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 comprehensive reporting of all weed science research products and education funding and activities.

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2013–2015

<table>
<thead>
<tr>
<th>Project Title, PI</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>A meta-analysis of previous Canada thistle and field bindweed control and management studies, Fabian Menalled</td>
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<td>Assessing the influence of fire and grazing on cheatgrass spread and plant community composition, Erik Lehnhoff</td>
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<td>Biological control of: common tansy and oxeye daisy; invasive hawkweeds; Russian knapweed; and whitetop, Jeff Littlefield</td>
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<td>Biological control of invasive toadflax using stem inhabiting weevils, David Weaver</td>
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<td>Can targeted cattle grazing and biocontrol insects work together to suppress spotted knapweed? Jeff Mosley</td>
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<td>Determining the efficacy of biocontrol using Mecinus janthinus strains on Dalmatian, yellow, and hybrid toadflax, David Weaver</td>
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<td>Economic impact of noxious weeds on grazing capacity of Montana rangeland, Kate Fuller</td>
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<td>Identifying and testing candidate agents for biocontrol of Russian olive, David Weaver</td>
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<td>Managing dense cheatgrass infestations on rangeland, and understanding its impacts under an altered climate, Lisa Rew</td>
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<td>Memorize, recognize, prioritize: Noxious weed education action program, Jane Mangold</td>
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<td>Missouri River Watershed Coalition coordination, Elizabeth Galli-Noble</td>
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<td>Mitigating priority effects of invasive plants during revegetation by altering perennial grass planting date, Jane Mangold</td>
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<td>Montana Noxious Weed Education Campaign, Jane Mangold</td>
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<td>Montana's noxious weeds mobile app, Jane Mangold</td>
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<td>Optimizing available toadflax biocontrol resources and evaluation of efficacy of candidate stem-galling weevils, David Weaver</td>
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<td>Patterns and mechanisms of cheatgrass invasion in the Northern Great Plains, Craig Carr</td>
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<td>Predicting plant community response to weed control, Jane Mangold</td>
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<td>Tall buttercup ecology and integrated management, Jane Mangold</td>
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<tr>
<td>Understanding and mitigating the impact of cheatgrass under a changing climate, Erik Lehnhoff</td>
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<tr>
<td>Update and expand the “Mapping Noxious Weeds in Montana” publication and conduct EDDMapS West trainings, Elizabeth Galli-Noble</td>
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REPORT FOR THE MONTANA NOXIOUS WEED TRUST FUND ADVISORY COUNCIL • 2

FUTURE PLANS: 2016 MONTANA NOXIOUS WEED TRUST FUND GRANTS

Montana State University
Addressing challenges posed by yellow, Dalmatian, and hybrid toadflax using integrated approaches that support biological control, David Weaver and Sharlene Sing
Candidate agents for biological control of Russian olive, David Weaver and Sharlene Sing
Effect of herbicide application and soil texture on hoary alyssum seed biology and control, Jane Mangold, Stacy Davis, and Brad Bauer
Host specificity testing of biological control agents of weedy mustards, Jeff Littlefield
Host testing of biological control agents for hawkweeds, Jeff Littlefield
Integrated management of dense cheatgrass on productive rangelands, Lisa Rew and Jane Mangold
Mitigating priority effects of invasive plants during revegetation by altering perennial grass planting date, Jane Mangold
Montana Noxious Weed Education Campaign, Jane Mangold and Shantell Frame-Martin
Release and monitoring of Russian knapweed biological control agents, Jeff Littlefield
Screening of new biological control agents for common tansy and oxeye daisy, Jeff Littlefield

Examples of Extension Participation in 2016 Montana Noxious Weed Trust Fund Grant Programs
Cooperative control of houndstongue in the Larb Hills, Phillips County
Flesham Creek cooperative weed management project, Park County
Integrated noxious weed education across Livingston, Park County
Leave no weeds, Missoula County

University of Montana/MSU Collaborative Projects
Environmental–DNA for aquatic invasive plant species, Adam Sepulveda
MSU WEED SCIENCE ACTIVITY

Peer-reviewed journal articles: 62
Invited book chapters: 3
Peer-reviewed conference abstracts: 94
Completed theses and dissertations: 14
Graduate students in training: 24
Extension publications: 29
TV and radio appearances: 13

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)

PROJECT HIGHLIGHT

*Bromus tectorum Response to Fire Varies with Climate Conditions*
Kimberley Taylor, LRES; Tyler Brummer, LRES; Lisa Rew, LRES; Matt Lavin, PSPP; Bruce Maxwell, LRES

“The invasive annual grass *Bromus tectorum* (cheatgrass) forms a positive feedback with fire in some areas of western North America’s sagebrush biome by increasing fire frequency and size, which then increases *B. tectorum* abundance post-fire and dramatically alters ecosystem structure and processes. However, this positive response to fire is not consistent across the sagebrush steppe. Here, we ask whether different climate conditions across the sagebrush biome can explain *B. tectorum*’s variable response to fire. We found that climate variables differed significantly between 18 sites where *B. tectorum* does and does not respond positively to fire. A positive response was most likely in areas with higher annual temperatures and lower summer precipitation. We then chose a climatically intermediate site, with intact sagebrush vegetation, to evaluate whether a positive feedback had formed between *B. tectorum* and fire. A chronosequence of recent fires (1–15 years) at the site created a natural replicated experiment to assess abundance of *B. tectorum* and native plants. *B. tectorum* cover did not differ between burned and unburned plots but native grass cover was higher in recently burned plots. Therefore, we found no evidence for a positive feedback between *B. tectorum* and fire at the study site. Our results suggest that formation of a positive *B. tectorum*-fire feedback depends on climate; however, other drivers such as disturbance and native plant cover are likely to further influence local responses of *B. tectorum*. The dependence of *B. tectorum*’s response to fire on climate suggests that climate change may expand *B. tectorum*’s role as a transformative invasive species within the sagebrush biome.”


IMPACTS 2013–2015

Cheatgrass dominating the understory of mountain big sagebrush steppe in the area of Kelly Canyon after herbicides were used to manage the noxious weed St. Johnswort. High cheatgrass abundance outside its ecological optimum can result from mismanagement of vegetation.
MSU EXTENSION

PESTICIDE EDUCATION DELIVERED 2015†

<table>
<thead>
<tr>
<th>Region</th>
<th>Programs</th>
<th>Attendees</th>
<th>Training hours</th>
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<tr>
<td>1</td>
<td>71</td>
<td>360</td>
<td>875</td>
</tr>
<tr>
<td>2</td>
<td>135</td>
<td>716</td>
<td>2,250</td>
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<tr>
<td>3</td>
<td>90</td>
<td>126</td>
<td>1,100</td>
</tr>
<tr>
<td>4</td>
<td>44</td>
<td>107</td>
<td>850</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>80</td>
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</tbody>
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†Source: Cecil Tharp, MSU Pesticide Safety Program Coordinator. Regions defined at: pesticides.montana.edu/PAT.

MSU EXTENSION AG AGENTS IN 2015

Note: Bold type denotes Agents who contributed to a survey about Extension weed outreach and education activities.

Kellee Anderson, Silver Bow County • Melissa Ashley, Rosebud and Treasure Counties • Jason Badger, Sanders County • Nikki Bailey, Carbon County • Wendy Becker, Fort Peck Reservation • Verna Billedeaux, Blackfeet Reservation • Dave Brink, Mineral County • Colleen Buck, Sheridan County • Jeff Chilson, Roosevelt County • Darren Crawford, Fergus County • Tim Fine, Richland County • Jesse Fulbright, Liberty County • Nicole Gray, Hill County • Molly Hammond, Big Horn County • Danielle Harper, Wibaux County • Katie Hatlelid, Judith Basin County • Ben Hauptman, Blaine County • Marc King, Sweet Grass County • Rene Kittle, Flathead Reservation • Elin Kittelmann, Carter and Fallon Counties • Allison Kosto, Broadwater County • Steve Lackman, Yellowstone County • Tyler Lane, Chouteau County • Kari Lewis, Glacier County • Emily Lockard, Gallatin County • Dan Lucas, Granite County • Rose Malisani, Cascade County • Marko Manoukian, Phillips County • Jerry Marks, Missoula County • Pat McGlynn, Flathead County • Katrina Mendrey, Ravalli County • Shaelyn Meyer, Pondera County • Eric Miller, Garfield County • Shelley Mills, Valley County • Tracy Mosley, Park County • Ken Nelson, McCona County • Jodi Pauley, Powell County • Abbie Phillip, Deer Lodge County • Mandie Reed, Wheatland County • Brent Roeder, Teton County • Bobbie Roos, Daniels County • Ryhal Rowland, Northern Cheyenne Reservation • Mary Rumph, Powder River County • Sharla Sackman, Prairie County • Brent Sarchet, Lewis and Clark County • Lee Schmelzer, Stillwater County • Mike Schuld, Custer County • Bruce Smith, Dawson County • Jack Stivers, Lake County • Kimberly Suta, Toole County • Jackie Sutton, Beaverhead County • Mat Walter, Golden and Musselshell Counties • Elizabeth Werk, Fort Belknap Reservation • Billy Whitehurst, Jefferson and Madison Counties

MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH

Off-Campus MSU Weed Education Programs
- Programs delivered (2015): 81
- Individuals reached (2015): 3,991

MSU Schutter Diagnostic Lab
- Weed samples identified (2013–2015): 1,546

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

Professional Development
- Noxious Weed Management Certification Program, Levels 1–3

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**JOURNAL ARTICLES AND INVITED BOOK CHAPTERS**

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

**Herbicide Resistance**


**Integrated Pest Management**


Keren IN, Menalled FD, Weaver DK, Robison-Cox J. 2015. Interacting agricultural pests and their effect on crop yield: Application of a Bayesian decision theory approach to the joint management of *Bromus tectorum* and *Cephus cinctus*. *Plos One* 10(2).


**Rangeland Weed Management and Restoration**


Orloff LN, Mangold JM, Menalled FD. 2013. Role of size and nitrogen in competition between annual and perennial grasses.
RESEARCH PUBLICATIONS 2013–2015


Weed Biocontrol

Weed Biology and Ecology
Frost RA, Mosley JC, Roeder BL. 2013. Recovery and viability of sulfur cinquefoil seeds from the feces of sheep and goats.
Skurski TC, Maxwell BD, Rew LJ. 2013. Ecological tradeoffs in non-native plant management. Biological Conservation 159:
RESEARCH AND EXTENSION PUBLICATIONS 2013–2015

292–302.


THESES AND DISSERTATIONS


WEED MANAGEMENT EXTENSION PUBLICATIONS

Integrated Pest Management

Goodwin KM, Mangold JM, Tharp CI. 2013. “Herbicides and noxious weeds: Answers to frequently asked questions.”


Mangold JM, Parkinson H. 2013. “Plant identification basics.”

Mangold JM, Parkinson H. 2014. “Early detection and rapid response (EDRR) to new plant invaders.”

Mangold JM. 2014. “What’s that grass growing on the other side of the fence?” *Montana IPM Bulletin* (Fall).


Tharp CI. 2013. “Montana private certification addendum.”

Target Weeds


Menalled FD. 2015. “Biology, ecology, and management of foxtail barley (Hordeum jubatum).” Montana IPM Bulletin (Fall).
Strevey H, Mangold JM. 2015. “Emergence and growth of tall buttercup (Ranunculus acris L.) seedlings along a soil moisture gradient.”
Tharp CI. 2015. “What is a pesticide?” Big Sky Small Acres (Spring/Summer).

OUTREACH PRODUCTS

OUTREACH PUBLICATIONS
Rindos EJ. 2015. “Mapping Invasive Species in Montana: An EDDMapS-West User Guide” (iPhone and Android editions). Center for Invasive Species Management, MSU.