Montana State University: Montana Agricultural Experiment Station and Extension Service

REPORT FOR THE MONTANA NOXIOUS WEED TRUST FUND ADVISORY COUNCIL

JUNE 2019

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 2016–2018

Project Title, *PI*	2016	2017	2018
Biological Control Development Projects			
Biocontrol 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 a new biocontrol agent for common tansy and oxeye daisy, *Jeff Littlefield*	●	●	●
Host specificity testing of biocontrol agents of weedy mustards, *Jeff Littlefield*	●	●	
Host testing and field release of biocontrol agents for whitetop, *Jeff Littlefield*	●	●	●
Host testing of a gall wasp for the biocontrol of invasive hawkweeds, *Jeff Littlefield*	●	●	●
Candidate agents for biocontrol of Russian olive, *David Weaver and Sharlene Sing*	●		
Mass rearing, release, and monitoring of the northern tamarisk leaf beetle a biological control agent for saltcedar, *David Weaver*			●
Research Projects			
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*	●		
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*	●		
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, *David Weaver*		●	●
Integrated management of dense cheatgrass on productive rangelands, *Lisa Rew, Jane Mangold, and Erik Lehnhoff*	●		
Mitigating priority effects of invasive plants during revegetation by altering perennial glass planting date, *Jane Mangold and Zach Miller*	●		

Continued on next page

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*
Clayton Marlow, *Riparian/Livestock Interactions*
Emily Meccage, *Forage Extension Specialist*
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*
Noelle Orloff, *Schutter Diagnostic Lab, Botanist*
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

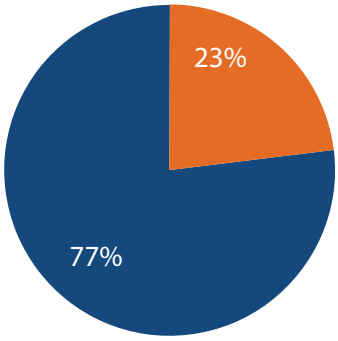
Mary Burrows, *Plant Pathology*
Bill Dyer, *Weed Physiology*
Matt Lavin, *Botany*
Ryan Thum, *Aquatic Plant Genetics and Ecology*

RESEARCH CENTERS

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

MSU WEED PROJECT FUNDING 2016–2018

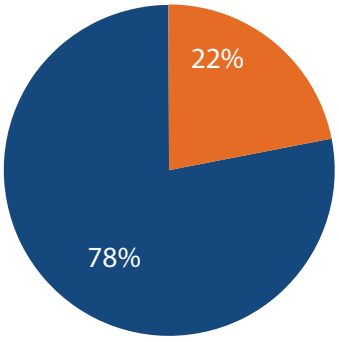
NEW AWARDS 2016



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

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

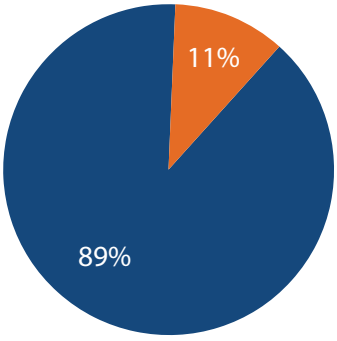
NEW AWARDS 2017



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

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

NEW AWARDS 2018



Noxious Weed Trust Fund
$312,217. . . . . 11%

Other
$2,566,908 . . . . . 89%

OTHER FUNDING SOURCES FOR WEED RESEARCH AND EDUCATION, 2016 – 2018

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 • National Park Service

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

REGIONAL

Western Sugar Cooperative • Western Sustainable Agriculture Research and Education Program • USA Dry Pea and Lentil Council

STATE

Central Michigan University • Colorado State University • Confederated Salish and Kootenai Tribes (MT) • Michigan Department of Natural Resources • Midwest Aquatic Plant Management Society • 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 • University of Illinois

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2016–2018 *CONTINUED*

Project Title, *PI*	2016	2017	2018
Education Projects			
Keeping it fresh: Revising weed publications, *Jane Mangold*			●
Montana Noxious Weed Education Campaign, *Jane Mangold and Shantell Frame-Martin*	●	●	●
Noxious weeds survey: Has 20+ years of weed education been effective?, *Mangold, Shantell Frame-Martin and Eric Raile*			●
Local Cooperative			
Rock Creek Cooperative Weed Management Project, *Tracy Mosley*			●

FUTURE PLANS: 2019 MONTANA NOXIOUS WEED TRUST FUND GRANTS

BIOLOGICAL CONTROL DEVELOPMENT PROJECTS:

Biological control of Russian knapweed: Continued host testing and agent monitoring, *Jeffrey Littlefield*

Continued host screening of new biocontrol agents for common tansy and oxeye daisy, *Jeffrey Littlefield*

Biocontrol invasive hawkweeds - host testing, rearing and monitoring, *Jeffrey Littlefield*

Continuing Development of Candidate Agents for Biological Control of Russian Olive, *David Weaver*

Continued mass rearing, release, and monitoring of the northern tamarisk leaf beetle: a biological control agent for saltcedar, *David Weaver*

Host testing and field release of biological control agents for whitetop, *Jeffrey Littlefield*

EDUCATION PROJECTS:

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

RESEARCH PROJECTS:

Effect of perennial grass seeding date on revegetation outcomes in weed-infested range and pasture, *Jane Mangold and Zachariah Miller*

Integrating management of invasive toadflax: field testing to identify new effective biocontrol and herbicide treatments, *David Weaver*

Stopping a wave of invasion: controlling cheatgrass, encouraging desired vegetation, and preventing spread, *Lisa Rew and Jane Mangold*

Ventenata in Gallatin County: Surveying, mapping, and evaluating chemical control, *Jane Mangold and Lisa Rew*

MSU WEED SCIENCE ACTIVITY

Peer-reviewed journal articles: 74
Invited book chapters: 2
Peer-reviewed conference abstracts: 120
Completed theses and dissertations: 17
Graduate students in training: 25
Extension publications: 26
TV and radio appearances: 50

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

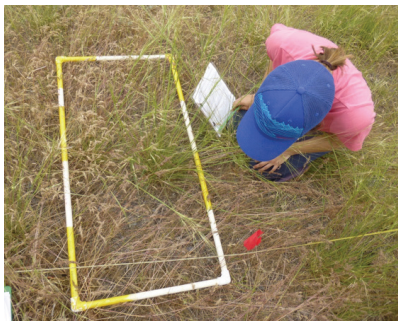
Canada thistle *(Cirsium arvense)*
Cheatgrass *(Bromus tectorum)*
Common tansy *(Tanacetum vulgare)*
Dalmatian toadflax *(Linaria dalmatica)*
Douglas fir *(Pseudotsuga menziesii)*
Field bindweed *(Convolvulus arvensis)*
Juniper *(Juniperus* spp.)
Leafy spurge *(Euphorbia esula)*
Orange hawkweed *(Hieracium 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)*
Ventenata *(Ventenata dubia)*
Western salsify *(Tragopogon dubius)*
Whitetop *(Cardaria draba)*
Wild oat *(Avena fatua)*
Yellow toadflax *(Linaria vulgaris)*

MONTANA NOXIOUS WEED TRUST FUND PROJECT HIGHLIGHTS

IS ONE INVASIVE, NON-NATIVE ANNUAL GRASS WORSE THAN ANOTHER?

By Jane Mangold, Stacy Davis, and Lisa Rew

Sampling Japanese brome near Miles City, MT. Photo by Stacy Davis, MSU.



Cover of non-native annual grasses and native grasses was collected in 0.5m² frames. Photo by Jane Mangold, MSU.

Four non-native annual grasses—cheatgrass (*Bromus tectorum*), Japanese brome (B. japonicus), medusahead *(Taeniatherum caput-medusae*), and ventenata (*Ventenata dubia*)—are increasing in Montana. While cheatgrass and, to a lesser extent, Japanese brome have been present across the state for many decades, medusahead and ventenata are new invaders. While it is increasingly clear that a suite of non-native annual grasses is problematic, we don't know if these annual grasses differ in their impacts and should therefore be prioritized for management differently.

With a grant from the Noxious Weed Trust Fund (grant #2017-063), we looked at the impact of these four annual grasses on livestock forage quantity and quality. In 2017 we sampled cover of non-native annual grasses and native perennial grasses at 13 sites (5 cheatgrass, 4 Japanese brome, 3 ventenata, 1 medusahead) across Montana. Each site was selected based on the presence of one target annual grass; our sites spanned the state from Miles City to Malta to Missoula.

At each site we collected data along three transects that had a range of annual grass abundance from low to high. In mid-May to early June 2018 (prior to flowering and seed head development), we collected biomass of the target annual grasses plus bluebunch wheatgrass (*Pseudoroegneria spicata*) and western wheatgrass (*Agropyron smithii*), two native species valued as livestock forage species. Biomass was analyzed for crude protein, neutral detergent fiber, acid detergent fiber, and silica. We used linear mixed effects models to examine the relationship between IAG and perennial grass cover and analysis of variance to examine forage quality differences among grasses.

In terms of forage quantity, perennial grass cover was negatively associated with cheatgrass and ventenata but not medusahead or Japanese brome. A 1% increase in cheatgrass or ventenata cover correlated with a 0.39% ± 0.05% or 0.48% ± 0.08%, respectively, decrease in perennial grass cover. When considering forage quality, we found no differences in crude protein among the grasses, and all grasses would be considered good (10-11% crude protein) to excellent (12% or higher crude protein) quality prior to flowering. We found some differences in neutral detergent fiber among the grasses (low values are desired). Specifically, cheatgrass was lower than ventenata, bluebunch wheatgrass, and western wheatgrass. Additionally, Japanese brome was lower than bluebunch wheatgrass. There were no differences among grasses in acid detergent fiber. Finally,

silica values ranged from 2.9 to 9.2% with cheatgrass having the lowest silica value and ventenata having the highest. High levels of silica are correlated with avoidance by livestock.

Our results suggest one non-native annual grass may be worse than another when considering impacts to the quantity and quality of livestock forage. Cheatgrass and ventenata appeared to have a larger impact on forage quantity than the other two non-native annual grasses. There were minimal differences in forage quality, but the higher silica content of ventenata and medusahead may keep animals from eating these species. The rapid expansion of ventenata in Montana and neighboring states is troublesome—it appears to impact forage quantity as much or more so than cheatgrass and will likely be avoided by livestock due to high silica—and it should be prioritized for management.

ADOPT A TRAILHEAD MONTANA A COOPERATIVE SUCCESS

By Shantell Martin and Jane Mangold, Montana Noxious Weed Education Campaign

Adopt a Trailhead Montana (AATM) is a community involvement campaign aimed at promoting trailhead stewardship and increased awareness about the prevention of noxious weeds. The program relies on civic volunteer groups who pledge their time to adopt a trailhead and perform annual maintenance, including noxious weed management. Educational kiosks installed at AATM trailheads feature information about noxious weed species found in the area and are equipped with a boot brush for use before and after recreating. Educational signage helps trail users learn about noxious weeds and how to prevent spreading them further up trail systems. Signs also serve as a reminder to always "Come Clean. Leave Clean," a key message in the national educational campaign, PlayCleanGo.

Beginning in 2015 at Rattlesnake National Recreation Area (RNRA) on the Lolo National Forest outside of Missoula, the program has installed 63 AATM kiosks from Makoshika State Park in the East to the Kootenai National Forest in the Northwest. Volunteer groups include chapters of the Back Country Horsemen of Montana, Bob Marshall Wilderness Foundation, Blackfoot Challenge, chapters of the Montana Audubon Society, Back Country Hunters and Anglers, and others. AATM is made possible by volunteers and funding partners of the Montana Noxious Weed Education Campaign (BLM, Forest Service, Montana Dept. of Ag Noxious Weed Trust Fund, Montana Dept. of Natural Resources, Montana Dept. of Transportation, Montana State University, and the Montana Weed Control Association).

AmeriCorps volunteers assist with sign installation at Lewis & Clark Caverns, 2017. Photo courtesy of Scott Harvey, MT FWP.

WEED DAYS THROUGHOUT MONTANA

Powder River County producers swept for flea beetles at the Noxious Weed and Range Tour held at Powderville in July of 2018.

A producer examines flea beetles, a biological control for leafy spurge during the 2018 Powder River County Noxious Weed and Range Tour," reported Mary Rumph, MSU Extension Agent Powder River County.

After sweeping for flea beetles, the "catch" was emptied into a separator to harvest the flea beetles. The harvested flea beetles were then sent with producers for distribution at other sites. Biological control is just one of many tools used for the controlling the spread of leafy spurge.

(See Dillon County Grasses Day and Beaverhead County Weed Day on back cover)

OTHER WEED-RELATED PROJECT HIGHLIGHTS

MONTANA ORGANIC FARMERS, MSU LEAD $2 MILLION GRANT FOR PERENNIAL WEEDS

By Jenny Lavey, MSU News, December 11, 2018

A creeping thistle infestation in an organic farm in western Montana. A new grant jointly managed by Montana State University, Montana farmers and a four-state region intends to find new methods of suppressing field bindweed and creeping thistle infestations in organic systems. MSU photo courtesy of the Western Agricultural Research Center in Corvallis.

BOZEMAN – Researchers at Montana State University are leading a collaborative grant across the four-state Northern Great Plains and Pacific Northwest regions with a multi-pronged attack on what is said to be the chief hardship in organic farming – perennial weeds.

A four-year, $2 million grant from the United States Department of Agriculture National Institute of Food and Agriculture Organic Research and Extension Initiative has been awarded to MSU.

MSU agriculture faculty will lead a consortium that will work jointly with Montana organic farmers to find control methods for bindweed and creeping thistle. Co-investigators are located at Washington State University, Oregon State University, North Dakota State University and the USDA Agricultural Research Station in Sidney.

The funding will allow statewide experiments at three of MSU's agricultural research centers and eight statewide organic farms with bindweed and creeping thistle infestations. The farms will mirror the MSU research experiments and farmer cooperators will be active participants and will help researchers collect data on their farms and interpret analyses, according to Patrick Carr, superintendent of MSU's Central Agricultural Research Center and principal investigator on the grant.

The research, Carr said, will operate as a multi-faceted approach that includes an array of experiments with livestock grazing, cropping rotations, soil microbiology and tilling tactics. Additionally, the grant includes faculty investigating soil microbial communities and plant genetics.

More at https://www.montana.edu/news/18243/montana-organic-farmers-msu-lead-2-million-grant-for-perennial-weeds

Contact Patrick Carr, Patrick.carr@montana.edu, 406-423-5421

MSU'S SCHUTTER DIAGNOSTIC LABORATORY IMPACTS CITIZENS' LIVES

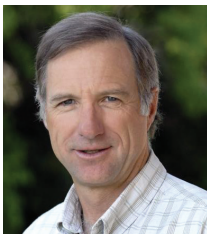
The following article appeared in USDA National Institute of Food and Agriculture Bulletin "Fresh From the Field,"

Editor: Falita Liles, April 11, 2019

Montana's Schutter Diagnostic Laboratory is a critical component of extension outreach, and routinely processes over 2,000 samples per year for county extension, agricultural professionals, and citizens. The diagnostic lab is often the first place new pests in the state are identified. In 2017, first reports included the elm seed bug - *Arocatus melanocephalus* - from Ravalli County, damage to cabbage on a local foods farm by the invasive root weevil - *Cathormiocerus spinosus* - in Gallatin County, Fusarium root rot on chia and quinoa from Hill County, and Phoma stem blight on quinoa from Toole county. Researchers helped clients accurately identify plants to assess plant toxicity. For example, several elk died after eating an ornamental shrub identified as ornamental yew (*Taxus x media*), a shrub that has been implicated in wildlife losses in Idaho residential areas. Through the proper identification of an invasive weed *Crepis tectorum* – narrowleaf hawksbeard – Schutter Laboratory helped growers reduce populations and conserve crop yield. Growers have changed management practices, increased scouting, and have saved over $6 million in Valley County and over $200 million in the MonDak area due to crop yield losses that would have been incurred from this weed.

More at https://content.govdelivery.com/accounts/USDANIFA/bulletins/23d5da2

WEED SCIENCE SOCIETY HONORS MSU WEED SCIENTISTS



In recognition of his contributions to society's understanding of weeds and weed control, Montana State University Researcher Bruce Maxwell won a national award from the Weed Science Society of America.

By Marshall Swearingen, MSU News Service, April 19, 2019 (MSU photo of Bruce Maxwell by Kelly Gorham)

BOZEMAN — Bruce Maxwell, professor in the Department of Land Resources and Environmental Sciences in MSU's College of Agriculture, received the Outstanding Research Award at the organization's annual meeting in New Orleans in February. Maxwell's recent research publications span a range of topics, including strategies for managing a common herbicide-resistant weed, findings about how cheatgrass takes hold on the landscape and methods of using GIS to estimate crop yield. Other recent studies have focused on the invasion of pines in New Zealand and the Patagonia region of South America.

More at https://www.montana.edu/news/18637/msu-professor-wins-national-award-for-weed-research

Contact: Bruce Maxwell, bmax@montana.edu, 406-994-5717.

Continued on next page

SOCIETY HONORS MSU WEED SCIENTISTS *CONTINUED*

Montana State University agriculture professor Prashant Jha. Jha was named the Outstanding Early Career Weed Scientist by the Weed Science Society of America for his prolific weed science research, mentoring and outreach.

By Evelyn Boswell for the MSU News Service, February 22, 2018 (MSU photo of Prashant Jha by Sepp Jannotta)

BOZEMAN — Prashant Jha, an associate professor at the Southern Agricultural Research Center in the College of Agriculture and the Montana Agricultural Experiment Station, was named Outstanding Early Career Weed Scientist during the Weed Science Society of America's 2018 annual meeting in Arlington, Virginia. The society selects one recipient a year. The scientist must have earned a Ph.D. within the past 10 years.

Stationed at MSU's SARC near Huntley, Jha researches a number of weed-related issues, but his major focus at MSU has been glyphosate-resistant kochia. His research program focuses on weed biology and ecology and evolutionary dynamics and integrated management of herbicide resistance. His current research also includes precision weed management.

More at https://www.montana.edu/news/17478/national-award-goes-to-msu-scientist-fighting-weeds

Contact Prashant Jha, pjha@montana.edu, 406-348-3400

MSU NAMED TO HOST USDA'S WESTERN SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM

By Jenny Lavey, MSU News Service, February 9, 2018

Barley is seen in a Montana field in this MSU photo.

BOZEMAN – Montana State University was selected as the next Western region host institution of the Sustainable Agriculture Research and Education organization, the country's foremost, producer-led research and education grant program for sustainable agriculture.

Beginning in the fall of 2018 and with an annual grant and operational budget of $5.5 million — totaling $27.5 million over five years — MSU will administer four of five grant programs through Western SARE: research and education grants, farmer-rancher grants, professional and producer grants, and graduate student grants. The University of Wyoming will administer Western SARE's professional development grant program.

Fabian Menalled, professor of weed ecology and integrated pest management in the Department of Land Resources and Environmental Sciences in MSU's College of Agriculture, has been named the Western SARE regional coordinator. Menalled and Western SARE staff in Wyoming and California will support members of the Western SARE Administrative Council and coordinate sharing research results with agricultural stakeholders.

"The Western region of the United States is incredibly diverse, in agricultural economies, demographics and geography," Menalled said. "As we look to the future, our common challenges are certainly water, a warming climate, urban and rural interfaces, and generational and demographic shifts in agriculture. These are pressing issues and they present opportunities for producer-led, collaborative research across the West."

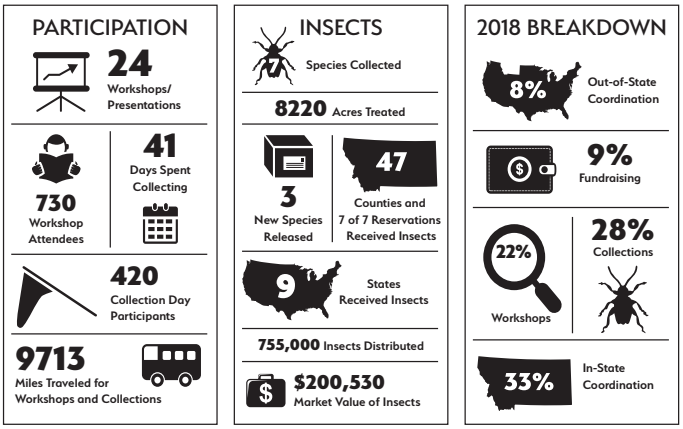
More at http://www.montana.edu/news/17438/msu-named-regional-host-of-national-sustainable-agriculture-program-western-sare

Contact: Fabian Menalled, menalled@montana.edu, 994-4783

MONTANA BIOCONTROL COORDINATION PROJECT

The Montana Biocontrol Coordination Project works to provide the leadership, coordination, and education necessary to enable land managers across Montana to successfully incorporate biological weed control into their noxious weed management programs. This is a soft-funded project with over 50 annual, individual contributors

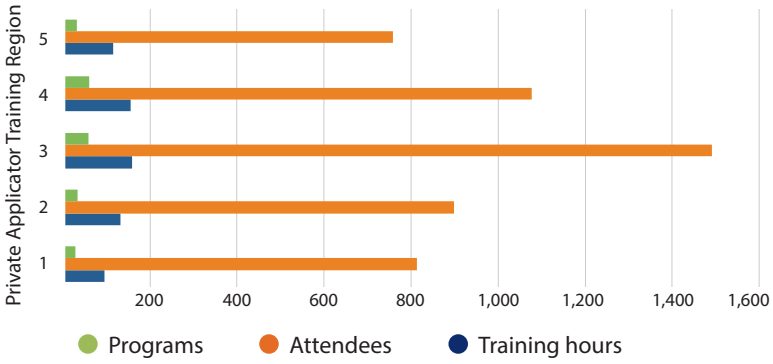
Contact Melissa Maggio, Project Coordinator, mmaggio@missoulaeduplace.org



EDUCATION IMPACTS 2016–2018

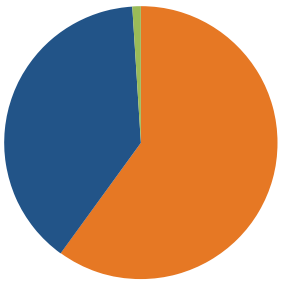
MSU EXTENSION

PESTICIDE EDUCATION DELIVERED 2018†



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

WEED MANAGEMENT CONSULTATIONS (ACRES) 2018‡



Crop land
307,225 . . . . . 60%

Non-crop land
197,230 . . . . . 39%

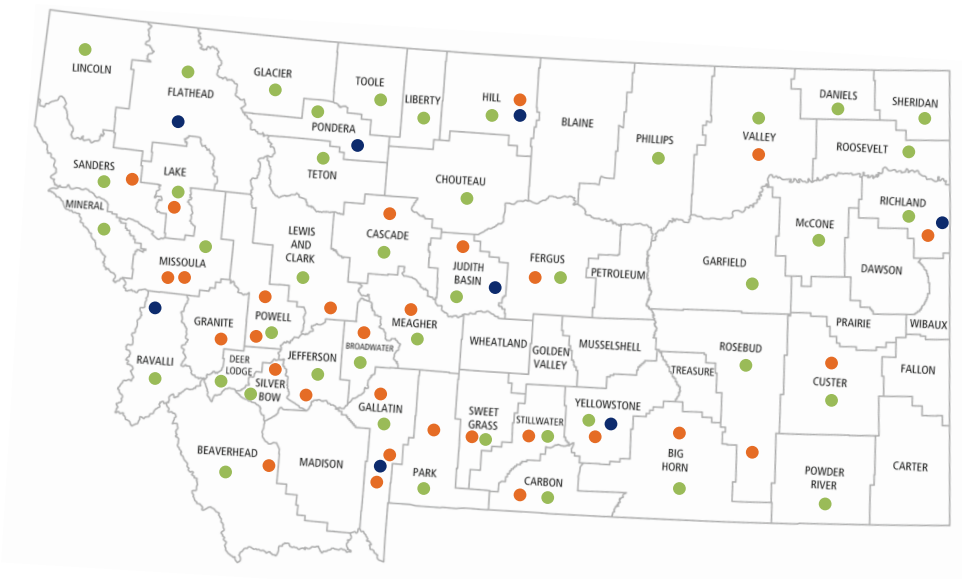
Small acreage
7,060 . . . . . 1%

‡*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, H*ill 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



- MSU MAES Research Centers
- Off-campus MSU weed education locations 2018
- Counties which submitted plant sample(s) to MSU Schutter Diagnostic Lab in 2018

Off-Campus MSU Weed Education Programs
Programs delivered (2018): 135
Individuals reached (2018): 7,962

MSU Schutter Diagnostic Lab
Weed samples identified (2016–2018): 1,596

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 2016–2018

JOURNAL ARTICLES AND INVITED BOOK CHAPTERS

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

ECONOMICS

Mangold J, Fuller K B, Davis S C, Rinella M J. 2018. The economic cost of noxious weeds on Montana grazing lands. *Invasive Plant Science and Management, 11*, 96-101.

HERBICIDE RESISTANCE

Burns E, Lehnhoff E, Maxwell B, Dyer W, Menalled F 2018. You cannot fight fire with fire: Model suggests alternate approaches to manage multiple herbicide resistant *Avena fatua* L. *Weed Research, 58*, 357-368.

Dyer W. 2018. Stress-induced evolution of herbicide resistance and related pleiotropic effects in weeds. *Pest Management Science, 74*, 1759-1768.

Dyer W, Burns E E, Keith B K, Bothner B. 2018. Constitutive redox and phosphoproteome changes in multiple herbicide resistant *Avena fatua* L. are similar to those of systemic acquired resistance and systemic acquired acclimation. *Journal of Plant Physiology, 220*, 105-114.

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 E E, Keith B, Talbert L. 2018. Non-target site resistance to flucarbazone, imazamethabenz, and pinoxaden is controlled by three linked genes in *Avena fatua* L. *Weed Research, 58*, 8-16.

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, Reddy K N. 2018. The role of herbicide-resistant crops in integrated weed management. In Robert Zimdahl (Ed.), *Integrated Weed Management for Sustainable Agriculture* (pp. 215-224). London: Burleigh Dodds Science Publishing.

Kumar V, Jha P, Jugulam M, **Yadav R**, Stahlman P W. 2018. Herbicide-Resistant Kochia (*Bassia scoparia*) in North America: A Review. *Weed Science 67*(1), 4-15.

Menalled FD, **Peterson RKD**, Smith RG, Curran WS, Paez DJ, **Maxwell BD**. 2016. The eco-evolutionary imperative: Revisiting weed management in the midst of an herbicide resistance crisis. *Sustainability* 8(12): 1297.

Nugent P W, Shaw J, **Jha P**, Scherrer B J, Donelick A, **Kumar V.** 2018. Discrimination of herbicide-resistant kochia with hyperspectral imaging. *Journal of Applied Remote Sensing (SPIE), 12*(1), 016037.

Thum R. 2018. Genetic variation and aquatic plant management: key concepts and practical implications. *Journal of Aquatic Plant Management, 56S*, 101-106.

INTEGRATED PEST MANAGEMENT

Davis S, Mangold J, Menalled F, Orloff L N, Miller Z, Lehnhoff, E. 2018. A meta-analysis of *Convolvulus arvensis* (field bindweed) management in annual and perennial systems. *Weed Science, 66*(4), 540-547.

Davis S, Mangold J, Menalled F, Orloff L N, Miller Z, Lehnhoff, E. 2018. A meta-analysis of Canada thistle (*Cirsium arvense*) management. *Weed Science, 66*(4), 548-557.

Guastello P R, **Thum R**. 2018. Mesocosm and field evaluation of Eurasian and hybrid watermilfoil response to endothall in Jefferson Slough, Montana. *Journal of Aquatic Plant Management, 56*, 63-67.

Ishaq SL, **Johnson SP, Miller Z**, **Lehnhoff E**, Olivo SK, **Yeoman C**, **Menalled F**. 2017. Impact of cropping systems, soil inoculum, and plant species identity on soil bacterial community structure. *Microbial Ecology* 73(2) 417–434.

Johnson SP, **Miller ZJ**, **Lehnhoff EA**, **Miller PR**, **Menalled FD**. 2016. Cropping systems modify soil biota effects on wheat *(Triticum aestivum)* growth and competitive ability. *Weed Research* 57(1): 6–15.

Lehnhoff E, **Miller Z**, **Miller P**, **Johnson S**, **Scott T**, **Hatfield P**, **Menalled F**. 2017. Organic agriculture and the quest for the holy grail in water-limited ecosystems: Managing weeds and reducing tillage intensity. *Agriculture* 7(33).

Maxwell B, **Weed B**, **Ippolito L**, **Bekkerman A**, **Boone M**, Mills-Novoa M, **Weaver D**, **Burrows M**, **Burkle L**. 2017. Agriculture and climate change in Montana. Pp 196–244 In Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA (eds.), "*2017 Montana Climate Assessment: Stakeholder driven, science informed.*"

Orloff L N, Mangold J, Miller Z, Menalled F 2018. A meta-analysis of field bindweed (Convolvulus arvensis L.) and Canada thistle (*Cirsium arvense* L.) management in organic agricultural systems. *Agriculture, Ecosystems and Environment, 254*, 265-272.

Sharma A, **Jha P, Reddy G**. 2018. Multidimensional relationships of herbicides with insect-crop food webs. *Science of The Total Environment, 643*, 1522-1532.

Peterson R, Higley L G, Pedigo L P 2018. Whatever happened to IPM? *American Entomologist, 64*, 146-150.

RANGELAND WEED MANAGEMENT AND RESTORATION

Ament R, Pokorny M, **Mangold J**, **Orloff LN**. 2017. Native plants for roadside revegetation in Idaho. *Native Plants Journal* 18(1): 4–19.

Harker KN, Mallory-Smith C, **Maxwell B**, Mortensen DA, Smith RG. 2017. Another view. *Weed Science* 65(2): 203–205.

Hunter H E, Husby P O, Fidel J, **Mosley J**. 2018. Ecological Health of Grasslands and Sagebrush Steppe on the Northern Yellowstone Range. *Rangelands, 40*(6), 212-223.

Larson C, **Lehnhoff E**, **Rew L**. 2017. Warming and drying does not promote a *B. tectorum*-fire feedback in northern sagebrush steppe. *Oecologia* 185: 763–774.

Lembrechts J, Alexander J, Cavieres L, Haider S, Lenior J, Kueffer C, McDougall K, Naylor B, Nunez M, Pauchard A, **Rew L**, Nijs I, Milbau A. 2017. Mountain roads shift native and non-native plant species ranges. *Ecography* 40: 353–364.

RESEARCH PUBLICATIONS 2016–2018

McDougall K, Lembrechts J, **Rew L**, Cavieres L, Haider S, Kueffer C, Milbau A, Naylor B, Nunez M, Pauchard A, **Seipel T**, Speziale K, Wright G, Alexander J. 2017. Running off the road: roadside non-native plants invading mountain vegetation. *Biological Invasions*.

McKenzie SC, **Goosey HB**, **O'Neill KM**, **Menalled FD**. 2016. Integrating livestock for cover crop termination in horticultural vegetable production: Impacts on weed and ground beetle (Coleoptera: carabidae) communities. *Agriculture, Ecosystems and Environment* 218: 141–149.

Metier E, Rew L, Rinella M. 2018. Restoring Wyoming big sagebrush to annual brome-invaded landscapes with seeding and herbicides. *Rangeland Ecology and Management, 71*, 705-713.

Mosley J, **Frost R**, **Roeder BL**, **Kott R**. 2017. Targeted sheep grazing to suppress sulfur cinquefoil *(Potentilla recta)* on northwestern Montana rangeland. *Rangeland Ecology and Management* 70: 560–568.

Mosley J, Fidel J, Hunter H E, Husby P O, Kay C ., Mundinger J G, Yonk R M 2018. An Ecological Assessment of the Northern Yellowstone Range: Introduction to the Special Issue. *Rangelands, 40*(6), 173-176.

Mosley J, Fidel J, Hunter H E, Husby P O, Kay C E, Mundinger J G, Yonk R M 2018. An Ecological Assessment of the Northern Yellowstone Range: Synthesis and Call to Action. *Rangelands, 40*(6), 224-227.

Rew L, **Brummer T**, **Pollnac F**, **Larson C**, **Taylor K**, Taper M, Fleming J, Balbach H. 2017. Hitching a ride: seed accrual rates on different types of vehicles. *Journal of Environmental Management* 206: 546–555.

Sheley R, Boyd C, Dobrowolski J, Hardegree S, James J, **Mangold JM**. 2016. Editorial: A scientifically rigorous and user-friendly Rangeland Ecology and Management. *Journal of Rangeland Ecology and Management* 69(1): 1–3.

Stringham T, Snyder D, Snyder K, Lossing S, **Carr C**, Weltz M, Stringham B. 2018. Rainfall interception by singleleaf piñon and Utah juniper: implications for stand-level effective precipitation during the growing season. *Rangeland Ecology and Management* 71:327-335

Taylor KT, **Maxwell B**, **McWethy D**, Pauchard A, Nunez MA, **Whitlock C**. 2017. *Pinus contorta* invasions increase wildfire loads and may create a positive feedback with fire. *Ecology* 98: 678–687.

Yonk R M, **Mosley J**, Husby P O 2018. Human Influences on the Northern Yellowstone Range. *Rangelands,* 40(6), 177-188.

WEED BIOCONTROL

Gaffke A M, Sing S E, Dudley T L, Bean D, Russak J, Grieco P, **Peterson R, Weaver D** 2018. Semiochemicals to enhance herbivory by Diorhabda carinulata aggregations in saltcedar (Tamarix spp.) infestations. *Pest Management Science, 74*(6), 1494 - 1503.

Lesieur V, Martin J-F, **Weaver DK**, Hoelmer KA, Smith DR, **Morrill WL**, Kadiri N, Peairs FB, Cockrell DM, Randolph TL, Waters DK, Bon M-C. 2016. Phylogeography of the wheat stem sawfly, *Cephus cinctus* Norton (Hymenoptera: Cephidae): Implications for pest management. *PLoS ONE* 11(12): e0168370.

Mosley JC, **Frost RA**, **Roeder BL**, **Mosley TK**, **Marks G**. 2016. Combined herbivory by targeted sheep grazing and biological control insects to suppress spotted knapweed *(Centaurea stoebe)*. *Invasive Plant Science and Management* 9: 22–32.

Weaver D. 2018. Twenty-five years after: post-introduction association of *Mecinus janthinus* with invasive host toadflaxes *Linaria vulgaris* and *Linaria dalmatica* in North America. *Annals of Applied Biology, 173*(1), 16-34.

WEED BIOLOGY AND ECOLOGY

Adhikari, S. Impacts of dryland farm management systems on weed and ground beetle (Carabidae) communities in the Northern Great Plains. *Sustainability, 10*(4096).

Alexander J, Chalmandrier L, Lenior J, Burgess T, Essl F, Haider S, Kueffer C, McDougall K, Milbau A, Nunez M, Pauchard A, Rabitsch W, **Rew L**, Sanders N, Pellissier L. 2018. Lags in the response of alpine plant communities to climate change. *Global Change Biology, 24*(2), 563-579.

Alexander JM, Lembrechts JJ, Cavieres LA, Daehler C, Haider S, Kueffer C, Liu G, McDougall K, Milbau A, Pauchard A, **Rew LJ**, **Seipel TP**. 2016. Plant invasions into mountains and alpine ecosystems: Current status and future challenges. *Alpine Botany* 126(2): 89–103.

Boswell A, **Sing SE**, Ward SM. 2016. Plastid DNA analysis reveals cryptic hybridization in invasive Dalmatian toadflax populations. *Invasive Plant Science and Management* 9: 112–120.

Brummer TJ, **Taylor KT**, **Rotella J**, **Maxwell BD**, **Rew LJ**, **Lavin M**. 2016. Drivers of *Bromus tectorum* abundance in the Western North American sagebrush steppe. *Ecosystems* 19: 986–1000.

Buckmaster J, **Marlow CB**, **Carr C**, **Rew LJ**, Roberts S. 2016. Post-grazing compositional analysis of an anthropogenically altered northern fescue grassland in Northwestern Montana. *Northwest Science* 90(4): 379–393.

Chauhan B S, Manalil S, Florentine S, **Jha P**. 2018. Germination ecology of *Chloris truncata* and its implication for weed management. PLOS ONE 13(10):e0206870.

Espeland E, **Mangold J**, West N. 2017. Spatial variation in germination of two annual brome species in the Northern Great Plains. *The Prairie Naturalist* 48(2).

Farruggia F T, **Lavin M,** Wojciechowski M F. 2018. Phylogenetic systematics and biogeography of the pantropical genus Sesbania (Leguminosae). *Systematic Botany, 43*(2), 414–429.

Gaskin J, **Littlefield JL**. 2017. Invasive Russian knapweed *(Acroptilon repens)* creates large patches almost entirely by rhizomic growth. *Invasive Plant Science and Management* 10: 119–124.

Gaskin JF, Pokorny ML, **Mangold JM**. 2016. An unusual case of seed dispersal in an invasive aquatic, yellow flag iris *(Iris pseudacorus)*. *Biological Invasions* 18: 2067–2075.

Haider S, Kueffer C, Bruelheide H, **Seipel T F**, Alexander J, Arevalo J, Cavieres L, McDougall K, Milbau A, Naylor B, **Rew L,** Speziale K, Pauchard A. 2018. Mountain roads and non-native species modify elevational patterns of plant diversity. *Global Ecology and Biogeography, 27*(6), 667-678.

Herron-Sweet CR, **Lehnhoff EA**, **Burkle LA**, **Littlefield JL**, **Mangold JM**. 2016. Temporal and density dependent impacts of an invasive plant on pollinators and pollination services to a native plant. *Ecosphere* 7(2): 1–13.

RESEARCH AND EXTENSION PUBLICATIONS 2016–2018

Klypina N, Pinch M, Schutte B, Maruthavanan J, **Sterling T**. 2017. Water-deficit stress tolerance differs between two locoweed genera (Astragalus and Oxytropis) with fungal endophytes. *Weed Science* 65: 626–638.

Larson, C., Lehnhoff, E., **Noffsinger, C., Rew, L**. 2018. Competition between cheatgrass and bluebunch wheatgrass is altered by temperature, resource availability, and atmospheric CO_2 concentration. *Oecologia, 186*(3), 855-868.

Lembrechts JJ, Alexander JM, Cavieres LA, Haider S, Lenoir J, Kueffer C, McDougall K, Naylor BJ, Nuñez MA, Pauchard A, **Rew LJ**, Nijs I, Milbau A. 2016. Mountain roads shift native and non-native plant species ranges. *Ecography* 40: 353–364.

McDougall K L, Lembrechts J, **Rew L,** Haider S, Cavieres L A, Kueffer C, Milbau A, Naylor B J, Nuñez M A, Pauchard A, **Seipel T**, Speziale K L, Wright G T, Alexander J M 2018. Running off the road: roadside non-native plants invading mountain vegetation. *Biological Invasions, 20(12)*, 3461–3473.

Menalled U D, Davis S A, Mangold J. 2018. Effect of herbicides on hoary alyssum (*Berteroa incana*) seed biology and control. *Invasive Plant Science and Management, 11*, 101-106.

Moody ML, Palomino PS, Weyl PS, Coetzee JA, Newman RM, Liu X, Xu X, Harms N, **Thum RA**. 2016. Unraveling the biogeographic history of the Eurasian watermilfoil invasion in North America. *American Journal of Botany* 103: 709–718.

Newton J, Sepulveda A, Sylvester K, **Thum RA**. 2016. Potential utility of environmental DNA for early detection of Eurasian watermilfoil *(Myriophyllum spicatum)*. *Journal of Aquatic Plant Management* 54: 46–49.

Parks SR, McNair JN, Hausler P, Tyning P, **Thum RA**. 2016. Divergent responses of cryptic invasive watermilfoils to treatment with auxinic herbicides in a large Michigan Lake. *Lake and Reservoir Management* 32: 366–372.

Pauchard A, Albibn A, Alexander J, Burgess T, Daehler C, Englund G, Essl F, Evengart B, Greenwood G, Haider S, Lenoir J, McDougall K, Milbau A, Muths E, Nunez M, Olofsson J, Pellissier L, Rabitsch W, **Rew LJ**, Robertson M, Sanders N, Kueffer C. 2016. Non-native and native organisms moving into high elevation and high latitude ecosystems in an era of climate change: New challenges for ecology and conservation. *Biological Invasions* 18: 345–353.

Petitpierre B, McDougall K, **Seipel TP**, Broennimann O, Guisan A, Kueffer C. 2016. Will climate change increase the risk of plant invasions into mountains? *Ecological Applications* 26: 530–544.

Rew, L., Brummer, T., Pollnac, F., Larson, C., Taylor, K., Taper, M., Fleming, J., Balbach, H. 2018. Hitching a ride: seed accrual rates on different types of vehicles. *Journal of Environmental Management, 206*, 546-555.

Seipel, T. F., Rew, L., Taylor, K., Maxwell, B., Lehnhoff, E. 2018. Disturbance type influences plant community resilience and resistance to *Bromus tectorum* invasion in the sagebrush steppe. *Applied Vegetation Science, 21*(3), 385-394.

Seipel TP, Alexander JM, Edwards PJ, Kueffer C. 2016. Range limits and population dynamics of plants spreading along elevational gradients. *Perspectives in Plant Ecology Evolution and Systematics* 20: 46–55.

Thum, R., McNair, J. N. 2018. Inter- and intraspecific hybridization affects vegetative growth and invasiveness in Eurasian watermilfoil. *Journal of Aquatic Plant Management, 56*, 24-30.

Weyl PS, **Thum RA**, Moody ML, Newman RM, Coetzee JA. 2016. Was *Myriophyllum spicatum* L. (Haloragaceae) recently introduced to South Africa from Eurasia? *Aquatic Botany* 128: 7–12.

THESES AND DISSERTATIONS

Adhikari S. 2018. Impacts of dryland farming systems on biodiversity, plant-insect interactions and ecosystem services. PhD Dissertation. Major Advisor: Fabian Menalled.

Anderson J. 2018. The Decline of a Riparian Gallery Forest in Devils Tower National Mounument. MS Thesis. Major Advisor: Clayton Marlow.

Burns E. 2017. "Genetic and physiological characterization and ecological management of non-target site resistance in multiple herbicide resistant *Avena fatua* L." PhD dissertation. Major advisor: Bill Dyer.

Gaffke A. 2018. Overcoming the Challenges of *Tamarix* control with *Diorhabda carinulata* through the identification and application of semiochemicals. PhD Dissertation. Major Advisor: David Weaver.

Ehlert K. 2017. "Optimizing efficacy of *Bromus tectorum* (cheatgrass, downy brome) biological control in crops and rangelands." PhD dissertation. Major advisors: Jane Mangold and Fabian Menalled.

Holt C. 2016. "Making agro-ecological weed control decisions in small scale vegetable production of onions, spinach, leaf lettuce, and snap beans." MS thesis. Major advisors: Fabian Menalled and Bruce Maxwell.

Hubbard C. 2016. "Olfactory preference and reproductive isolation of two *Mecinus* spp. (Coleoptera: Curculionidae): Implications for biological control of Dalmatian, yellow, and hybrid populations of toadflax, *Linaria* spp." MS thesis. Major advisor: David Weaver.

Larson C. 2016. "An experimental approach to understanding how *Bromus tectorum* will respond to global climate change in the sagebrush-steppe." MS thesis. Major advisor: Lisa Rew.

Mediak R. 2016. "Distribution of *Bromus tectorum* in mid-elevation forests of the Bitterroot Mountains of Montana." MS LRON Professional Paper. Major advisor: Timothy Seipel.

Metier (Pierson) E. 2017. "Evaluating non-native annual brome control with herbicides and facilitating Wyoming big sagebrush establishment in degraded drylands." MS thesis. Major advisors: Lisa Rew and Matt Rinella.

Mills S. 2016. "Management of *Crepis tectorum* in CRP." MS LRON Professional Paper. Major advisor: Jane Mangold.

Ozeran R. 2016. "Disturbance and site characteristics relate to cheatgrass *(Bromus tectorum)* abundance on ranches in Montana foothills ecosystems." MS thesis. Major advisor: Craig Carr.

Payne J. 2018. Can Targeted Cattle Grazing Increase Abundance of Forbs or Arthropods in Sage-Grouse Brood-Rearing Habitat? MS Thesis. Major Advisor: Jeffrey Moseley.

RESEARCH AND EXTENSION PUBLICATIONS 2016–2018

Ranabhat N. 2017. "Effect of agronomic practices on disease incidence, severity, and impacts in Montana cropping systems." MS thesis. Major advisor: Fabian Menalled.

Soderquist L. 2017. "Understanding the role of social values in ranchland management decision-making: Collaborative research with Montana ranchers." MS thesis. Major advisor: Tracy Sterling.

Taylor K. 2016. "Driver, impacts, and feedbacks of global *Pinus contorta* (lodgepole pine) invasions." PhD dissertation. Major advisors: Bruce Maxwell and Lisa Rew.

Tittle S. 2017. "Effect of spectral band selection and bandwidth on weed detection in agricultural fields using hyperspectral remote sensing." MS thesis. Major advisor: Rick Lawrence.

Walker R. 2017. "Potential for and implications of cover cropping and grazing cover crops in wheat agroecosystems in Montana." MS thesis. Major advisors: Perry Miller and Catherine Zabinski.

WEED MANAGEMENT EXTENSION PUBLICATIONS

TARGET WEEDS

Davis S, **Mangold J**. 2017. "Common buckthorn." MSU Extension.

Fine T, **McKenzie S**, Chen C, **Menalled FD**. 2016. "MontGuide: Biology, identification, and management of glyphosate-resistant horseweed (marestail, *Conyza canadensis)*." MSU Extension.

Fulbright J, Good A, **Jha P,** Lewis K L, **Lane T**, Roeder B L, **Lamb P**. 2018. *Russian Thistle - Herbicide-Resistant Plants* (201816AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. http://msuextension.org/publications/AgandNaturalResources/mt201816AG.pdf

Fuller KB, **Mangold JM**. 2017. "The Costs of Noxious Weeds: What Do You Care About Them?" *Big Sky Small Acres.* MSU Extension.

Goodwin K, Graves-Medley M, Mangold J. 2018. *Identification, biology, and ecology of whitetop* (pp. 11). Bozeman, MT: Montana State University Extension. https://msuextension.org/publications/AgandNaturalResources/EB0138.pdf

Grubb R, Sheley R, Carlstrom R, **Mangold J**, **Lehnhoff E**. 2017. "Saltcedar *(Tamarisk)*." MSU Extension.

Harvey A, Mangold J. 2018. *Ventenata* (pp. 2). Bozeman, MT: Montana State University Extension. http://msuextension.org/publications/AgandNaturalResources/mt201810AG.pdf

Kedzie-Webb S, Sheley R, **Mangold J**, Brown M. 2017. "Houndstongue: Identification, biology, and integrated management." MSU Extension.

Lane T, Jha P, Kittelmann E, Lewis K L, Roeder B L, Fulbright J, Good A 2018. *Downy Brome - Herbicide-Resistant Plants* (201814AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. http://msuextension.org/publications/AgandNaturalResources/mt201814AG.pdf

Lewis K L, **Jha P, Lane T**, Fulbright J, Good A, Roeder B L. 2018. *Kochia - Herbicide-Resistant Plants* (201806AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. http://msuextension.org/publications/AgandNaturalResources/mt201806AG.pdf

Mangold J, Graves M, Jacobs J. 2018. *Biology, ecology, and management of blueweed* (pp. 11). Bozeman, MT: Montana State University Extension. https://msuextension.org/publications/AgandNaturalResources/EB0195.pdf

Mangold JM. 2014–2018. "Monthly weed posts." MSU Extension.

Mangold JM, Landsverk A. 2017. "Western salsify." MSU Extension.

Mangold JM, Sheley R. 2017. "Perennial pepperweed." MSU Extension.

Mangold JM, Sheley R, Brown M. 2017. "Oxeye daisy: Identification, biology, and integrated management." MSU Extension.

Mangold JM, Sheley R, Brown M. 2017. "St. Johnswort: Identification, biology, and integrated management." MSU Extension.

Menalled FD, **Mangold JM**, **Orloff LN**, **Davis ES**. 2017. "Cheatgrass." MSU Extension.

Mosley J. 2018. *Yellow Alyssum and Crested Wheatgrass Winterkill* (pp. 3). MSU Extension Ag Alert.

Mosley JC, **Frost RA**, **Roeder BL**, **Mosley TK**, **Marks G**. 2016. "Combined herbivory by targeted sheep grazing and biological control insects to suppress spotted knapweed." MSU College of Agriculture and Extension Research Report.

Mosley J, Frost R, Roeder BL, Kott R. 2017. "Can targeted sheep grazing suppress sulfur cinquefoil?" MSU College of Agriculture and Extension Research Report.

Orloff L N, Mangold J. 2018. *Dyer's Woad* (MT201820AG ed., pp. 2). https://www.msuextension.org/publications/AgandNaturalResources/MT201820AG.pdf

Orloff L N, Mangold J. 2018. *Medusahead* (MT201804AG ed., pp. 2). Bozeman, MT: MSU Extension. https://store.msuextension.org/Products/Medusahead__MT201802AG.aspx

Orloff L, Mangold J. 2016. "All thistles are not created equal." *Montana IPM Bulletin* (Spring). MSU Extension.

Orloff L, **Mangold J**. 2016. "Stop the friendly fire: Learn to differentiate between native beneficial thistle from exotic thistles." *Big Sky Small Acres* (Spring/Summer). MSU Extension.

Orloff L, **Mangold J.** 2016. "Watch out for phragmites." MSU Extension.

Parkinson H, **Mangold J**. 2017. "Yellow starthistle: Identification, biology, and integrated management." MSU Extension.

Pokorny M, **Mangold J**, Kittle R. 2017. "Black henbane: identification, biology, and integrated management." MSU Extension.

Rinella M, Sheley R, **Mangold J**, Kittle R. 2017. "Orange hawkweed and meadow hawkweed complex." MSU Extension.

Taylor K, **Mangold J**, **Rew L**. 2017. "Weed seed dispersal by vehicles." MSU Extension.

Taylor K, **Pollnac F**, **Brummer T**, **Mangold J**, **Rew L**. 2017. "Washing vehicles to prevent weed seed dispersal." MSU Extension.

Parkinson H, **Mangold J**, McLane C. 2016. "Biology, ecology, and management of curlyleaf pondweed *(Potamogeton crispus)*." MSU Extension.

OUTREACH PUBLICATIONS

Brink D, Burch D, **Frame-Martin S A**, Duncan C, Maggio M, **Mangold J,** Martin D, Rogge-Kindseth S 2018. *Weed management on small acreages in Montana* (pp. 36). Bozeman, MT: Montana State University Extension. https://www.msuextension.org/publications/AgandNaturalResources/EB0227.pdf

Continued on next page

OUTREACH PUBLICATIONS 2016–2018

Mosley J, Barta S, Frost R, Standley E N, Schuldt C, Caquelin R, Jenson H, Thompson F, McCauley A. 2018. *Monitoring for Success: Official Handbook of the Montana Rangeland Monitoring Program*. Helena, MT: Montana Department of Natural Resources and Conservation.

Parkinson H, Mangold J. 2018. *Plant Identification Basics* (pp. 8). Bozeman, MT: Montana State University Extension. https://www.msuextension.org/publications/AgandNaturalResources/MT201304AG.pdf

Schantz M, Espeland E, **Mangold JM**. 2016. "MontGuide: Pipeline reclamation." MSU Extension.

Tharp CI, Bower A. 2016. "MontGuide: Minimizing pesticide contaminated soil around the home and garden." MSU Extension.

Tharp CI. 2016. "MontGuide: Calibrating home and garden sprayers." MSU Extension.

Tharp CI. 2016. "MontGuide: Montana Private Applicator Program." MSU Extension.

Tharp CI. 2016. "MontGuide: Calibrating ground sprayers using shortcut methods." MSU Extension.

OUTREACH PRODUCTS

Eilers S E, Grimme E, Kerzicnik L M, **Orloff L N, Day T,** Palmer D. 2018. *2019 Calendar - Pests in the Garden*. Bozeman, MT: Montana State University Extension.

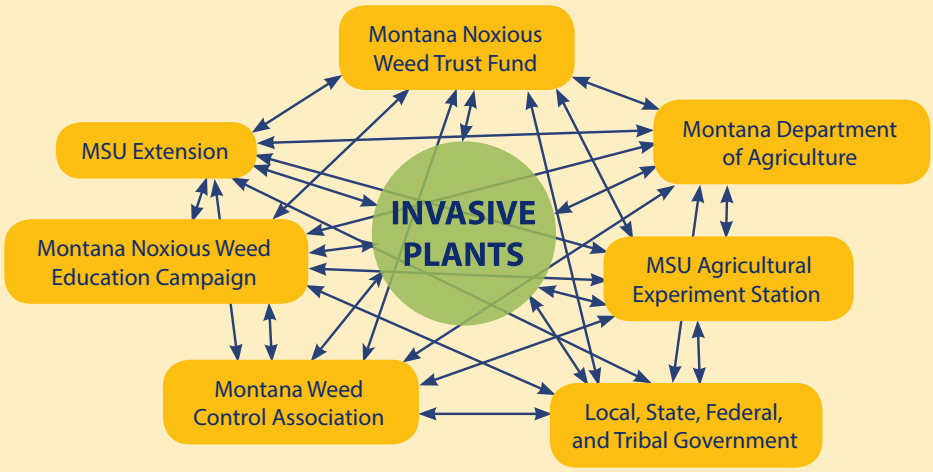
Lavin M, Tilt W, Gibson K, Holzworth L, **Parkinson HH**, **Mangold JM**. 2016. Montana Grass App (update). High Country Apps.

Mangold JM. 2016. Montana noxious weed key. EDDMapS West.

Beaverhead County Grasses Day, Dillon, MT, 2018

Beaverhead County Weed Day, 2018

RESEARCH AND EDUCATIONAL PARTNERSHIPS:
WORKING TOGETHER TO IMPROVE INVASIVE SPECIES MANAGEMENT IN MONTANA



MONTANA STATE UNIVERSITY | EXTENSION

MONTANA STATE UNIVERSITY | MONTANA AGRICULTURAL EXPERIMENT STATION

Compiled and edited by Tracy Sterling and Dan Lucas, June 2019.