 (est. \$6/bu) in farm revenue.

Biological controls for insects, weeds, and diseases are becoming more important as traditional chemical control methods are limited. The increase in public concern about food quality and safety, natural resource biodiversity, and sustainability of the quality of soil, air, and water is mandating less reliance on traditional pesticides and more research into environmentally friendly systems.

Montana's stakeholders need new and improved methods for controlling insects, weeds, and diseases. Pesticides are a major expense to producers; however delaying or eliminating pest control measures may not always be an option. An increase in public concern about food quality, natural resource biodiversity, and sustainability and quality of soil, air, and water resources is mandating less reliance on traditional pesticides and more research into biological control systems and organic food production. An emphasis on pest monitoring (using decision-making parameters and determining economic injury levels) will optimize the use of pesticides for controlling pests. Foreign trade partners especially want decreased pesticide residues in the wheat and barley exports.

- Disseminate information in print and online to provide pest control recommendations
- Produce regional management guides
- Conduct pesticide workshops and field days to share research results
- Support FIFRA Section 18c products labeling requests
- Update pesticide applicator training materials when necessary
- Update training materials for private and commercial pesticide applicators with new information

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

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	50000	25000	10000	5000

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

Patent Applications Submitted

Year: 2014

Actual: 1

Patents listed

201400394 "Egan"

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	0	300	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2014	300

Output #2

Output Measure

- Multidisciplinary journal articles published

Year	Actual
2014	125

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	Passing rate percentage for pesticide application licenses
4	New products registered.

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
2014	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Invasive pests threaten almost every facet of agricultural production and producers need to have the latest scientific research to remain competitive in the global marketplace. An increase in public concern about food safety, quality, cost, biodiversity, and sustainability and quality of soil, air, and water resources are also pushing scientists away from pesticides.

What has been done

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 100 presentations, 25 workshops and several poster presentations disseminated new research findings, recommendations and information.

Results

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	Diseases 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
2014	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	Diseases 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

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
2014	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	Diseases 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

New products registered.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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

What has been done

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

Results

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

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases 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.)
- Economy
- 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. The 2014 crop year faced warm and limited precipitation though out the year, but when precipitation was received hail often accompanied the storm. Montana recorded a record amount of acreage damaged by hail.

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

OWBM Pest Web Creation:

Scientists, extension personnel and staff developed a real-time monitoring of pests, including the orange wheat blossom midge across Montana. Statewide producers placed live traps in their field that were monitored via a live tracking system network. A new pest website housed real-time tracking of pests that has seen dramatic use by the public. Farmers need information gathered by a community trapping network in order to make management decisions on individual farms. In response to this need, a website has been set up (<http://pestweb.montana.edu/>) and farmer cooperators and county agents are entering trap counts for the orange wheat blossom midge (OWBM), *Sitodoplosis mosellana*. OWBM was found in Montana in 2006 when it devastated spring wheat fields in western Montana, and has since spread to the 'golden triangle,' the major winter wheat production area of the state, where it threatens wheat production. Currently the website is focused on one pest, but the platform can be extended to any pest in any crop. Eventually organizers would like to have push notifications and a web-based app for farmers similar to the scab project (www.scabusa.org). This program will determine the exact distribution of the wheat midge in Montana and will track adult emergence in order to help direct scouting efforts. The scouting efforts are then used to make informed decisions on whether insecticide treatments are warranted. This program will provide training on pest identification, monitoring, and the use of IPM tactics for pest management. We will train at least 200 cooperators per year how to use the web-based system. The success of this objective will be assessed by monitoring website traffic and by the number of volunteers who monitor for the midge and provide population data to the web-site. Google analytics will be used to measure numbers of users, number of views, length of time spent on each page, tracking of where viewers come from, and to track website growth and traffic. Evaluative surveys will be distributed at education events to determine if growers increased their knowledge of OWBM and intend to use the management information provided.

Implementation of Agronomic Crops included cutworm monitoring and distribution of research based information for pest management. IPM implementation in Montana communities included:

- Real estate agent training for noxious weed identification and management: Real estate agents are required by law to inform buyers of noxious weeds on the property, but they often have no training on weed identification nor do they have an adequate background to discuss impacts associated with noxious weeds or development of integrated management

plans. Buyers of small and large acreages across Montana are often people from out of state with a limited background in vegetation management, especially control of noxious weeds. The properties they purchase are often located in the wildland-urban interface (WUI) adjacent to publicly-owned recreational lands (e.g. Forest Service or Bureau of Land Management) or along rivers. Without adequate information about integrated weed management and the need to control weeds, these properties can become sources for further invasion, thus impacting surrounding areas and increasing the need for large scale application of herbicides. Education of landowners about invasive weeds is a major interest of our advisory group and is reflected in our letters of support. Our objective is to provide real estate agents training and materials about noxious weed identification, noxious weed laws, and integrated weed management that they can apply in their professional interactions with clientele. We will also provide them with a list of extension resources about noxious weeds that they can provide to their clientele. We will conduct a series of training webinars (five) and in-person trainings (three) in Y1 of this grant and repeat every two to three years (beyond this grant period), depending on level of interest.

- Included IPM education in Master Gardener training
 - Education for Early Detection and Rapid Response to invasive pests and first detector training for stakeholders
 - Urban IPM workshops for recertification of landscape professionals
 - Structural IPM education with Colorado and Wyoming
 - Distributed research-based education on pests in urban environment
- Establishment of an on-farm research network: Growers in Montana are constantly being bombarded by marketing information and social pressure to use pesticides, but have very little local data to evaluate product claims. In the past couple of years, we have sought to give growers and consultants a skill set to evaluate the statistical validity of claims. We will continue these efforts and attempt to train growers to conduct their own on farm trials. In a survey associated with these educational efforts, 277 pesticide applicators responded in 12 locations in Montana that represented 250,000 acres and a gross revenue of almost \$1 billion. Of the respondents, 70% said they would devote 1-5% of their farm budget to research in order to address their questions. This represents a potential in-kind grant of \$30 million for participatory research, and a high level of interest in the farming community. In addition, when asked where they prefer to get their information when making management decisions, 78% of respondents indicated that 'conversations with colleagues' were the 'most liked' resource. This was confirmed by members of our advisory committee. To meet that need, we have initiated an on-farm research network in 2014 modelled on those in Iowa, Nebraska, Indiana and other areas of the world. We have received funding from the Montana Wheat and Barley Committee and the Western Sustainable Agriculture and Research Education grant program to initiate this project. We currently have an emphasis on IPM management of crop pests. In 2014 we initiated fungicide strip trials with 6 growers in Pondera, Teton, and Gallatin Counties and expect the network to grow exponentially. Other contributions to this project include Winfield Solutions donating the use of their R7 remote sensing software, BASF donating fungicide, farmers putting in additional acres of the trial at their own expense, and a film student (Ian Johnson, eleven_eleven@mac.com) using the study for drone flights and comparing the satellite data provided by Winfield to his calculated normalized difference vegetation index

(NDVI) from the camera on the drone for his masters' thesis.

IPM support for pest diagnostic facilities included:

- Educated clients of the diagnostic laboratory on IPM-based pest management options
- Increased awareness of the services of the diagnostic laboratory

IPM education for pesticide applicators included:

- Pest management tour for pesticide applicators
- Create calibration kits and provide hands-on demonstrations at train the trainer updates as well as pesticide applicator trainings
- Delivery of integrated pest management information to pesticide applicators

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.