Montana State University: Montana Agricultural Experiment Station and Extension Service

REPORT FOR THE MONTANA NOXIOUS WEED TRUST FUND ADVISORY COUNCIL

JUNE 2018

INTRODUCTION

This report for the Montana Noxious Weed Management Advisory Council was assembled in compliance with the Montana Noxious Weed Trust Fund Act and Administrative Rules which require an annual report from the Montana Agricultural Experiment Station and Montana State University Extension Service on current projects and future plans. This report is a compilation of major weed science research and education activities conducted by MSU over the past three years and includes highlights of funded Montana Noxious Weed Trust Fund grants as well as comprehensive reporting of all weed science research products and education funding and activities.

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2015–2017

Project Title, *PI*	2015	2016	2017
Assessing the influence of fire and grazing on cheatgrass spread and plant community composition, *Erik Lehnhoff*		●	
Addressing challenges posed by yellow, Dalmatian, and hybrid toadflax using integrated approaches that support biological control, *David Weaver and Sharlene Sing*		●	
A meta-analysis of previous Canada thistle and field bindweed control and management studies, *Fabian Menalled, Noelle Orloff, Jane Mangold, Zach Miller, and Erik Lehnhoff*	●		
Biological control of: common tansy and oxeye daisy, invasive hawkweeds, Russian knapweed, weedy mustards, and whitetop, *Jeff Littlefield*	●	●	●
Can targeted cattle grazing and biocontrol insects work together to suppress spotted knapweed? *Jeff Mosley*	●		
Continuing development of candidate agents for biological control of Russian olive, *David Weaver*			●
Economic impact of noxious weeds on grazing capacity of Montana rangeland, *Jane Mangold and Kate Fuller*	●		
Effect of perennial grass seeding date on revegetation outcomes in weed-infested range and pasture, *Jane Mangold and Zach Miller*			●
Effect of herbicide application and soil texture on hoary alyssum seed biology and control, *Jane Mangold, Stacy Davis, and Brad Bauer*		●	
Host screening of a new biocontrol agent for common tansy and oxeye daisy, *Jeff Littlefield*			●
Host testing of a gall wasp for the biocontrol of invasive hawkweeds, *Jeff Littlefield*			●
Identifying and testing candidate agents for biocontrol of Russian olive, *David Weaver and Sharlene Sing*	●	●	
Impacts of invasive annual grasses on forage, biodiversity, and litter decomposition rates, *Jane Mangold, Lisa Rew, and Kate Fuller*			●
Increasing herbicide and biocontrol options for integrated toadflax management, *Jane Mangold*			●
Integrated management of dense cheatgrass on productive rangelands, *Lisa Rew, Jane Mangold, and Erik Lehnhoff*		●	
Managing dense cheatgrass infestations on rangeland, and understanding its impacts under an altered climate, *Lisa Rew, Jane Mangold, and Erik Lehnhoff*	●		

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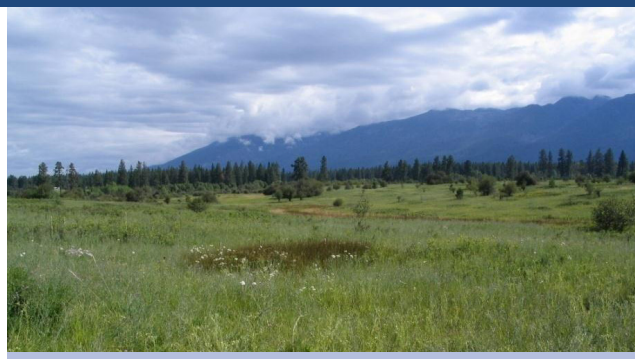


DEPARTMENTS INVOLVED WITH WEED RESEARCH AND EDUCATION

Montana Agricultural Experiment Station
MSU Extension Service

Agricultural Economics and Economics
Kate Fuller, *Extension Economist*

Animal and Range Sciences
Craig Carr, *Rangeland Ecology*
Pat Hatfield, *Range Sheep Nutrition*
Jeff Mosley, *Rangeland Ecology and Management*
Cecil Tharp, *Pesticide Education Specialist*

Land Resources and Environmental Sciences
Edward Davis, *Agricultural Specialist*
Erik Lehnhoff, *Invasive Plant Ecology*
Jeff Littlefield, *Biological Control of Weeds*
Jane Mangold, *Integrated Invasive Plant Mgmt.*
Bruce Maxwell, *Agroecology*
Fabian Menalled, *Weed Ecology and Management*
Robert Peterson, *Plant-Insect Interactions*
Lisa Rew, *Non-native Plant Ecology*
Timothy Seipel, *Plant Ecology*
Sharlene Sing *(Affiliate Research Professor from US Forest Service)*, *Biological Control of Weeds*
Tracy Sterling, *Weed Physiology*
David Weaver, *Entomology*

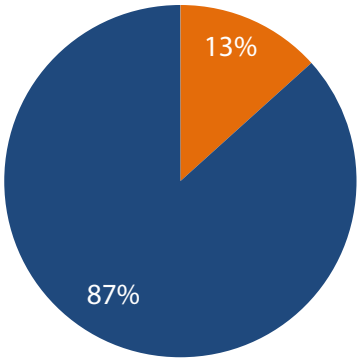
Montana Noxious Weed Education Campaign
Shantell Frame-Martin, *Coordinator*

Plant Sciences and Plant Pathology
Mary Burrows, *Plant Pathology*
Bill Dyer, *Weed Physiology*
Matt Lavin, *Botany*
Ryan Thum, *Aquatic Plant Genetics and Ecology*

Research Centers
Prashant Jha, *Weed Science*
Zach Miller, *Plant Ecology*

MSU WEED PROJECT FUNDING 2015–2017

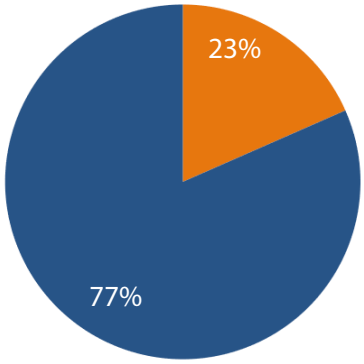
NEW AWARDS 2015



Noxious Weed Trust Fund
$332,835..... 13%

Other
$2,164,532.....87%

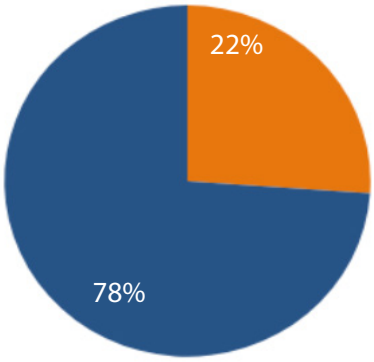
NEW AWARDS 2016



Noxious Weed Trust Fund
$291,596..... 23%

Other
$1,293,076.....77%

NEW AWARDS 2017



Noxious Weed Trust Fund
$309,854..... 22%

Other
$1,094,050.....78%

OTHER FUNDING SOURCES FOR WEED RESEARCH AND EDUCATION, 2015 – 2017

NATIONAL

US Department of Agriculture
Animal and Plant Health Inspection Service • Forest Service • National Institute of Food & Agriculture

US Department of Defense
Army Research Office

US Department of the Interior
Bureau of Indian Affairs • Bureau of Land Management • US Fish and Wildlife Service

Aquatic Plant Management Society • Bayer CropScience • Crop Life America • Dow AgroSciences

REGIONAL

Western Sugar Cooperative • Western Sustainable Agriculture Research and Education Program

STATE

Central Michigan University • Colorado State University • Confederated Salish and Kootenai Tribes (MT) • Minnehaha Creek Watershed District (WI) • Missoula County Weed District • Montana Department of Agriculture • Montana Department of Natural Resources and Conservation • Montana Fertilizer Advisory Committee • Montana Research and Economic Development Initiative • Montana Weed Control Association • Montana Wheat and Barley Committee • Organic Advisory and Education Council • South Dakota State University • Wisconsin Department of Natural Resources

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2015–2017 *Continued*

Project Title, *PI*	2015	2016	2017
Mitigating priority effects of invasive plants during revegetation by altering perennial glass planting date, *Jane Mangold and Zach Miller*	●	●	
Montana Noxious Weed Education Campaign, *Jane Mangold and Shantell Frame-Martin*	●	●	●
Optimizing available toadflax biocontrol resources and evaluation of efficacy of candidate stem-galling weevils, *David Weaver*	●		
Predicting plant community response to weed control, *Jane Mangold*	●		

FUTURE PLANS: 2018 MONTANA NOXIOUS WEED TRUST FUND GRANTS

Montana State University

Biological control of Russian knapweed: Host testing and agent monitoring, *Jeff Littlefield*

Continuing development of candidate agents for biological control of Russian olive, *David Weaver*

Host screening of new biocontrol agents for common tansy and oxeye daisy, *Jeff Littlefield*

Host testing and field release of biocontrol agents for whitetop, *Jeff Littlefield*

Host testing of a gall wasp for the biological control of invasive hawkweeds, *Jeff Littlefield*

Increasing effective options for integrated management of invasive toadflax, *David Weaver*

Keeping it fresh: Revising weed publications, *Jane Mangold*

Mass rearing, release, and monitoring of the Northern tamarisk leaf beetle, a biological control agent for saltcedar, *David Weaver*

Montana Noxious Weed Education Campaign, *Jane Mangold and Shantell Frame-Martin*

Noxious weeds survey: Has 20+ years of weed education been effective?, *Jane Mangold and Shantell Frame-Martin*

Rock Creek Cooperative Weed Management Project, *Tracy Mosley (Park County Extension)*

MSU WEED SCIENCE ACTIVITY

Peer-reviewed journal articles: 53
Invited book chapters: 3
Peer-reviewed conference abstracts: 92
Completed theses and dissertations: 18
Graduate students in training: 24
Extension publications: 31
TV and radio appearances: 16

Collaborators

Agriculture and Agri-Foods Canada
BBCA Rome
CABI Europe
Landcare New Zealand
Montana Department of Agriculture
Montana Department of Environmental Quality
Private landowners
Russian Zoological Institute
Task Force/Consortium Groups
University of Idaho
USDA Agricultural Research Service
USDA Animal and Plant Health Inspection Service
USDA ARS European Biological Control Lab
USDA Forest Service
USDA National Institute of Food and Agriculture
USDA Western Invasive Pest Management Center
USDI Bureau of Land Management

Target Weeds

Canada thistle *(Cirsium arvense)*
Cheatgrass *(Bromus tectorum)*
Common tansy *(Tanacetum vulgare)*
Dalmatian toadflax *(Linaria dalmatica)*
Douglas fir *(Pseudotsuga menziesii)*
Field bindweed *(Convolvulus arvensis)*
Juniper *(Juniperus* spp.)
Leafy spurge *(Euphorbia esula)*
Orange hawkweed *(Hieracium aurantiacum)*
Oxeye daisy *(Leucanthemum vulgare)*
Perennial pepperweed *(Lepidium latifolium)*
Ponderosa pine *(Pinus ponderosa)*
Rush skeletonweed *(Chondrilla juncea)*
Russian knapweed *(Acroptilon repens)*
Russian olive *(Elaeagnus angustifolia)*
Saltcedar *(Tamarix* spp.)
Spotted knapweed *(Centaurea stoebe)*
St. Johnswort *(Hypericum perforatum)*
Sulfur cinquefoil *(Potentilla recta)*
Tall buttercup *(Ranunculus acris)*
Tansy ragwort *(Senecio jacobaea)*
Western salsify *(Tragopogon dubius)*
Whitetop *(Cardaria draba)*
Wild oat *(Avena fatua)*
Yellow toadflax *(Linaria vulgaris)*

MONTANA NOXIOUS WEED TRUST FUND PROJECT HIGHLIGHTS

Figure 1. Hoary alyssum plant that contains both flowers and seed pods.

Effect of Herbicide Applications on Hoary Alyssum Seed Production: A Weed Manager-driven Project

By Uri Menalled, Stacy Davis, and Jane Mangold

Hoary alyssum *(Berteroa incana* L.) has low forage value, is toxic to horses if it constitutes 30% or more of their diet, and can dominate sites with coarse soils. Noxious weed managers expressed a need to improve hoary alyssum control, in particular they wondered whether herbicides applied when plants contained seedpods were effectively reducing viable seed production. Chemical control recommendations state that herbicides will be most effective when applied at the rosette stage, but hoary alyssum is difficult to identify in its vegetative stage, and many managers do not treat the weed until it is flowering. Because hoary alyssum flowers and produces seeds nearly simultaneously (Figure 1), spraying it when it is flowering may not eliminate seed production.

Through collaboration with noxious weed managers, this project examined how herbicides applied to flowering hoary alyssum affected seed production and viability. Managers sprayed hoary alyssum with various herbicides as part of their regular management practices at six sites in southwestern Montana in summer 2016; they collected key application information and left an area untreated to serve as a control. We collected hoary alyssum plants four weeks later to determine seed production and viability (Figure 2). Across the six sites, non-sprayed hoary alyssum produced an average of 429 seeds per plant. Seed production was reduced by 64 to 99% with 7 of 11 different herbicide applications. Seed viability in non-sprayed areas averaged 53%. Nine of 10 herbicide applications reduced seed viability 49 to 100%. These results suggest that noxious weed managers can reduce hoary alyssum viable seed production even when spraying plants that have flowered and formed seed pods, which is good news for managers who are dealing with this noxious weed.

This project serves as a great example of how managers, MSU, and the Noxious Weed Trust Fund can work together to answer questions relevant to noxious weed management in Montana. The results of this project were shared at six professional conferences at the state (Montana Weed Control Association, LRES Research Colloquium), regional (Western Society of Weed Management, Northern Rockies Invasive Plant Council, Idaho Weed Control Association), and national (Ecology Society of America) levels. Additional outcomes of this project were the revision and reprinting of an Extension publication

Figure 2. Uri Menalled collecting hoary alyssum plants four weeks after herbicide application.

on hoary alyssum and a peer-reviewed journal article (currently under revision) in Invasive Plant Science and Management. In addition to funding from the Noxious Weed Trust Fund, an MSU Undergraduate Scholars Fellowship supported Uri Menalled who conducted all of the lab analyses and co-authored the journal article.

Cooperators on this project included Susan Lamont (Forest Service), John Ansley and Mike Jones (Gallatin County Weed District), Julie McLaughlin (The Nature Conservancy), Ray Shaw (Ruby Resources), and Brad Bauer (formerly Gallatin County Extension).

New Biocontrol Agent for Whitetop Approved for Release

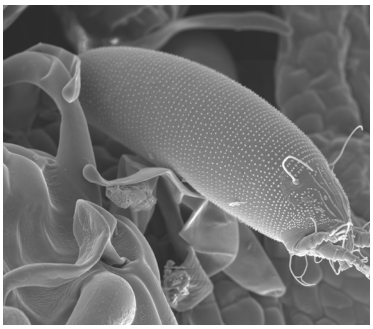
By Jeff Littlefield

I started testing the whitetop gall mite, *Aceria drabae,* nearly twenty years ago to the day. We have had our ups and downs in funding and have had good years for testing combined with those where we received only dead mites in our shipments. After years of testing and six years of regulatory review by TAG, USDA APHIS, USFWS, Tribal consultation and public comment, APHIS has finally issued a release permit for this mite. Field releases are planned for this summer in Montana and will represent the first release of a classical biocontrol agent for an invasive weedy mustard worldwide.

Whitetop (also known as the hoary cresses *Lepidium draba* and *L. chalapense)* are perennial weeds in the cabbage family. Introduced from Eurasia to the United States in the late 1800 they have since spread across much of North America. In the past twenty years, whitetop has dramatically increased its distribution in the Intermountain West, including much of Montana. Although herbicides are available for whitetop management, repeated treatments may be required, and in many cases they are not effective or economical to apply. Biological control will hopefully provide land managers with another tool to help manage whitetop.

Aceria drabae is a microscopic mite that can stunt plant growth and will reduce or completely eliminate seed production. Based on laboratory and field studies in its native range in Eastern Europe, the mite is very host-specific. In cooperation with USDA ARS, European Biological Control Laboratory, Greece, and the BBCA (Rome, Italy), host specificity studies on the mite were completed at the biological control containment facility located at Montana State University. Other biocontrol agents are currently being screened by CABI Switzerland, and if approved they will help augment the impact caused by this gall mite.

CABI studies are supported by the Hoarycress Consortium, which includes funding from the Montana Noxious Weed Trust Fund. Additional support for the gall mite work is provided by the BLM, APHIS, Nez Perce Biocontrol Center, and the Montana State University Experiment Station.



Left: Whitetop gall mite (Aceria drabae). *Right: Whitetop* (Lepidium draba).

OTHER WEED-RELATED PROJECT HIGHLIGHTS

MSU Researchers Find That Beetle Odor Could Help Tackle Tamarisk

PI: Alexander Gaffke, David Weaver, and Sharlene Sing

By Marshall Swearingen, MSU News Service | March 27, 2018

BOZEMAN – In the fight against an invasive plant colonizing portions of the state, a Montana State University doctoral student is luring shrub-munching beetles with an odor as tantalizing to them as the smell of bacon and pancakes, or perhaps a barbecue, is to humans.

"It communicates that it's a safe area, that there's lots of food," researcher Alex Gaffke said of the scent, which is a synthetic version of a pheromone that northern tamarisk beetles release to alert others to feeding areas.

"The beetles are very eager, very gregarious," Gaffke said. "They all want to be where the party is."

According to Gaffke, scientists have known about the beetle pheromone for a decade or more. But for the first time, his research team has demonstrated the potential for using the odor as a tool for combating the spread of tamarisk — the non-native shrub that the beetles feed on.

By attaching small dollops of a waxy, putty-like substance containing the pheromone, the researchers found that they could more than double the number of tamarisk beetles congregating on the bushes, which often doubled the die-back of the plants as the beetles consumed the leaves and twigs.

"We did not expect to see this level of impact," Gaffke said. "We really had no idea whether it would work or not."

The researchers published the results of their multi-year study, which took place along the Bighorn River in Wyoming, in the journal Pest Management Science in January.

"This paper is something pretty special, because it really shows a proof of the concept," said David Weaver, a member of the research team and a professor in the Department of Land Resources and Environmental Sciences in MSU's College of Agriculture.

Weaver said the research has already generated "great interest" among land managers tasked with controlling tamarisk, which has gained a foothold along waterways in eastern Montana. The invasive shrub — also called saltcedar — crowds out cottonwoods and other native vegetation, consumes inordinate amounts of water and forms thickets so dense they contribute to flooding.

Starting in 1999, the US Department of Agriculture released northern tamarisk beetles from Kazakhstan and China as a form of biocontrol at the Wyoming study site and across the western

US. But in areas of Wyoming and Montana, where tamarisk is spread more thinly on the landscape, the beetles — which eat only tamarisk — struggled to reproduce and achieve a density that could have a significant impact on tamarisk, according to study co-author Sharlene Sing, a research entomologist at the Rocky Mountain Research Station in Bozeman, which is operated by the USDA Forest Service.

That makes the results of the study particularly important for Montana, said Sing, who earned her doctorate in land resources and environmental sciences from MSU. The findings suggest that the pheromone could be used to concentrate migrating beetles in areas that are priorities for tamarisk control. By congregating in greater densities, the beetles are also more likely to reproduce and grow their numbers, she said.

Compared to other methods of battling tamarisk, which include herbicides and mechanical removal, the synthetic pheromone would be a more precise, lower-cost method to use in areas where tamarisk is starting to colonize but hasn't yet dominated, such as along the Yellowstone River near Billings, Sing said.

Gaffke, a Bozeman-area native who earned his bachelor's in environmental biology from MSU before starting his doctoral research with Weaver, is working on another paper that will make practical recommendations to land managers about how to use the beetle odor.

"I like working on taking science … and developing tools to apply it in the field," he said.

Contact: Alex Gaffke (alexander.gaffke@msu.montana.edu); David Weaver (weaver@montana.edu).

Noxious Weed Training for Realtors

by Shantell Frame-Martin and Jane Mangold

The Montana Noxious Weed Education Campaign (MNWEC), a multi-agency cooperative effort that is housed within the Department of Land Resources and Environmental Sciences at Montana State University, has an online training course for realtors. Support from the Montana Noxious Weed Trust Fund (NWTF) allows the MNWEC to work on this project along with many others.

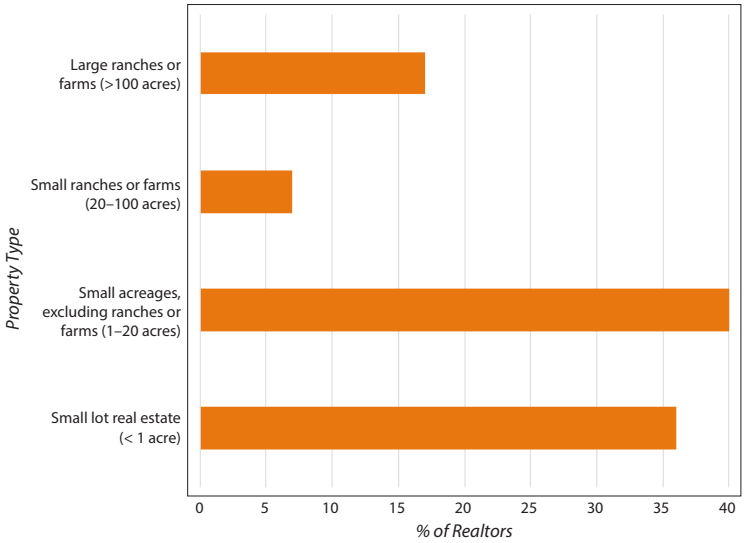
The online training course provides realtors with a broad understanding of noxious weeds through five modules:

- Noxious Weeds 101, Plant Anatomy and Identification
- Noxious Weed Identification
- Understanding MT County Noxious Weed Control Act
- Integrated Weed Management.

While the course cannot transform realtors into noxious weed experts, it provides them with the basics, so they can comfortably direct buyers and sellers to tools and resources for managing noxious weeds and encouraging desired vegetation that meets land use objectives.

The course is certified through the Montana Association for Real Estate License Law Officials and the Montana Board of Realty Regulation and is approved for four continuing education credits in the Environmental Issues category. The course has been offered

Property Types Represented by Realtors Participating in the MNWEC's Montana Realtor Online Noxious Weed Training.

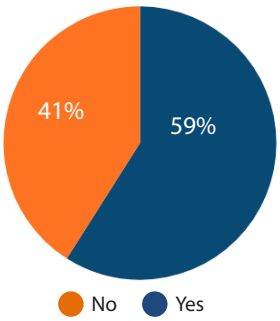


every six months since February 1, 2016. To date, 61 realtors have successfully completed the course. Comments from participants have been positive, for example, "Best training I have taken on-line in a long time," "Would love to see more of the same in the future if possible," and "Once I got started I didn't want to stop!"

With the help of the Yellowstone Evaluation Service, course participants were surveyed to gauge their knowledge both before and after taking the course as well as to determine how they will share their new knowledge with clients. Most of the surveyed realtors specialize in small acreages (parcel size of 20 acres or less), and the majority believe noxious weeds are a problem on the properties they list.

Course participants self-rated their level of awareness about noxious weeds before taking the course, and the results were as follows: very aware 19%, very aware: 63%; unaware: 12%; very unaware: 7%.

Before taking the course, 45% of the participants informed or directed clients to resources about noxious weeds, whereas after taking the course, 90% of participants will inform or direct clients to noxious weed resources. Participants also reported that 83% of their real estate clients will follow suggested direction and/or advice as it relates to identifying and/or managing noxious weeds on their properties.



Percent of realtors who believe noxious weeds affect their listed properties.

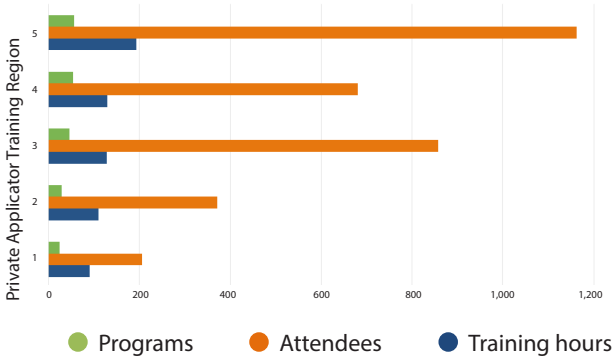
The fourth session of the Montana Realtor Online Noxious Weed Training ran from November 20, 2017 to May 20, 2018.

For more information, please contact Shantell Frame-Martin (shantell.frame@montana.edu) or Jane Mangold (jane.mangold@montana.edu).

EDUCATION IMPACTS 2015–2017

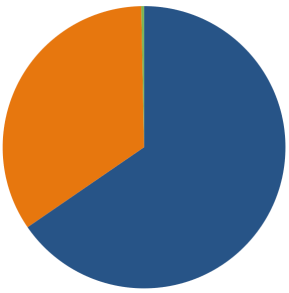
MSU EXTENSION

PESTICIDE EDUCATION DELIVERED 2017†



†*Source: Cecil Tharp, MSU Pesticide Safety Program Coordinator. Regions defined at: pesticides.montana.edu/PAT.*

WEED MANAGEMENT CONSULTATIONS (ACRES) 2017‡



Crop land
772,420 . . . . . 66%

Non-crop land
404,700 . . . . . 34%

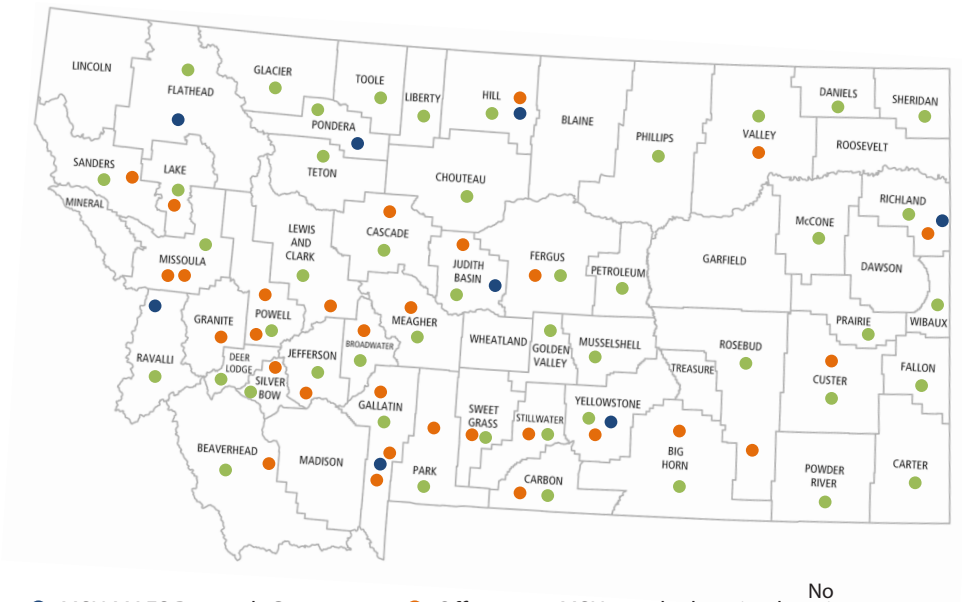
Small acreage
3,711 . . . . . 0%

‡*Data represents approximately 56% of MSU Extension offices.*

MSU Extension Agents Contributing to Weed Education

Juli Thurston, *Sanders County* • Josh Bilbao, *Gallatin County* Wendy Becker, *Fort Peck Reservation* • Danielle Harper, *Wibaux County* • Dave Brink, *Mineral County* • Emily Standley, *Fergus County* • Tim Fine, *Richland County* • Shylea Wingard, *Hill County* Molly Hammond, *Big Horn County* • Katie Hatlelid, *Judith Basin County* • Melissa Ashley, *Rosebud and Treasure Counties* Marc King, *Sweet Grass County* • Allison Kosto, *Broadwater County* Callie Cooley, *Yellowstone County* • Ben Hauptman, *Granite County* Pat McGlynn, *Flathead County* • Rose Malisani, *Cascade County* Marko Manoukian, *Phillips County* • Jerry Marks, *Missoula County* • Patrick Mangan, *Ravalli County* • Wendy Wedum, *Pondera County* • Eric Miller, *Garfield County* • Shelley Mills, *Valley County* • Tracy Mosley, *Park County* • Ken Nelson, *McCone County* • Kim Suta, *Toole County* • Jodi Pauley, *Powell County* • Inga Hawbaker, *Daniels County* • Mary Rumph, *Powder River County* • Sharla Sackman, *Prairie County* • Brent Sarchet, *Lewis and Clark County* • Mike Schuldt, *Custer County* • Mat Walter, *Musselshell and Golden Valley Counties* • Bruce Smith, *Dawson County* • Jack Stivers, *Lake County* • Jessica Murray, *Beaverhead County* • Elin Kittelmann, *Fallon and Carter Counties* • Kerry Taylor, *Madison and Jefferson Counties* • Verna Billadeaux, *Blackfeet Reservation* • Nikki Bailey, *Carbon County* • Tyler Lane, *Choteau County* • Kimberly Richardson, *Deer Lodge County* • Elizabeth Werk, *Fort Belknap Reservation* Kari Lewis, *Glacier County* • Jesse Fulbright, *Liberty County* Bob Sager, *Meagher County* • Jeff Chilson, *Roosevelt County* Lee Schmelzer, *Stillwater County* • Brent Roeder, *Teton County* Mandie Reed, *Wheatland County*

MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH



No

- MSU MAES Research Centers
- Off-campus MSU weed education locations 2017
- Counties which submitted plant sample(s) to MSU Schutter Diagnostic Lab in 2017

Off-Campus MSU Weed Education Programs

Programs delivered (2017): 58
Individuals reached (2017): 3,843

MSU Schutter Diagnostic Lab

Weed samples identified (2015–2017): 1,459

Undergraduate and Graduate Level Courses

AGSC 401: Integrated Pest Management
ENSC 443/LRES 543: Weed Ecology and Management
ENSC 410/LRES 510: Biodiversity Survey and Monitoring Methods
LRES 540: The Ecology of Plants and Plant Communities
LRES 569: Ecology of Invasive Plants in the Greater Yellowstone Ecosystem
PSPP 546: Herbicide Mode of Action

RESEARCH PUBLICATIONS 2015–2017

JOURNAL ARTICLES AND INVITED BOOK CHAPTERS

Bold type denotes MSU faculty, staff, and graduate students.

Herbicide Resistance

Chahal PS, **Jha P**, Jackson-Ziems T, Wright R, Jhala AJ. 2015. Glyphosate-resistant volunteer maize *(Zea mays* L.): Impact and management. In *Weed and Pest Control,* ed. Travlos IS, Bilalis D, and Chachalis D, 83–98. Hauppauge, NY: Nova Science Publishers.

Dyer W, **Burns EE**, **Keith B**, **Bothner B**, Carey CC, Mazurie A, **Hilmer JK**, Biyiklioglu S, Burg G. 2017. Intensive herbicide use has selected for constitutively elevated levels of stress-responsive mRNAs and proteins in multiple herbicide resistant *Avena fatua* plants. *Pest Management Science* 73(11): 2267–2281.

Dyer W, Burns EE, **Keith B**, **Bothner B**, **Hilmer JK**. 2017. Proteomic and biochemical assays of glutathione-related proteins in susceptible and multiple herbicide resistant *Avena fatua* L. *Pesticide Biochemistry and Physiology* 140: 69–78.

Dyer W, **Burns EE**, **Keith B**, **Talbert L**. 2017. Non-target site resistance to flucarbazone, imazamethabenz, and pinoxaden is controlled by three linked genes in *Avena fatua* L. *Weed Research* 58: 8–16.

Jha P, **Kumar V**, Garcia J, Reichard N. 2015. Tank mixing pendimethalin with pyroxasulfone and chloroacetamide herbicides enhances in-season residual weed control in corn. *Weed Technology* 29(2): 198–206.

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RESEARCH AND EDUCATIONAL PARTNERSHIPS:
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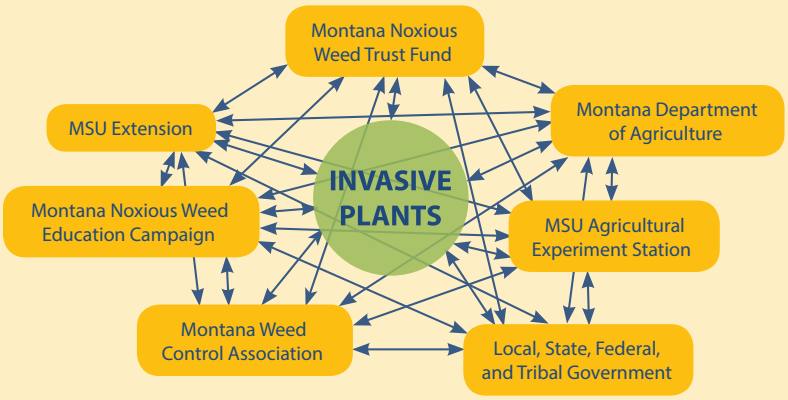

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