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

<table>
<thead>
<tr>
<th>Project Title, PI</th>
<th>2016</th>
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<tr>
<td><strong>Biological Control Development Projects</strong></td>
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<td>Biocontrol of Russian knapweed: Host testing and agent monitoring, Jeff Littlefield</td>
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<td>Continuing development of candidate agents for biological control of Russian olive, David Weaver</td>
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<td>Host screening of a new biocontrol agent for common tansy and oxeye daisy, Jeff Littlefield</td>
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<td>Host specificity testing of biocontrol agents of weedy mustards, Jeff Littlefield</td>
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<td>Host testing and field release of biocontrol agents for whitetop, Jeff Littlefield</td>
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<td>Host testing of a gall wasp for the biocontrol of invasive hawkweeds, Jeff Littlefield</td>
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<td>Candidate agents for biocontrol of Russian olive, David Weaver and Sharlene Sing</td>
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<td>Mass rearing, release, and monitoring of the northern tamarisk leaf beetle a biological control agent for saltcedar, David Weaver</td>
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<td><strong>Research Projects</strong></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>Addressing challenges posed by yellow, Dalmatian, and hybrid toadflax using integrated approaches that support biological control, David Weaver and Sharlene Sing</td>
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<td>Effect of perennial grass seeding date on revegetation outcomes in weed-infested range and pasture, Jane Mangold and Zach Miller</td>
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<td>Effect of herbicide application and soil texture on hoary alyssum seed biology and control, Jane Mangold, Stacy Davis, and Brad Bauer</td>
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<tr>
<td>Impacts of invasive annual grasses on forage, biodiversity, and litter decomposition rates, Jane Mangold, Lisa Rew and Kate Fuller</td>
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<tr>
<td>Increasing herbicide and biocontrol options for integrated toadflax management, David Weaver</td>
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<tr>
<td>Integrated management of dense cheatgrass on productive rangelands, Lisa Rew, Jane Mangold, and Erik Lehnhoff</td>
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<tr>
<td>Mitigating priority effects of invasive plants during revegetation by altering perennial glass planting date, Jane Mangold and Zach Miller</td>
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</tbody>
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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%)

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2016–2018

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<td>Keeping it fresh: Revising weed publications, Jane Mangold</td>
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<tr>
<td>Montana Noxious Weed Education Campaign, Jane Mangold and Shantell Frame-Martin</td>
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<td>Noxious weeds survey: Has 20+ years of weed education been effective?, Mangold, Shantell Frame-Martin and Eric Raile</td>
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<td>Local Cooperative</td>
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<td>Rock Creek Cooperative Weed Management Project, Tracy Mosley</td>
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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

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
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

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).
IMPACTS 2016–2018

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.


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.


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

More at next page
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 by 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.

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

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.

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

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)

Barley is seen in a Montana field in this MSU photo.
EDUCATION IMPACTS 2016–2018

MSU EXTENSION

MSU Extension Agents Contributing to Weed Education

Juli Thurston, Sanders County • Josh Bilbao, Gallatin County
Wendy Becker, Fort Peck Reservation • Danielle Harper, Wibaux County
Dave Brink, Mineral County • Emily Standley, Fergus County
Tim Fine, Richland County • Shylea Wingard, Hill County
Molly Hammond, Big Horn County • Katie Hatlelid, Judith Basin County
Melissa Ashley, Rosebud and Treasure Counties • Marc King, Sweet Grass County
Allison Kosto, Broadwater County • Callie Cooley, Yellowstone County
Ben Hauptman, Granite County • Pat McGlynn, Flathead County
Rose Malisani, Cascade County • Marko Manoukian, Phillips County
Jerry Marks, Missoula County • Patrick Mangan, Ravalli County
Wendy Wedum, Pondera County • Brent Sarchet, Lewis and Clark County
Shelley Mills, Valley County • Tracy Mosley, Park County • Ken Nelson, McConaught County • Kim Suta, Toole County • Jodi Pauley, Powell County
Inga Hawbaker, Daniels County • Mary Rumph, Powder River County
Sharla Sackman, Prairie County • Brent Roeder, Teton County
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
Jessica Murray, Beaverhead County • Elin Kittelmann, Fallon and Carter Counties • Kerry Taylor, Madison and Jefferson Counties
Jeff Chilson, Roosevelt County • Lee Schmelzer, Stillwater County
Brent Roeder, Teton County • Mandie Reed, Wheatland County

PESTICIDE EDUCATION DELIVERED 2018

WEED MANAGEMENT CONSULTATIONS (ACRES) 2018

Crop land 307,225 ............ 60%
Non-crop land 197,230 ............ 39%
Small acreage 7,060 ............ 1%

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

MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH

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


HERBICIDE RESISTANCE


Dyer W, Burns EE, 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.


INTEGRATED PEST MANAGEMENT


RANGELAND WEED MANAGEMENT AND RESTORATION


**WEED BIOCONTROL**


**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).


**THeses and Dissertations**


**RESEARCH AND EXTENSION PUBLICATIONS 2016–2018**


**WEED MANAGEMENT EXTENSION PUBLICATIONS**

**TARGET WEEDS**


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


**OUTREACH PUBLICATIONS**


Continued on next page


OUTREACH PRODUCTS


RESEARCH AND EDUCATIONAL PARTNERSHIPS:

WORKING TOGETHER TO IMPROVE INVASIVE SPECIES MANAGEMENT IN MONTANA

- Montana Noxious Weed Trust Fund
- Montana Department of Agriculture
- MSU Extension
- Montana Noxious Weed Education Campaign
- Montana Private Applicator Program
- Montana Noxious Weed Control Association
- MSU Agricultural Experiment Station
- Local, State, Federal, and Tribal Government