Montana State University: Montana Agricultural Experiment Station and Extension Service

# REPORT FOR THE MONTANA NOXIOUS WEED TRUST FUND ADVISORY COUNCIL

JUNE 2014

## 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 2011–2013

| Project Title, *PI* | 2011 | 2012 | 2013 |
|---|---|---|---|
| Assessing the Influence of Fire and Grazing on Cheatgrass Spread and Plant Community Composition, *Erik Lehnhoff* | | | ● |
| Biological Control of Common Tansy and Oxeye Daisy, *Jeff Littlefield* | ● | ● | ● |
| Biological Control of Invasive Hawkweeds, *Jeff Littlefield* | ● | ● | ● |
| Biological Control of Russian Knapweed, *Jeff Littlefield* | ● | ● | ● |
| Biological Control of Whitetop, *Jeff Littlefield* | ● | ● | ● |
| Can Biological Control and Targeted Sheep Grazing Be Integrated to Suppress Spotted Knapweed?, *Jeff Mosley* | ● | ● | |
| Continental Divide Barrier Zone, *Kim Goodwin* | ● | | |
| Determining the Efficacy of Biocontrol Using *Mecinus janthinus* strains on Dalmatian, Yellow, and Hybrid Toadflax, *David Weaver* | | | ● |
| Establishing and Monitoring Insectaries for Yellow Toadflax Biocontrol, *David Weaver* | ● | ● | |
| Herbicide Resistance Extension Info for Producers, *Bill Dyer* | ● | | |
| Identifying and Testing Candidate Agents for Russian Olive Biocontrol, *David Weaver* | ● | ● | ● |
| Memorize, Recognize, Prioritize: Noxious Weed Education Action Program, *Jane Mangold* | | | ● |
| Missouri River Watershed Coalition Coordination, *Elizabeth Galli-Noble* | ● | ● | ● |
| Montana Noxious Weed Education Campaign, *Jane Mangold* | | | ● |
| Predicting Plant Community Response to Weed Control, *Jane Mangold* | | | ● |
| Tall Buttercup Ecology and Integrated Management, *Jane Mangold* | | ● | ● |
| Update and Expand the "Mapping Noxious Weeds in Montana" Publication and Conduct EDDMapS West Trainings, *Elizabeth Galli-Noble* | | | ● |
| Weed Free Borders Protection Program, *Kim Goodwin* | | ● | |
| Weed Management Certification Program, *Jane Mangold* | ● | | |
| Weed Seedling Identification Guide, *Jane Mangold* | | ● | |

## DEPARTMENTS INVOLVED WITH WEED RESEARCH AND EDUCATION

### Montana Agricultural Experiment Station
### MSU Extension Service

### Animal and Range Sciences
Craig Carr, *Rangeland Ecology*
Rachel Frost, *Rangeland Ecology and Management*
Pat Hatfield, *Range Sheep Nutrition*
Rodney Kott, *Range Sheep Production*
Jeff Mosley, *Rangeland Ecology and Management*
Bret Olson, *Rangeland Ecology and Management*
Cecil Tharp, *Pesticide Education Specialist*

### Center for Invasive Species Management
Elizabeth Galli-Noble, *Director*
Kim Goodwin, *Weed Science*

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

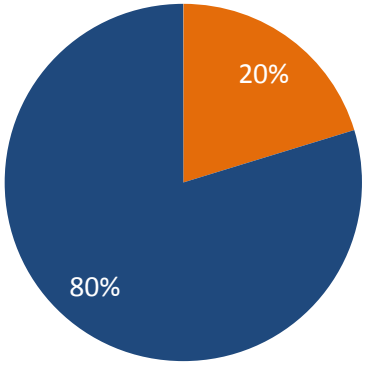
### Montana Noxious Weed Education Campaign
Shantell Frame-Martin, Coordinator

### Plant Sciences and Plant Pathology
Mary Burrows, *Plant Pathology*
Bill Dyer, *Weed Physiology*
Matt Lavin, *Botanist*

### Research Centers
Prashant Jha, *Weed Science*

# MSU WEED PROJECT FUNDING 2011–2013

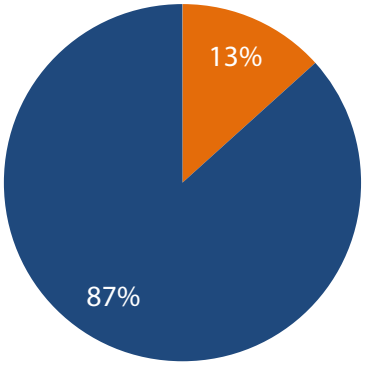
### NEW AWARDS 2011




Noxious Weed Trust Fund
$415,611. . . . . 20%

Other
$1,634,314. . . . . 80%

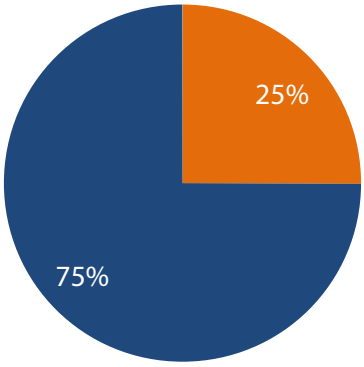
### NEW AWARDS 2012




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

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

### NEW AWARDS 2013




Noxious Weed Trust Fund
$393,783. . . . . 25%

Other
$1,177,657 . . . . . 75%

## OTHER FUNDING SOURCES FOR WEED RESEARCH AND EDUCATION

NATIONAL

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

**US Department of the Interior**
Bureau of Indian Affairs
Bureau of Land Management

**US Department of Defense**
**US Environmental Protection Agency**
**National Science Foundation**
**World Wildlife Fund**

REGIONAL

Algoma University
Gonzales Stoller LLC
North Dakota State University
Northern Pulse Growers Association
University of California
University of Nebraska
Utah State University
Western Integrated Pest Management Center
Western Sustainable Agriculture Research and Education Program
Wyoming Department of Agriculture

STATE

Fort Belknap Indian Community
Montana Department of Agriculture
Montana Disaster and Emergency Services
Montana Wheat and Barley Committee

## FUTURE PLANS: 2014 MONTANA NOXIOUS WEED TRUST FUND GRANTS

### Montana State University

Understanding and Mitigating the Impact of Cheatgrass Under a Changing Climate, *Erik Lehnhoff*
Biological Control of Common Tansy and Oxeye Daisy, *Jeff Littlefield*
Biological Control of Invasive Hawkweeds, *Jeff Littlefield*
Biological Control of Invasive Toadflax Using Stem Inhabiting Weevils, *David Weaver*
Biological Control of Russian Knapweed, *Jeff Littlefield*
Biological Control of Whitetop, *Jeff Littlefield*
Montana Noxious Weed Education Campaign, *Jane Mangold*
Montana's Noxious Weeds Mobile App, *Jane Mangold*
Patterns and Mechanisms of Cheatgrass Invasion in the Northern Great Plains, *Craig Carr*
Predicting Plant Community Response to Weed Control: When is Revegetation Necessary?, *Jane Mangold*

### Examples of Extension Participation in 2013 Montana Noxious Weed Trust Fund Grant Programs

Can Biological Control and Targeted Sheep Grazing Be Integrated to Suppress Spotted Knapweed?, *Missoula County and Park County*
Clearwater River Yellowflag Iris Eradication Project, *Missoula County*
Leave No Weeds, *Missoula County*
North Horseshoe Hills, *Gallatin County*
Swan Valley Cooperative Weed Management Project, *Missoula County*
West Boulder River – Mission Creek Watersheds Cooperative Weed Management Project, *Park County*
Yellowstone River Corridor Cooperative Weed Management Project, *Park County*

### University of Montana/MSU Collaborative Projects

Search Dogs for the Detection of Dyer's Woad, *Marilyn Marler*
Missoula Conservation Lands Restoration Project, *Morgan Valliant*
Noxious Weed Listing Research, *Peter Rice, Jane Mangold, and Montana Weed Control Association*

## MSU WEED SCIENCE RESEARCH ACTIVITY

Peer-reviewed journal articles: 64
Invited book chapters: 3
Peer-reviewed conference abstracts: 115
Completed theses and dissertations: 13
Graduate students in training: 24
Extension publications: 19
TV and radio appearances: 12

### Research 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

### Tall Buttercup Ecology and Integrated Management

**PI:** Jane Mangold, LRES

The objective of this project was to increase our knowledge about the ecology and integrated management of tall buttercup, one of the more recently listed yet poorly understood species on the Montana noxious weed list. We cooperated with the Madison County weed district and private landowners near Twin Bridges to investigate two primary questions: (1) What is the correlation between tall buttercup and plant community diversity and productivity? and (2) How will tall buttercup respond to the control practices of herbicides, mowing, and fertilization alone and applied in combination with each other? Both of these questions were explored with field studies over two years at two sites. With a greenhouse study, we also investigated the effect of soil moisture on tall buttercup seedling emergence and growth.

We found that tall buttercup is, in general, not associated with reductions in plant community diversity or productivity. However, at one site perennial grass biomass, primarily that of creeping meadow foxtail, was reduced as tall buttercup biomass increased. We also found that all herbicides tested (Perspective, Milestone, dicamba) provided up to two years of tall buttercup control at both sites and mowing and fertilization controlled tall buttercup at one site.

Forage production increased following applications of Milestone and dicamba treatments; however, Perspective reduced perennial grasses; all herbicides decreased other forbs in the plant community, several of which are important forage species (i.e., red and white clover).

In the greenhouse study tall buttercup seedling performance was best when soil moisture was around 50% field capacity; 25% and 100% field capacity treatments greatly reduced emergence and growth, suggesting that irrigation could potentially be used to help manage this species.

Over the course of this study, an M.S. thesis was completed and degree awarded to Hally Strevey; three professional conference papers were presented; one Monthly Weed Post was disseminated to at least 300 people across the region; Hally Strevey won two scholarships for her research and academic performance; and a field tour was held.

Over the next several months, we will be submitting peer-reviewed manuscripts describing this project and its results and management implications. We also plan to write additional outreach publications, including an Extension publication.

*Left:* M.S. student Hally Strevey talks to the county weed board during a tall buttercup field tour in Madison County in 2013. *Right:* Sampling plots in 2013.

### Can Biological Control and Targeted Sheep Grazing Be Integrated to Suppress Spotted Knapweed?

**PI:** Jeff Mosley, ANRS **Co-PIs:** Rachel Frost and Brent Roeder, ANRS; Tracy Mosley, Park County Extension; Jerry Marks, Missoula County Extension

Populations of the three biological control insects studied, *Larinus* spp., *Cyphocleonus achates*, and *Agapeta zoegana*, were not harmed by targeted sheep grazing applied in either July or August.

Spotted knapweed seed production, viable seed production, seedling/juvenile plant density, and adult plant density were suppressed more where targeted sheep grazing and biological control insects were combined versus areas treated with biological control insects alone.

Combined herbivory by targeted sheep grazing and biological control insects was additive and prevented compensatory recruitment of spotted knapweed, whereas treatment with biological control insects alone was insufficient to suppress the spotted knapweed population.

In 2013, project results were presented in one invited proceedings paper, two invited contributed papers, three invited Extension seminars, and a refereed journal manuscript is in review for *Rangeland Ecology and Management*.

### Assessing the Influence of Fire and Grazing on Cheatgrass Spread and Plant Community Composition

**PI:** Erik Lehnhoff, LRES **Co-PIs:** Timothy Seipel and Lisa Rew, LRES

The purpose of our research is to gain a greater understanding of factors leading to cheatgrass invasion and dominance on Montana rangelands and how to prevent and control it. Research and management of cheatgrass is especially important now, as its distribution and abundance in Montana is predicted to increase with decreasing regional precipitation, and increasing mean temperatures. This will make our climate more similar to the Great Basin where cheatgrass is a major problem due to a positive feedback with fire (i.e., cheatgrass increases after fire, which then leads to shorter fire return internals and a further advantage to cheatgrass) and disturbance.

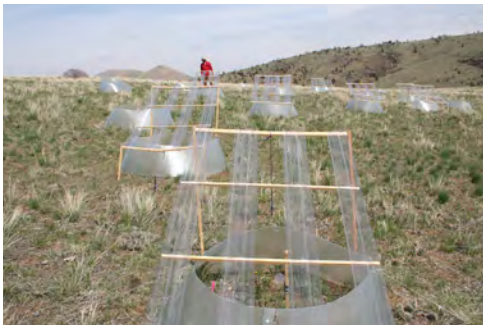
In the first year of our project we studied the response of cheatgrass and the rest of the plant community to fire at three sites. One site had burned the previous year and a bulldozer line had been constructed as a fire break. At all sites, we observed that cheatgrass cover was similar in burned and unburned plots, and at Red Bluff it was much higher on the bulldozer line. In contrast, native bluebunch wheatgrass cover was higher in both the burned and unburned areas but had not recovered on the bulldozer line, suggesting that disturbance, but not fire, provides an advantage to cheatgrass. This year we will continue to sample these plots to assess two-year vegetation responses to fire and bulldozer line disturbance.

In addition, we have set up climate chambers to increase temperature and alter precipitation at Red Bluff and the Post Farm. These chambers will allow us to determine the role of climate on the growth rate and productivity of cheatgrass under both rangeland and agricultural settings.

### Optimizing Biological Control of Dalmatian, Yellow, and Hybrid Toadflax

**PI:** David Weaver, LRES **Co-PIs:** Sharlene Sing and Jeff Littlefield, LRES

The primary goal of this research is to identify one or more agents that will be effective in controlling hybrid toadflax. Increasing the size of weevil releases from 250–500 to 800, while increasing the frequency of releases to include a second year, plus making more releases in the same area mitigated high over-wintering mortality of Dalmatian toadflax stem mining weevil, *Mecinus janthiniformis*, associated with harsh environmental conditions typically encountered on fire-affected forests and rangelands. This strategy significantly improved successful biological control, and at a landscape scale, in areas where establishment and population buildup of the same agent was previously minor. State, federal, and private administrators, resource managers, and



*Left:* Results of a research project near Polson indicate that mammalian herbivory may need to be combined with biological control insect herbivory to suppress spotted knapweed in North American habitats where spotted knapweed seedlings and juvenile plants thrive. *Center and right:* Climate chambers were constructed at the Post Farm and Red Bluff project site to evaluate the role of climate and fire on wheat and cheatgrass, and other vegetation and cheatgrass respectively.

### Optimizing Biological Control of Dalmatian, Yellow, and Hybrid Toadflax *(continued)*

other stakeholders participated in a field tour of the associated study area in August 2013.

Long term monitoring showed that significant biological control might not occur for up to three years post-release under more challenging environmental conditions, even on higher density, frequency and intensity release sites.

Results from a long term field based study clearly indicate that the Dalmatian toadflax weevil, *M. janthiniformis*, preferentially attacks Dalmatian toadflax host plants and therefore exerts effectively no biological control over yellow toadflax, even when these two weeds grow in close proximity. Attack on hybrid toadflax occurring in mixed infestations of the three toadflax genotypes was minimal, but higher than on yellow toadflax.

A petition for a permit to make the first US field releases of a candidate agent for yellow toadflax, the stem galling weevil *Rhinusa pilosa*, has been submitted to USDA APHIS PPQ following a positive review of the petition by TAG. The test plant list and petition were co-authored with Canadian, Swiss, and Serbian collaborators. Host specificity results included in the petition were recently accepted for publication in a peer reviewed journal article.

Evaluations of candidate agents are ongoing in the MSU quarantine facility. Agent screening includes the yellow toadflax stem galler *Rhinusa pilosa* and stem miner *Mecinus heydeni*, and the Dalmatian toadflax stem galler *Rhinusa brondellii*.

### Identifying and Testing Candidate Agents for Russian Olive Biocontrol – Limiting Target Plant Reproductive Capacity

**PI:** David Weaver, LRES **Co-PI:** Sharlene Sing, LRES

Speakers from California, Colorado, Idaho, Kentucky, Montana, Washington, Wyoming, Switzerland, and Canada delivered 24 talks addressing topics such as conflicting perceptions, basic and invasive biology, environmental impacts and management of Russian olive during a two-day USDA NIFA AFRI sponsored symposium. The purpose for holding the symposium was to bring together diverse stakeholders and researchers to facilitate information exchange and to encourage dialogue on the risks, benefits and management of this contentious and frequently polarizing invasive species. Symposium presentations specifically addressed conflicts of interest related to the biological control of Russian olive, identified research gaps that may mitigate some biocontrol-related concerns, and developed recommendations for stakeholder involvement in biocontrol projects for this and other invasive weeds.

Overseas screening of candidate agents for biological control of Russian olive focused exclusively on herbivores that would reduce flower and/or fruit production. Members of the Russian olive biocontrol consortium have collaboratively contributed to the development of a test plant list, acquisition of test species, and in-depth ecological assessments of proposed initial North American field release sites.

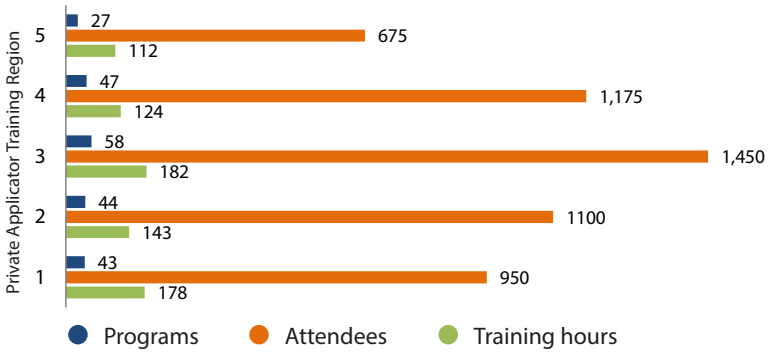
As an additional project not funded by the Montana Noxious Weed Trust Fund, field-based proof-of-concept research conducted in 2013 confirmed that an existing commercial medium could be used to successfully deploy both pheromones and host plant volatiles for the purpose of manipulating the spatial distribution of a saltcedar *(Tamarix* spp.) biological control agent, the northern tamarisk beetle, *Diorhabda carinulata* (Desbrochers). The overall goal of this project is to determine if semiochemicals can be used to attract and retain beetles when populations are low or scattered, primarily to strategically intensify herbivory on specific desired locations, while minimizing non-target risks in ecologically sensitive areas. This project is being conducted using a model system in northern Wyoming, about 20 miles south of the Montana border. Lure-mediated biocontrol damage and monitoring procedures developed from this project will also serve as a framework for future application to other weed biological control systems.

*Left:* A field tour of a toadflax biocontrol release study area was held in August 2013. *Right:* Field tour participants studying munched Dalmatian toadflax.

# EDUCATION IMPACTS 2011–2013

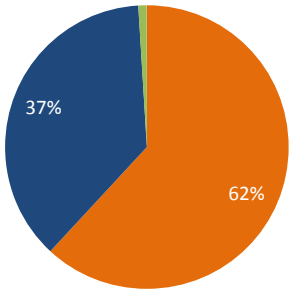
## MSU EXTENSION

### PESTICIDE EDUCATION DELIVERED 2013†




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

### WEED MANAGEMENT CONSULTATIONS (ACRES) 2013‡




Crop land
375,110 . . . . . 62%

Non-crop land
225,110 . . . . . 37%

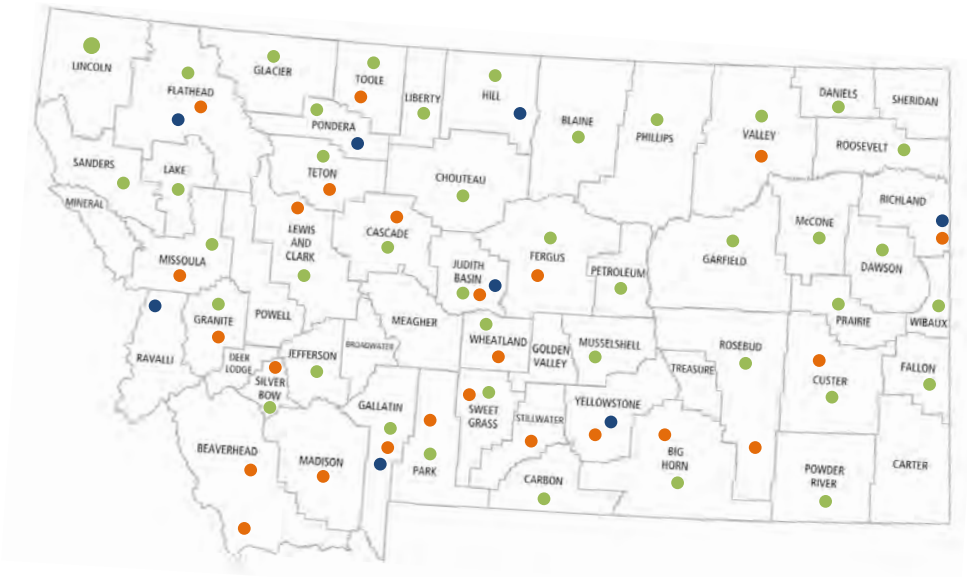
Small acreage
5,878 . . . . . 1%

‡*Data represents approximately 46% of MSU Extension offices.*

### MSU Extension Personnel Contributing to Weed Education Efforts in 2013‡

Wendy Becker, *Fort Peck Reservation* • Dave Bertelsen, *Wibaux County* • Dave Brink, *Mineral County* • Chrissy Cook, *Judith Basin County* • Darren Crawford, *Fergus and Petroleum Counties* • Tim Fine, *Richland County* • Nicole Gray, *Hill County* • John Halpop, *Sanders County* • Byron Hould, *Rosebud and Treasure Counties* • Marc King, *Sweet Grass County* • Rene Kittle, *Flathead Reservation* • Virginia Knerr, *Broadwater County* • Steve Lackman, *Yellowstone County* • Emily Lockard, *Gallatin County* • Dan Lucas, *Granite County* • Pat McGlynn, *Flathead County* • Rose Malisani, *Cascade County* • Marko Manoukian, *Phillips County* • Jerry Marks, *Missoula County* • Katrina Mendrey, *Ravalli County* Eric Miller, *Garfield County* • Shelley Mills, *Valley County* • Tracy Mosley, *Park County* • Ken Nelson, *McCone County* • Joe Parks, *Toole County* • Jodi Pauley, *Powell County* • Anne Ronning, *Roosevelt County* • Bobby Roos, *Daniels County* • Ryhal Rowland, *Northern Cheyenne Reservation* • Mark Rude, *Sheridan County* Mary Rumph, *Powder River County* • Sharla Sackman, *Prairie County* • Andrea Sarchet, *Madison and Jefferson Counties* • Brent Sarchet, *Lewis and Clark County* • Mike Schuldt, *Custer County* • Brenda Serrano, *Musselshell and Golden Valley Counties* • Bruce Smith, *Dawson County* • Jack Stivers, *Lake County* J.P. Tanner, *Beaverhead County* • Elin Westover, *Fallon and Carter Counties* • Gail Whiteman, *Fort Belknap Reservation*

## MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH




- MSU MAES Research Centers
- Off-campus MSU Weed Education Program locations
- Counties which submitted plant sample(s) for identification by MSU Schutter Diagnostic Lab

**Off-Campus MSU Weed Education Programs**
Programs delivered (2013): 71
Individuals reached (2013): 3,464

**MSU Schutter Diagnostic Lab**
Weed samples identified (2011–2013): 1,454

**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 2011–2013

## JOURNAL ARTICLES AND INVITED BOOK CHAPTERS

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

### Early Detection

**Goodwin KM**, Sheley RL, Jacobs JS, Wood S, et al. 2012. Cooperative prevention systems to protect rangelands from the spread of invasive plants. *Rangelands* 34: 26–31.

### Integrated Pest Management

**Burrows ME, Miller ZJ**, **Menalled FD**. 2013. Estimating susceptibility to wheat streak mosaic virus infection in non-crop grasses. *Phytopatology* 103: 22–22.

**Davis PB**, **Maxwell BD**, **Menalled FD**. 2013. Impact of growing conditions on the competitive ability of *Camelina sativa* (L.) Crants (Camelina), a proposed biofuel crop. *Canadian Journal of Plant Science* 93: 243–247.

**Davis PB**, **Menalled FD**, **Peterson RKD**, **Maxwell BD**. 2011. Refinement of weed risk assessment for biofuels using *Camelina sativa* as a model species. *Journal of Applied Ecology* 48: 989–997.

Ito D, **Miller ZJ**, **Menalled FD**, Moffet M, **Burrows ME**. 2012. Relative susceptibility among alternative host species prevalent in the Great Plains to wheat streak mosaic virus. *Plant Disease* 98: 1185–1192.

**Menalled FD**, **Keren EN**, **Weaver DK**, Dyer A, Robinson-Cox J. 2012. Assessing the ecological basis of a multi-pest approach to management of wheat-fallow systems. *Canadian Journal of Plant Science* 92: 595–596.

**Miller ZJ**, **Burrows ME**, **Menalled FD**. 2013. Winter annual grassy weeds increase disease induced overwinter mortality in fall-sown cereals. *Weed Research* 53: 102–109.

**Miller ZJ**, **Burrows ME**, **Menalled FD**. 2013. Effects of nitrogen fertilization risks and impacts of wheat streak mosaic disease. *Phytopathology* 103: 97–97.

**Miller ZJ**, **Menalled FD**, **Burrows ME**. 2012. Downy brome increases disease-induced overwinter mortality in wheat *(Triticum aestivum)*. *Canadian Journal of Plant Science* 92: 1185–1192.

Smith R, Ryan MR, **Menalled FD**. 2011. Direct and indirect impacts of weed management practices on soil quality. In *Soil Management: Building a Stable Base for Agriculture*, ed. Hatfield J and Sauer T, 275–286. Madison, WI: American Society of Agronomy.

### Herbicide Resistance

Bagavathiannan MV, Norsworthy JK, **Jha P**, Smith KL. 2011. Does resistance to propanil or clomazone alter the growth and competitive abilities of barnyardgrass? *Weed Science* 59: 353–358.

Egan FL, **Maxwell BD**, Mortensen DA, Ryan MR, Smith RG. 2011. 2,4-D resistant crops and the potential for evolution of 2,4-D resistant weeds. *Proceedings of the National Academy of Sciences* 108: E37.

Harker KN, O'Donovan JT, Blackshaw RE, Beckie JJ, Mallory-Smith C, **Maxwell BD**. 2012. Our view. *Weed Science* 60: 143–144.

**Jha P**, Norsworthy JK. 2012. Influence of late-season herbicide applications on control, fecundity, and progeny fitness of glyphosate-resistant Palmer amaranth biotypes from Arkansas. *Weed Technology* 26: 807–812.

**Jha P**, Stougard SE. 2013. Camelina tolerance to selected pre-emergence herbicides. *Weed Technology* 27: 712–717.

**Keith BK**, **Kalinina EB**, **Dyer WE**. 2011. Differentially expressed genes in dicamba-resistant and susceptible biotypes of *Kochia scoparia*. *Weed Biology and Management* 11: 224–234.

**Lehnhoff EA**, **Keith BK**, **Dyer WE**, **Menalled FD**. 2013. Does multiple herbicide resistance modify crop-weed competitive interactions? Impact of biotic and abiotic stresses on multiple herbicide resistant wild oat *(Avena fatua)* in competition with wheat *(Triticum aestivum)*. *PLoS ONE* 8(5): e64478.

**Lehnhoff EA**, **Keith BK**, **Dyer WE**, **Peterson RKD**, **Menalled FD**. 2013. Multiple herbicide resistance in wild oat and impacts on physiology, germinability, and seed production. *Agronomy Journal* 105: 854–862.

Mortensen DA, Egan JF, **Maxwell BD**, Ryan MR, Smith RG. 2012. Navigating a critical juncture for sustainable weed management. *BioScience* 61: 75–84.

Norsworthy JK, Riar D, **Jha P**, Scott RC. 2011. Confirmation, control, and physiology of glyphosate-resistant giant ragweed in Arkansas. *Weed Technology* 25: 430–435.

### Rangeland Weed Management and Restoration

Fansler VA, **Mangold JM**. 2011. Restoring native plants to crested wheatgrass stands. *Restoration Ecology* 19: 16 –23.

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**Lehnhoff EA**, **Menalled FD**, **Rew LJ**. 2011. Tamarisk *(Tamarix* spp.) establishment in its most northern range. *Invasive Plant Science and Management* 4: 58–65.

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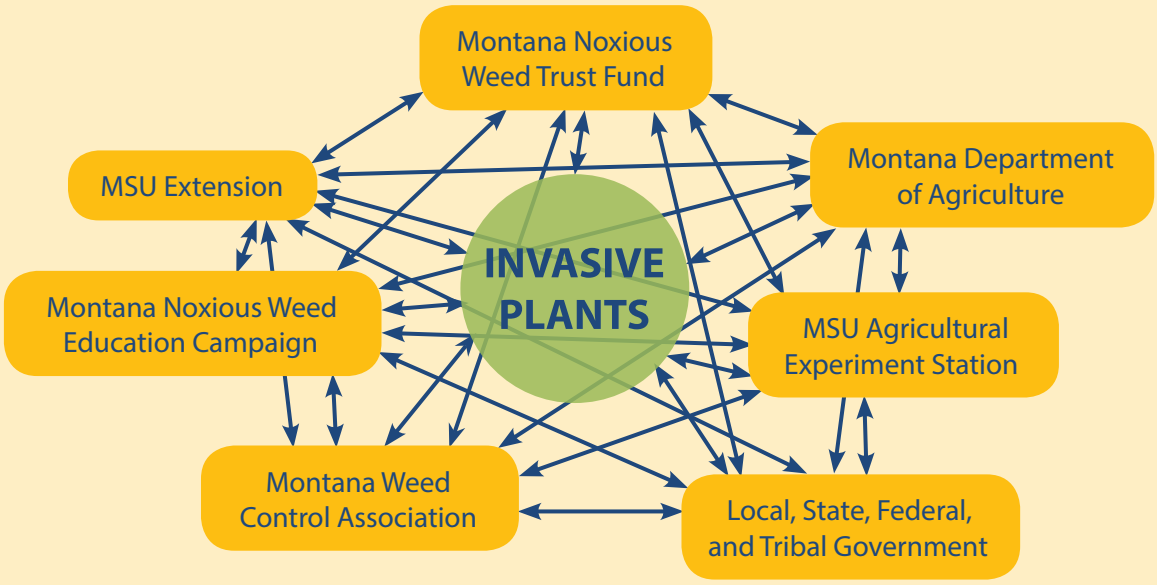
## RESEARCH AND EDUCATIONAL PARTNERSHIPS:
### WORKING TOGETHER TO IMPROVE INVASIVE SPECIES MANAGEMENT IN MONTANA

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*Compiled and designed by Emily Rindos, Center for Invasive Species Management.*