

Report for the Montana Noxious Weed Management Advisory Council

JUNE 2021



Photo of houndstongue

Montana State University
Montana Agricultural Experiment Station and Extension

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 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.

DEPARTMENTS INVOLVED WITH WEED RESEARCH AND EDUCATION

MONTANA AGRICULTURAL EXPERIMENT STATION

MSU EXTENSION

AGRICULTURAL ECONOMICS AND ECONOMICS

Kate Fuller, Extension Economist

ANIMAL AND RANGE SCIENCES

Craig Carr, Rangeland Ecology

Pat Hatfield, Range Sheep Nutrition

Jeff Mosley, Rangeland Ecology and Management

Bret Olson, Targeted Grazing

Cecil Tharp, Pesticide Education

LAND RESOURCES AND ENVIRONMENTAL SCIENCES

Edward Davis, Weed Management

Jeff Littlefield, Biological Control of Weeds

Jane Mangold, Integrated Invasive Plant Management

Bruce Maxwell, Agroecology

Fabian Menalled, Weed Ecology and Management

Noelle Orloff, Plant Diagnostics

Robert Peterson, Plant-Insect Interactions

Lisa Rew, Non-native Plant Ecology

Timothy Seipel, Plant Ecology

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

Barb Keith, Weed Molecular Biology

Matt Lavin, Botany

Ryan Thum, Aquatic Plant Genetics and Ecology

RESEARCH CENTERS

Clint Beiermann, Cropping systems (started July 2020)

Pat Carr, Cropping systems

Zach Miller, Plant Ecology

Lovreet Shergill, Weed Science (started July 2020)

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2018–2020

Project Title, PI	2018	2019	2020
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, Sharlene Sing	●	●	●
Host screening of a new biocontrol agent for common tansy and oxeye daisy, Jeff Littlefield	●	●	●
Host testing and field release of biocontrol agents for whitetop, Jeff Littlefield	●		
Rearing and release of the hoary cress gall mite and screening of a seed pod weevil, Jeff Littlefield			●
Host testing of a gall wasp for the biocontrol of invasive hawkweeds, Jeff Littlefield	●	●	●
Mass rearing, release, and monitoring of the northern tamarisk leaf beetle, a biological control agent for saltcedar, David Weaver, Sharlene Sing, Alex Gaffke	●	●	●
Research Projects			
Developing monitoring protocols for evaluating weed management outcomes, Lisa Rew and Jane Mangold			●
Effect of perennial grass seeding date on revegetation outcomes in weed-infested range and pasture, Jane Mangold and Zach Miller		●	
New solutions for old problems: identifying the best available biological and chemical and control options for the integrated management of invasive toadflaxes, David Weaver, Sharlene Sing	●	●	●
Stopping a wave of invasion: controlling cheatgrass, encouraging desired vegetation, and preventing spread, Lisa Rew and Jane Mangold		●	
<i>Ventenata</i> in Gallatin County: Surveying, mapping, and evaluating chemical control, Jane Mangold and Lisa Rew		●	
Researching best strategies for managing baby's breath (<i>Gypsophila paniculata</i>) in hay field, waste areas, and CRP, Shelley Mills, Stone Tihista, Inga Hawbaker, Bobbie Roos, Connie Wittak, Jane Mangold		●	

Project Title, PI	2018	2019	2020
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? Jane Mangold, Shantell Frame-Martin and Eric Raile	●		
Local Cooperative Projects			
Rock Creek Cooperative Weed Management Project, Tracy Mosley	●		

FUTURE PLANS: 2021 MONTANA NOXIOUS WEED TRUST FUND GRANTS

(Recommended for FY22 Funding 08Mar2021)

BIOLOGICAL CONTROL DEVELOPMENT PROJECTS

- Continued mass rearing, release, and monitoring of the northern tamarisk leaf beetle: a biological control agent for saltcedar, *David Weaver*
- Continuing Development of Candidate Agents for Biological Control of Russian Olive, *David Weaver and Sharlene Sing*
- Continued host testing of a flea weevil on Russian knapweed, *Jeffrey Littlefield*
- Continued screening of biocontrol agents for Oxeye daisy and common tansy, *Jeffrey Littlefield*
- Continued host testing and release of biological control agents for invasive hawkweeds, *Jeffrey Littlefield*
- Rearing and release of the hoary cress gall mite and continued screening of agents by CABI, *Jeffrey Littlefield*

EDUCATION PROJECTS

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

RESEARCH PROJECTS

- New solutions for old problems: identifying the best available biological control options for management of invasive toadflaxes, *David Weaver and Sharlene Sing*
- Development and assessment of thistle rust (*Puccinia punctiformis*) to reduce Canada thistle (*Cirsium arvense*) in Montana's rangelands, *Tim Seipel*
- Multi-scale analysis of Ventenata control treatments on the Crow Reservation, *Jane Mangold and Scott Powell*

LOCAL COOPERATIVE PROJECTS WITH MSU EXTENSION COUNTY COOPERATORS

- Middle Fork CWMA, *Ben Hauptman*
- Douglas CWMA, *Ben Hauptman*
- Upper Valley CWMA, *Ben Hauptman*
- Upper Rock Creek Cooperative weed management area, *Dan Lucas*

EDUCATION IMPACTS

2018–2020

MSU EXTENSION

MSU Extension Education Promoting Healthy Plant Communities

While Private Applicator Training often comes to mind as Extension education to help address weed populations in Montana, MSU Extension provides much more to resource stewards to promote healthy plant communities. Despite challenges presented by COVID-19 during 2020, MSU Extension continued serving the needs of commercial agriculture producers, small acreage stewards, commercial and consumer horticulturalists, and residential homeowners.

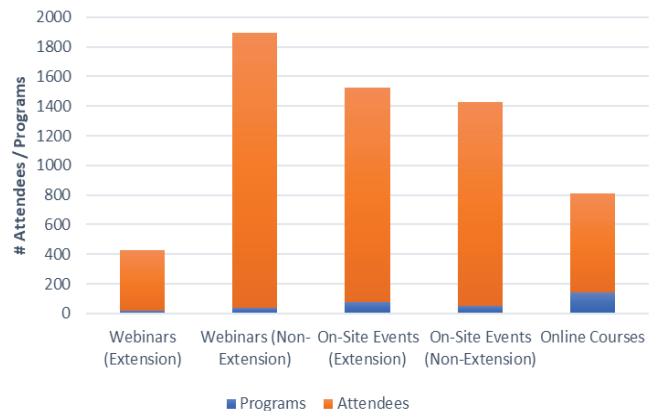
As documented by MSU County Agents across Montana, over 1,200 walk-in clients were served at MSU Extension offices with specific education about topics including pest identification, pest management options, methods to promote plant health, grazing systems designed for healthy rangelands, and more. In addition to walk-in clients, non-formal education in group settings including virtual and in-person delivery methods served over 110 commercial crop producers representing over 104,000 acres of cropland, over 370 rangeland livestock producers representing over 510,000 acres of range and pasture lands, and over 540 horticulture practitioners representing over 7,000 acres of yards and gardens.

Extension programs addressing healthy plant communities provided by field faculty across Montana are delivered in many ways. For example, Southeast Montana County Agents work together annually to bring a winter series of classes to crop and rangeland producers; small grain workshops are provided across the state to assist grain growers addressing pest challenges; Master Gardener courses are provided to assist horticulture enthusiasts learn best management practices for pests; and Rancher Roundtable programs and Annual Noxious Weed Management workshops are held across the state.

Positive impacts from MSU Extension education to promote healthy plant communities across Montana are designed, delivered, and evaluated to meet local needs and anticipate new local challenges. MSU Extension brings the resources of the entire Land Grant University System to each community to serve the people and places of Montana.

The Importance of the MSU Extension Pesticide Education Program

The MSU Extension Pesticide Education Program (PEP) serves as a hub for the certification and training of 5,500 private (farm) pesticide applicators. This program integrates 56 MSU county agents appointed as county Private Pesticide Training (PAT) coordinators,



one statewide MSU Pesticide Education Specialist, and multiple MSU Extension faculty to deliver information on weeds, insects, rodents, plant diseases, and a variety of pesticide core topics (i.e. pesticide safety, calibration and pesticide fate). During 2020, there were a total of 188 in-state sponsored private applicator events, with 96 MSU Extension and 92 non-MSU sponsored events approved to deliver private applicator credit information to 5,082 attendees. Almost all events are at least supported by MSU Extension guest speakers. By offering these in-state MSU Extension credit opportunities thousands of private applicators retain access to highly effective chemistries, thus saving the agricultural industry millions of dollars through proper management of pests.

Weed Management Consultations (acres) 2020

Crop land, 110 consultations covering

113,090 acres18%

Pasture and Rangeland, 366 consultations covering

528,060 acres81.5%

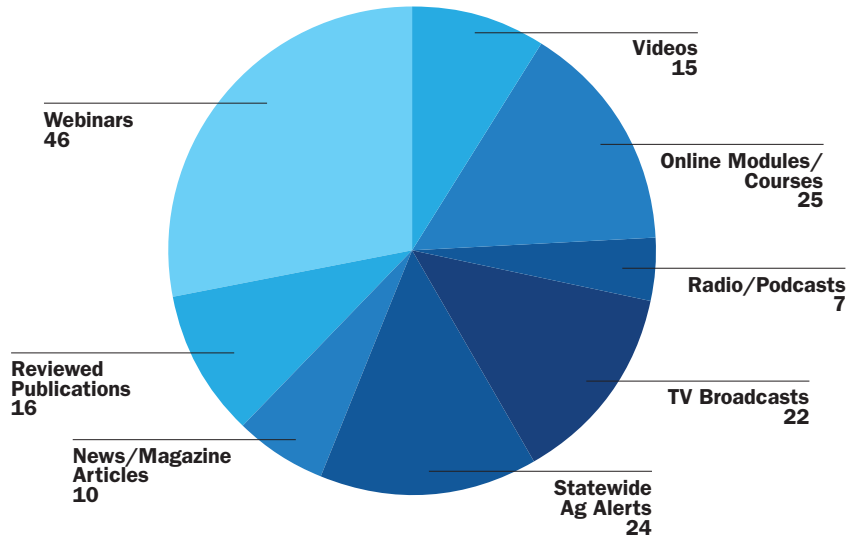
Small acreage/Horticulture, 544 consultations covering

2,490 acres.....2%

MSU Extension Agents Contributing to Weed Education

Juli Thurston, Sanders County · Wendy Becker, Fort Peck Reservation · Danielle Harper, Wibaux County · Dave Brink, Mineral County · Emily Standley, Fergus County · Tim Fine, Richland County · Colleen Buck, Hill County · Molly Masters, 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, Missoula County · Adrienne Good, Pondera County · Eric Miller, Garfield County · Shelley Mills, Valley County · Ken Nelson, McCone County · Kim Woodring, Toole County · Robert Walker, Powell County · Inga Hawbaker, Daniels County · Mary Rumph, Powder River County · Sharla Sackman, Prairie County · Mat Walter, Lewis and Clark County · Mike Schuldt, Custer County · Jennifer Solf, Musselshell and Golden Valley Counties · Jack Stivers, Lake County · Jessica Murray, Beaverhead County · Kaleena Miller, Madison and Jefferson Counties · Verna Billadeaux, Blackfeet Reservation · Nikki Bailey, Carbon County · Tyler Lane, Chouteau County · Kimberly Richardson, Deer Lodge County · Elizabeth Werk, Fort Belknap Reservation · Kari Lewis, Glacier County · Jesse Fulbright, Liberty County · Josh Bilbao, Park County · Jeff Chilson, Roosevelt County · Lee Schmelzer, Stillwater County · Mandie Reed, Wheatland County



MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH

Montana State University Extension Agriculture & Natural Resources: Meeting Public Needs During COVID-19

MSU Extension agricultural & natural resource faculty have adapted to the pandemic to meet the critical needs of agricultural clientele by using innovative educational platforms. From webinars to deliver pesticide education credits to individuals at home, to significantly increasing the access of information with webinars, videos, online courses, TV appearances, or publications that can be downloaded or ordered. Since the stay at home order, MSU Extension agricultural & natural resource faculty have delivered 46 webinars, 24 PDIS-Ag Alerts, 25 online courses, 7 radio news/podcasts, 22 TV appearances (i.e. Montana Ag. Live; Fox News) and created 15 videos in only 9 months (Figure 1). MSU Extension Specialists have also received three national awards, two regional awards and one statewide award in recognition of their education/outreach efforts during this difficult period. These resources and faculty are critical to serving the agricultural & natural resource industry during the pandemic and demonstrates the resourcefulness of MSU Extension Ag & NRS faculty.

Weed programming was also provided in other cropland weeds. Palmer amaranth and water hemp are both herbicide-resistant weeds common in the Midwest. The cropland weeds MSU Extension team lead by Tim Seipel has been educating Montana’s ag professionals about the threat through in-person meetings, field visits, Extension bulletins, news media, and virtual presentations. Through leadership, Palmer amaranth was added to the restricted seeds list in Montana, and producers were made aware to help divert Palmer amaranth-contaminated millet seed from being planted in southeastern Montana.

This effort helped prevent establishment, saving Montana ag producers potentially large sums of money. The group will continue to help educate and prevent establishment of these weeds.

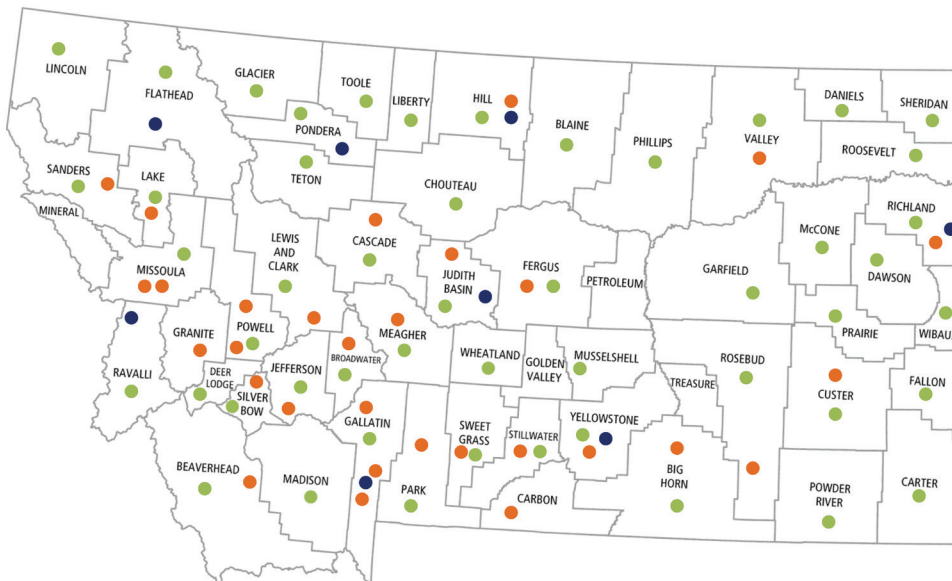
Weed Programs delivered (2020).....	69
Individuals reached (2020).....	4619

Undergraduate and Graduate Level Courses

- AGSC 401: Integrated Pest Management
- AGSC 454: Agrostology
- BIOO 435: Plant Systematics
- 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
- NRSM 102: Montana Range Plants
- NRSM 350: Vegetation of Western Wildlands
- NRSM 351: Biomes of Western Wildlands
- NRSM 353: Grazing Ecology and Management
- NRSM 453: Habitat Inventory and Analysis
- PSPP 546: Herbicide Mode of Action

Noxious Weed Manager Training

Noxious Weed Management Certification Program: Levels 1 through 3, one level offered annually.



- MSU MAES Research Centers
- Off-campus MSU weed education locations 2020
- Counties which submitted plant sample(s) to MSU Schutter Diagnostic Lab in 2020

MSU Schutter Diagnostic Lab Weed Activities

Weed samples identified (2020) 437
 Programs delivered (2020) 8
 Individuals reached (2020) 550
 MT Counties sending in samples (2020) 50

PARTICIPATION

8 in-person workshops/presentations | **5** virtual workshops/presentations

1 Outreach poster created | **1** field guide updated

41 Days Spent Collecting

357 Collection Day Participants

22,037 Miles Traveled For Workshops and Collections

INSECTS

9 species released | **8** species collected

10,117 Acres Treated

107 sites monitored | **36** counties received insects

11 States Received Insects

1,213,900 Insects Distributed

\$342,350 Market Value of insects

2020 BREAKDOWN

8% Out of State Coordination

15% Fundraising

44% Collections and Monitoring

10% Education

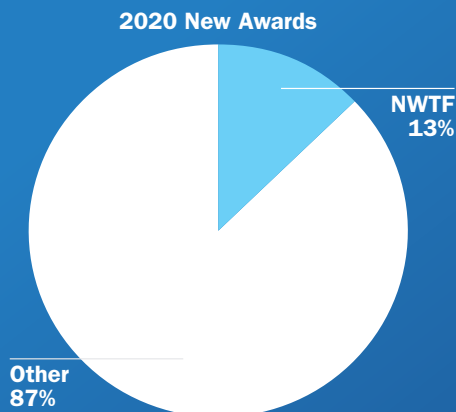
23% In-state Coordination

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

MSU WEED PROJECT FUNDING 2018–2020



2020 New Awards

Noxious Weed Trust Fund \$289,383	13%
Other Sources \$1,855,066	87%

2019 New Awards

Noxious Weed Trust Fund \$351,151	41%
Other Sources \$501,802	59%

2018 New Awards

Noxious Weed Trust Fund \$312,217	11%
Other Sources \$2,566,908	89%

OTHER FUNDING SOURCES FOR WEED RESEARCH AND EDUCATION, 2018–2020

National

U.S. DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service · Forest Service · National Institute of Food & Agriculture · Western SARE

U.S. DEPARTMENT OF DEFENSE

Army Research Office

U.S. DEPARTMENT OF THE INTERIOR

Bureau of Indian Affairs · Bureau of Land Management · U.S. Fish and Wildlife Service · National Park Service

INDUSTRY

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

Bair Ranch Foundation · 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 (MN) · 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

COLLABORATORS

Agriculture and Agri-Foods Canada
 BBKA 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 NRCS
 USDI Bureau of Land Management

TARGET WEEDS

Canada thistle (*Cirsium arvense*)
 Cheatgrass (*Bromus tectorum*)
 Crested wheatgrass (*Agropyron cristatum*)
 Common tansy (*Tanacetum vulgare*)
 Dalmatian toadflax (*Linaria dalmatica*)
 Desert allyssum (*Alyssum desertorum*)
 Douglas fir (*Pseudotsuga menziesii*)
 Field bindweed (*Convolvulus arvensis*)
 Houndstongue (*Cynoglossum officinale*)
 Juniper (*Juniperus* spp.)
 Leafy spurge (*Euphorbia esula*)
 Orange hawkweed (*Hieracium aurantiacum*)

Target Weeds, continued:

Oxeye daisy (*Leucanthemum vulgare*)
Narrowleaf hawkbeard (*Crepis tectorum*)
Palmer amaranth (*Amaranth palmeri*)
Perennial pepperweed (*Lepidium latifolium*)
Ponderosa pine (*Pinus ponderosa*)
Rush skeletonweed (*Chondrilla juncea*)
Russian knapweed (*Acroptilon repens*)
Russian olive (*Elaeagnus angustifolia*)
Saltcedar (*Tamarix* spp.)
Smooth brome (*Bromus inermis*)
Spotted knapweed (*Centaurea stoebe*)
St. Johnswort (*Hypericum perforatum*)

Sulfur cinquefoil (*Potentilla recta*)
Tall buttercup (*Ranunculus acris*)
Tansy ragwort (*Senecio jacobaea*)
Ventenata (*Ventenata dubia*)
Whitetop (*Cardaria draba*)
Wild oat (*Avena fatua*)
Yellow toadflax (*Linaria vulgaris*)

RESEARCH PUBLICATIONS 2018–2020

Journal articles and invited book chapters. **Bold type** denotes MSU faculty, staff, and graduate students contributing to the work.

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 EE, 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, Talbert L. 2018. Non-target site resistance to flucarbazone, imazamethabenz, and pinoxaden is controlled by three linked genes in *Avena fatua* L. *Weed*

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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, Stahman P W. 2018. Herbicide-Resistant Kochia (*Bassia scoparia*) in North America: A Review. *Weed Science* 67(1), 4-15.

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.

Scherrer, B, Sheppard, J, Jha, P, Shaw, J. 2019. Hyperspectral imaging and neural networks to classify herbicide-resistant weeds. *Journal of Applied Remote Sensing (SPIE)*, 13(4), 044516.

INTEGRATED PEST MANAGEMENT

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- Briar, SS, **Carr, PM**, Miller, GG, **Menalled, F, Miller, PR.** 2019. Current status and soil biology impacts of organic conservation tillage in the U.S. Great Plains. In C. Sarath Chandran, S. Thomas, and M.R. Unni (Ed.), *Organic Farming: New Advances Towards Sustainable Agricultural Systems* (pp. 11-23). New York NY: Springer International Publishing AG. eBook.
- 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.
- Ishaq, S, Seipel, TF, Yeoman, C, Menalled, F.** 2020. Dryland cropping systems, weed communities, and disease status modulate the effect of climate conditions on wheat soil bacterial communities. *mSphere*, 5(4).
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- Peterson R,** Higley LG, Pedigo LP. 2018. Whatever happened to IPM? *American Entomologist*, 64, 146-150.
- Sainju, U, Ragen, DL, **Hatfield, P.** 2020. Sheep grazing to control weeds enhances soil carbon, not nitrogen. *Soil Research*. www.publish.csiro.au/journals/sr
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- Bailey DW, **Mosley JC**, Estell RE, Cibils AF, Horney M, Hendrickson JR, Walker JW, Launchbaugh KL, Burritt EA. 2019. Synthesis Paper--Targeted Livestock Grazing: Prescription for Healthy Rangelands. *Rangeland Ecology and Management*, 72, 865-877.
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- Ehlert K, Mangold J, Menalled F, Miller Z.** 2019. Seeding, herbicide, and fungicide impact on perennial grass establishment in cheatgrass infested habitats. *Ecological Restoration*, 37, 67-70.
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- Yonk, RM, **Mosley, JC**, Husby, PO 2020. Native American influences on the Northern Yellowstone Range--A Reply. *Rangelands*, 42(3), 80-82.

WEED BIOCONTROL

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WEED BIOLOGY AND ECOLOGY

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- date on establishment and subsequent ability to resist invasion by *Bromus tectorum* (cheatgrass). *Ecological Restoration*, 38, 145-152.
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- Ringelberg, JJ, Zimmermann, NE, Weeks, A, **Lavin, M**, Hughes, CE. 2020. Biomes as evolutionary arenas: Convergence and conservatism in the trans-continental succulent biome. *Global Ecology and Biogeography*, 29(7), 1100-1113. <https://onlinelibrary.wiley.com/doi/full/10.1111/geb.13089>
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- Thum R**, McNair JN. 2018. Inter- and intraspecific hybridization affects vegetative growth and invasiveness in Eurasian watermilfoil. *Journal of Aquatic Plant Management*, 56, 24-30.

GRADUATE STUDENTS TRAINED 2018–2020

- 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 Monument." MS Thesis. Major Advisor: Clayton Marlow.
- Bhandari R**. 2020. "Assessment of Host Selection Behaviors and Oviposition Preferences of *Cephus cinctus* Norton (Hymenoptera: Cephidae) Using Wheat and Smooth Brome." MS Thesis. Major Advisors: Tracy Sterling & David Weaver.
- Dagati, K**. 2020. Long Term Multispecies Cover Crops in Semi-Arid Montana: Soil Response and Aboveground Biomass." MS Thesis. Major Advisors: Perry Miller and Cathy Zabinski.
- Davis S**. 2019. "The Role of Canopy Tree diversity on Understory Plant Richness and Tree Seedling Abundance in a *Pinus Strobus* Forest in the Southeastern US." MS Professional Paper. Instructor: Lisa Rew.
- Dillard S**. 2019. "Restoring Semi-Arid Lands with Microtopography." MS Thesis. Major Advisor: Tony Hartshorn.
- Douglas J**. 2019. "Toward 'Hypertemporal' Remote Sensing of Plant Function: A Comparison of Phenocams and Goes NDVI Data Products." MS Professional Paper. Instructor: Paul Stoy.
- Dupre, ME**. 2020. "Integrating Cover Crop Mixtures in the Northern Great Plains An Ecological Assessment on Crop Productivity, Biodiversity, and Temperature and Moisture Conditions." MS Thesis. Major Advisors: Fabian Menalled & Tim Seipel.
- 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.
- Harvey A**. 2019. "Understanding the Biology, Ecology, and Integrated Management of *Ventenata dubia*." MS Thesis. Major Advisor: Jane Mangold.
- Hauptman, B**. 2020. "Effectiveness of pre-emergent herbicide indaziflam on the restoration of cheatgrass (*Bromus tectorum*)

- infested rangelands in Montana.” MS Professional Paper. Instructor: Jane Mangold.
- Lim, CA.** 2020. “Management of Kochia (*Bassia scoparia*) in a Time of Herbicide Resistance”, PhD Plant Science. Major Advisors: Prashant Jha and William Dyer.
- Majeski, M.** 2020. “Understanding Mechanisms of Invasion and Restoring Lands Impacted by Non-native Annual Grasses.” MS Thesis. Major Advisor: Jane Mangold.
- Malone, S.** 2020. “Soil legacy effects alter plant volatile emissions in response to diversified cropping systems.” MS Thesis. Major Advisor: David Weaver.
- Massey J.G.** 2019. “Soil Restoration and Invasive Plants at the Block P Mill and Tailings Site, MT.” Major Advisor: Bill Kleindl.
- Morford-Graziano, D.** 2019. “The Impact of Elevation on Biodiversity in Mountain Ecosystems.” MS Professional Paper. Instructor: Lisa Rew.
- Nixon, M.** 2020. “Pest Management Challenges and Climate Change in Water Limited Winter Wheat Agroecosystems in Southwest Montana.” MS Thesis. Major Advisor: Fabian Menalled.
- Payne J.** 2018. “Can Targeted Cattle Grazing Increase Abundance of Forbs or Arthropods in Sage-Grouse Brood-Rearing Habitat?” MS Thesis. Major Advisor: Jeffrey Mosley.
- Peppel L.** 2019. “Native Shrub dynamics at Restoration Plots in the Southern San Joaquin Valley, CA.” MS Professional Paper. Instructor: Scott Powell.
- Supplee, H.** 2020. “The Impact of Recreational Hunting on Exotic Plant Invasion through the Control of White-tailed Deer (*Odocoileus virginianus*) Populations in Northern Pennsylvania.” MS Professional Paper. Instructor: Slominski.
- Walaszczyk, E.** 2020. “The application of remote sensing for monitoring vegetation disturbance and reclamation for Appalachian surface mines: A case study on the Fola Mining Complex in West Virginia.” MS Professional Paper. Instructor: Scott Powell.
- Williams, A.** 2020. “Relationship Between the Presence of Yellow Toadflax (*Linaria vulgaris*) and Plant Species Richness Near West Yellowstone, MT.” MS Professional Paper. Instructor: Lisa Rew.

EXTENSION OUTREACH/PUBLICATIONS

2018–2020

TARGET WEEDS

- Davis S, Mangold J.** 2019. Rush skeletonweed (MT201902AG ed., pp. 2). Bozeman: Montana State University Extension. [Rush skeletonweed \(msuextension.org\)](https://www.msu.edu/doc/extension/201902AG-edition-rush-skeletonweed.pdf)
- Frame-Martin S, Mangold J.** 2020. Invasive Grasses in Montana. Montana Noxious Weed Awareness Campaign.
- Fulbright J, Good A, Jha P, Lewis KL, Lane T, Roeder BL, Lamb P.** 2018. *Russian Thistle - Herbicide-Resistant Plants* (201816AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. <https://store.msuextension.org/publications/AgandNaturalResources/MT201816AG.pdf>
- Goodwin K, Graves-Medley M, Mangold J.** 2018. *Identification, biology, and ecology of whitetop* (pp. 11). Bozeman, MT: Montana State University Extension. [Biology, Ecology and Management of Whitetop \(msuextension.org\)](https://www.msu.edu/doc/extension/Biology_Ecology_and_Management_of_Whitetop.pdf)
- Harvey A, Mangold J.** 2018. *Venttenata* (pp. 2). Bozeman, MT: Montana State University Extension. [Venttenata \(msuextension.org\)](https://www.msu.edu/doc/extension/Venttenata.pdf)
- Lane T, Jha P, Kittelmann E, Lewis KL, Roeder BL, Fulbright J, Good A.** 2018. *Downy Brome - Herbicide-Resistant Plants* (201814AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. [Downy Brome \(msuextension.org\)](https://www.msu.edu/doc/extension/Downy_Brome_Herbicide-Resistant_Plants.pdf)
- Lavin MT, Mangold J.** 2019. In Katie Gibson and Whitney Tilt (Ed.), *Montana Grasses App*. Bozeman Montana: High Country Apps. <http://highcountryapps.com/MontanaGrasses.aspx>
- Lewis KL, Jha P, Lane T, Fulbright J, Good A, Roeder BL.** 2018. *Kochia - Herbicide-Resistant Plants* (201806AG ed., pp. 2). Bozeman, MT: Montana State University Extension Publications. [MT201806AG.pdf \(msuextension.org\)](https://www.msu.edu/doc/extension/201806AG-edition-kochia-herbicide-resistant-plants.pdf)
- Mangold, J.** 2020. Identifying Invasive Annual Grasses in Montana Video – Integrated Pest Management Series: <https://www.youtube.com/watch?v=if2wKRfdWYY>
- Mangold J, Graves M, Jacobs J.** 2018. *Biology, ecology, and management of blueweed* (pp. 11). Bozeman, MT: Montana State University Extension. [Biology, Ecology and Management of Blueweed \(msuextension.org\)](https://www.msu.edu/doc/extension/Biology_Ecology_and_Management_of_Blueweed.pdf)
- Orloff LN.** 2020. *Hoary alyssum identification Video*. <https://www.youtube.com/watch?v=jncJBTXeREc>.
- Orloff LN.** 2020. *Roving bellflower identification Video*. <https://www.youtube.com/watch?v=xSN-AuMvnV4>
- Orloff LN.** 2020. *White bryony identification Video*. <https://www.youtube.com/watch?v=6571nXVOWuk>.

- Orloff LN, Mangold J.** 2018. *Dyer's Woad* (MT201820AG ed., pp. 2). [Dyer's Woad \(msuextension.org\)](http://www.msuiextension.org/Dyers-Woad)
- Orloff LN, Mangold J.** 2018. *Medusahead* (MT201804AG ed., pp. 2). Bozeman, MT: [MSU MT201802AG.pdf \(msuextension.org\)](http://www.msuiextension.org/MSU-MT201802AG.pdf)
- Parkinson H, Mangold J.** 2018. *Plant Identification Basics* (pp. 8). Bozeman, MT: Montana State University Extension. [Plant Identification Basics \(msuextension.org\)](http://www.msuiextension.org/Plant-Identification-Basics)
- Parkinson H, Mangold JM, Menalled FM, Orloff LN.** 2019. *Weed Seedling Identification Guide for Montana and the Northern Great Plains* (EB0215 ed., pp. 167). Bozeman, Montana: Montana State University Extension. [Weed Seedling Identification Guide for Montana and the Northern Great Plains - Montana State University Extension \(msuextension.org\)](http://www.msuiextension.org/Weed-Seedling-Identification-Guide-for-Montana-and-the-Northern-Great-Plains-Montana-State-University-Extension)
- Seipel, TF, Mangold, JM, Fine, T, Pokorny, M, Orloff, LN.** 2020. *Palmer amaranth (Amaranthus palmeri)* (MT202011AG ed., pp. 4). Bozeman, MT: Montana State University Extension. [Palmer amaranth \(msuextension.org\)](http://www.msuiextension.org/Palmer-amaranth)

INTEGRATED PEST MANAGEMENT

- Brink D, Burch D, Frame-Martin SA, 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.msuiextension.org/publications/AgandNaturalResources/EB0227.pdf>.
- Davis S, Mangold J.** 2019. *Managing weeds after wildfire* (vol. EB0230, pp. 27). Bozeman, MT: Montana State University Extension. [Managing Weeds After Wildfire \(msuextension.org\)](http://www.msuiextension.org/Managing-Weeds-After-Wildfire)
- Eilers SE, Grimme E, Kerzicnik LM, Orloff LN, Day T, Palmer D.** 2018, 2019 *Calendar - Pests in the Garden*. Bozeman, MT: Montana State University Extension.
- Eilers, SE, Grimme, E, Kerzicnik, LM, Orloff, LN, Palmer, D.** 2020. *2021 Calendar - Urban IPM Calendar*. Bozeman, MT: Montana State University Extension.
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- Mangold J, Orloff LN.** 2020. *Plants Poisonous to Livestock in Montana and Wyoming* (Plant Materials Technical Note MT-124 ed., pp. 43). Bozeman, Montana: USDA-NRCS, Bozeman State Office. [Plants Poisonous to Livestock in Montana and Wyoming \(usda.gov\)](http://www.usda.gov/Plants-Poisonous-to-Livestock-in-Montana-and-Wyoming)
- Mosley J, Barta S, Frost R, Standley EN, 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.
- Orloff LN.** 2020. In Jane Mangold (Ed.), *Hairy Cat's Ear (Hypochaeris radicata)*. Monthly Weed Post. <http://www.msuiextension.org/extension/monthly-weed-posts/202001mwp-january-hairy-cats-ear.html>.
- Orloff LN.** 2020. In Jane Mangold (Ed.), *Managing Canada Thistle in Lawns*. <http://www.msuiextension.org/extension/monthly-weed-posts/202008mwp-managing-canada-thistle-in-lawns.html>.

- Orloff LN.** In Jane Mangold (Ed.), 2020. *Non-Target Herbicide Injury on Plants*. Monthly Weed Post. <http://www.msuiextension.org/extension/monthly-weed-posts/202011mwp-non-target-herbicide-injury.html>.
- Orloff LN, Mangold J, Seipel TF.** 2020. *A Guide to Diagnosing Non-Target Herbicide Injury on Plants* (EB0232 ed., pp. 38). Bozeman, Montana: Montana State University Extension. <https://www.msuiextension.org/pubs/herbicideinjuryguide/index.html>.
- Pokorny M, Mangold JM.** 2020. *Montana's Noxious Weeds*. (EB0159). Bozeman, Montana: [Montana State University Extension. Montana's Noxious Weeds by MSU Extension - Issuu](http://www.msuiextension.org/Montana-s-Noxious-Weeds-by-MSU-Extension-Issuu)
- Seipel TF.** 2020. *Managing Herbicide Resistance Video - Integrated Pest Management Series*: <https://www.youtube.com/watch?v=W-fmszwSCcg4>

PESTICIDE EDUCATION

- Bowser A, Tharp C.** 2019. *Understanding Herbicide Contaminated Soil Amendments: For Greenhouses, Nurseries, and Home Gardens*. (SKU4628, 6 pages). Bozeman, MT: MSU Extension. [Understanding Herbicide Contaminated Soil Amendments for Greenhouses, Nurseries and Home Gardens \(msuextension.org\)](http://www.msuiextension.org/Understanding-Herbicide-Contaminated-Soil-Amendments-for-Greenhouses-Nurseries-and-Home-Gardens)
- Bowser A, Tharp CI.** 2020. *Understanding Pesticide Drift and Drift Reduction Strategies*. In MSU Extension Publications (Ed.), *No* (EB0233 ed., vol. EB0233, pp. 15). Bozeman, MT: MSU Extension Publications. [Understanding Pesticide Drift and Drift Reduction Strategies \(msuextension.org\)](http://www.msuiextension.org/Understanding-Pesticide-Drift-and-Drift-Reduction-Strategies)
- Tharp CI.** 2019. *Montana Pesticide Recordkeeping Manual* (EB0158A ed., 50 pages). Bozeman: MSU Extension Publications. [Pesticide Record Keeping Handbook and Calibration Guide for Private Applicators - Montana State University Extension \(msuextension.org\)](http://www.msuiextension.org/Pesticide-Record-Keeping-Handbook-and-Calibration-Guide-for-Private-Applicators-Montana-State-University-Extension)
- Tharp CI.** 2020. *Calibrating Spray Equipment Using Short-Cut Methods* - [Integrated Pest Management Series: Calibrating Pesticide Application Equipment - YouTube](http://www.msuiextension.org/Integrated-Pest-Management-Series-Calibrating-Pesticide-Application-Equipment-YouTube)
- Tharp CI.** 2020. *The Quick and Simple Way to Calibrate Boom Sprayers* - [Integrated Pest Management Series: The Quick and Simple Way to Calibrate Boom Sprayers - YouTube](http://www.msuiextension.org/Integrated-Pest-Management-Series-The-Quick-and-Simple-Way-to-Calibrate-Boom-Sprayers-YouTube)
- Tharp CI, Bowser A.** 2018. *Understanding Integrated Pest Management Video* - [Integrated Pest Management Series: Integrated Pest Management - YouTube](http://www.msuiextension.org/Integrated-Pest-Management-Series-Integrated-Pest-Management-YouTube)
- Tharp CI, Bowser A.** 2019. *Cold Weather Storage and Handling of Pesticides*. MSU Extension MontGuide (MT201801AG ed., pp. 6). [MT201801AG.pdf \(msuextension.org\)](http://www.msuiextension.org/MT201801AG.pdf)
- Tharp C, Bowser A.** 2020. *Montana Private Pesticide Certification Addendum*. (4509AD) [Montana Private Pesticide Certification Addendum \(msuextension.org\)](http://www.msuiextension.org/Montana-Private-Pesticide-Certification-Addendum)
- Tharp CI, Bowser AJ, Vantassel S, Wanner K.** 2019. *Montana Non-Soil Fumigant Manual for Private Applicators* (pp. 50 pages). Bozeman: MSU Extension. [Non-Soil Agricultural Fumigation Manual for Private Applicators - Montana State University Extension \(msuextension.org\)](http://www.msuiextension.org/Non-Soil-Agricultural-Fumigation-Manual-for-Private-Applicators-Montana-State-University-Extension)

IMPACT STORIES

MSU WEED SPECIALIST RECEIVES NATIONAL AWARD

montana.edu (click for full story)



A Montana State University professor and [MSU Extension](#) specialist was recognized with a national award by the [Weed Science Society of America](#) for her excellence in outreach.

[Jane Mangold](#), a professor in the [Department of Land Resources and Environmental Sciences](#) in MSU's [College of Agriculture](#), received the WSSA's Outstanding Extension Award

at the society's virtual annual meeting in February 2020. She was nominated by scientists and weed control specialists from around the university and state.

"I continue to be impressed with the energy and innovation Jane commits to her responsive and strong programming in weed science," said Tracy Sterling, head of the Department of Land Resources and Environmental Sciences. "She has truly integrated her research and Extension programming, which allows her to create relevant educational programs built upon her research questions."

Mangold, who has been a part of the MSU faculty since 2008, leads MSU's [Integrated Invasive Plant Management Group](#) and has presented at nearly 400 Extension programs across all 56 Montana counties. In addition to community education programs through Extension, she researches ecology and the management of invasive plants. Between Extension and research grants, she has managed more than \$4 million in funding since she arrived at MSU.

MSU EXTENSION HOSTED CROPPING SEMINARS JANUARY 2021 IN THE GOLDEN TRIANGLE

montana.edu (click for full story)

[Montana State University Extension](#) broadcast its annual cropping seminar series in January 2021 at several locations in the Golden Triangle. Speakers discussed grasshopper control, antagonistic effects of herbicides, management of herbicide-resistant weeds, and farm and ranch safety and more.

Viewing locations for the free seminars were in Chester, Choteau, Conrad, Cut Bank, Denton, Fort Benton, Great Falls, Havre and Shelby. Some locations hosted a live presenter at lunch. Both commercial and

private pesticide licensing recertification credits were available.

Speakers included: Gary Adams, state plant health director with the Animal and Plant Health Inspection Service, discussing the cooperative grasshopper and Mormon cricket suppression program, approved control methods for those species, and 2021 control programs; Tim Seipel, MSU Extension cropland weed specialist, examined antagonistic effects of herbicides and spoke specifically on tank mixing and important points to consider for herbicide chemistries; Lovreet Shergill, assistant professor of weed science at MSU's Southern Agricultural Research Center, presented "Management of Herbicide Resistant Weeds in Montana Cropping Systems," discussing integrated weed management tactics to manage problematic weeds such as kochia, Russian thistle, wild oats, prickly lettuce, sow thistle, Canada thistle and more; and Austin Grazier, director of agricultural safety with the Montana Agriculture Safety Program, covered farm and ranch safety while highlighting ATV safety.

MSU DOCTORAL STUDENT PRIORITIZES EXCELLENCE IN TEACHING WITH ENHANCEMENT GRANT

montana.edu (click for full story)



Colter Mumford, right, a second-year doctoral student advises a student in collecting samples during an intensive field study experience before the start of the Fall 2020 semester.

A Montana State University doctoral student is using a [Graduate School](#) grant to create the best possible learning environment for undergraduate students while integrating experiential field work with classroom pursuits and research projects.

Colter Mumford, a second year PhD student in the [Department of Land Resources and Environmental Sciences](#) in MSU's [College of](#)

[Agriculture](#), received one of 12 [Ph.D. Enhancement Grants](#) for the 2020-2021 academic year. The funding is for graduate students to gain teaching experience, improve teaching skills and pursue activities that improve academic engagement.

A Kalispell native, Mumford received his bachelor's in conservation biology and ecology from MSU's [Department of Ecology](#) in 2017. He began teaching in 2019 and found that it was one of his favorite parts of his graduate studies.

"Programs like these enhancement grants help to make sure that graduate students across our university are well-rounded, not only excelling in research but also growing into compelling and engaging educators and science communicators," said Tracy Sterling, professor and head of the Department of Land Resources and Environmental Sciences. "In doing that, we ensure success not only for those graduate students, but also for the next generation of scientists."

Mumford's work teaching during the 2020-2021 academic year began before the fall semester. He led a weeklong intensive field study in which 26 undergraduate and graduate students learned about the importance of biodiversity, practiced collecting field samples and addressed questions about various land use types. During that week the group visited agricultural, restoration and rangeland sites around Bozeman and collected their own research data, which they will continue to use for the rest of the semester – all while maintaining social distancing.

"The students are in the classroom for a couple hours each day during that week, then spend the rest of each day practicing sampling methods in the field," said Mumford. "It's a really great experience because we're able to demonstrate methodology in the field, the students collect data and then we bring it back and incorporate it into their work throughout the semester."

Many of the topics Mumford teaches are skills he uses in his own studies into the spread of cheatgrass in Montana's Centennial Valley. Working with mentor [Lisa Rew](#), his project partners with the [Nature Conservancy](#) and the [National Wildlife Refuge System](#) as well as local private landowners. Invasive cheatgrass is found most frequently on south-facing hillsides, which are critical habitat for sage grouse, said Mumford. The weed also threatens to cattle grazing acreage when it encroaches on existing forage grasses. Mumford's project examines the effectiveness of herbicide and reseeding treatments on areas affected by the grass. It also explores the general ecology and potential feedback cycles of the weed in Montana. In addition to the pre-semester field study, he is also helping teach a 130-student first-year environmental science course.

MSU RESEARCHERS STUDY HOW WEEDS BECOME RESISTANT TO HERBICIDES

[\(montana.edu\)](#) [\(click for full story\)](#)

Herbicide-resistant weeds are a critical but often overlooked issue facing modern agriculture, according to Montana State University researcher [William Dyer](#). Thanks to a new grant from the U.S. Department of Agriculture, Dyer and research scientist [Barbara Keith](#)

will continue decades of research into exactly how weeds develop that resistance.

Herbicides are used to combat weeds without killing crops, as opposed to pesticides, which target insects, fungi and other non-plant threats to crops. Herbicides represent more than 75% of all pest-mitigating chemicals used in conventional agriculture, said Dyer, a professor in the [Department of Plant Sciences and Plant Pathology](#) in MSU's [College of Agriculture](#). However, low doses of herbicide can cause a weed to develop resistance to that treatment. Dyer's research, in collaboration with Keith of MSU's [Department of Land Resources and Environmental Sciences](#), focuses on herbicide-resistant wild oats, which plague producers of grains such as barley by competing with crop plants for resources like water and fertilizer.

"When a plant gets sprayed with an herbicide or if it's under stress, it does the same kinds of things that every organism does, including humans," said Dyer. "It turns on some genetic pathways that allow it to deal with whatever the stress is. The plants that we're working on are permanently ready to respond to stress. They have these pathways turned on all the time, and so anytime a new stressor comes along, the plant is already ready to deal with it."

Dyer's work began in 1993 when farmers in north-central Montana's Golden Triangle noticed that two different wild oat herbicides had stopped working. Laboratory studies revealed that the resistant plants could pump the chemicals out of their cells, the same mechanism used by drug-resistant bacteria in humans. By 2018, wild oats were found that resist all of the most common herbicides used on them.

Dyer and Keith recently received \$455,000 from the USDA to study how resistance developed and how it operates in samples of wild oats collected over 25 years. The work combines genetics, molecular biology and biochemistry to pinpoint the physiological and biological changes.

"We can understand how resistance develops over time in an evolutionary lineage, providing us with a unique opportunity to make some very important and fundamental discoveries with this funding," said Dyer. "If we can learn how these weeds have turned on these stress response pathways, maybe we could transfer those systems into crop plants and make them more resistant to stresses as well."

As their work continues, Dyer and Keith will also seek to develop new strategies for improving crop health under stressful conditions. Dyer recommends using herbicides sparingly, which can help slow down the natural selection for resistant weeds. With this research, he and Keith hope to provide growers with the information necessary to make their own informed decisions about herbicide use.

ONLINE PROGRAM ALLOWS JERIN BORREGO TO EARN MASTER'S DEGREE WHILE LIVING, WORKING IN HELENA

[\(montana.edu\)](#) [\(click for full story\)](#)

Jerin Borrego earned her undergraduate degree in Environmental Sciences from MSU and now works for the Montana Department of Agriculture as the pesticide registration specialist. Borrego wanted to

obtain a master's degree while continuing her professional experience and remaining in her hometown of Helena, Montana. The online [Master's Program in Environmental Sciences](#) through the Department of Land Resources and Environmental Sciences (LRES) was a perfect fit and also came highly recommend by co-workers who had been through the program. The program was very flexible, allowing her to take one class at a time so she could keep working but still manage a class load. She began in January 2017 and graduated in May 2020.

Borrego expected the courses to be structured like a traditional classroom where she quietly listened to a professor. However, she was surprised that the courses are discussion-based and she learned a lot from peer interaction with the faculty guiding the discussions.

"I have had more exchanges with students in these courses than I ever had in a classroom setting. The students come from different walks of life, educational backgrounds and professional experiences and offer different perspectives of Environmental Sciences. Whether my classmate's background is in biology or agriculture or something in between, hearing their experiences has been just as beneficial as learning from the professors."

As a self-described introvert, Borrego said that in a regular classroom setting she sometimes had difficulty speaking up in front of a professor and peers. Having an online form gave her time to think about her responses, type them out and post to the discussion page.

MONITORING FOR NON-TARGET IMPACTS FROM THE HOUNDSTONGUE ROOT WEEVIL

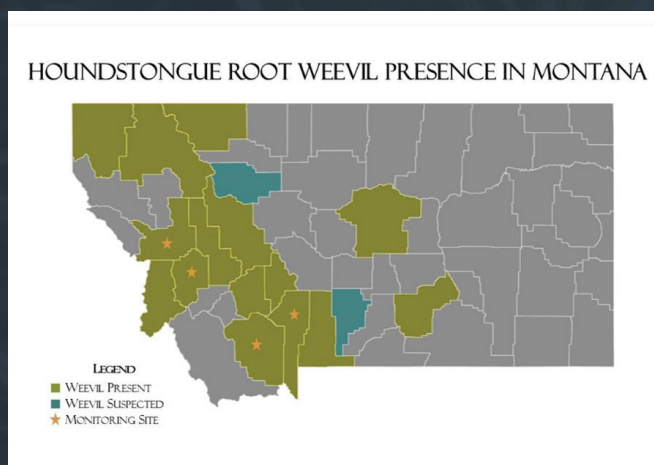
In 2019, the Montana Invasive Species Council held a Science Advisory Panel to evaluate the feasibility of approving and using the houndstongue root weevil (*Mogulones crucifer*) in the U.S. One of the panel's recommendations was to begin monitoring the root weevil and its impact on non-targets at locations it has naturally established.

The Montana Biocontrol Coordination Project received USFS Biological Control of Invasive Forest Pests funding to monitor for non-target impacts of the houndstongue root weevil in Montana, Washington, and Idaho. In 2020, the monitoring protocol was developed with the assistance of Jane Mangold, PhD, MSU, Sharlene Sing, PhD, USFS Rocky Mountain Research Station, and Rosemarie De

Clerk-Floate, PhD, Agriculture and Agri-Food Canada. Nine sites were identified in Montana with houndstongue, the weevil and a non-target, and eight of those sites were monitored. All sites will be monitored for three consecutive years, collecting data (vegetative form, height, number of flowers, feeding damage, and oviposition scarring) on houndstongue and the non-target individuals found within the 5 m x 5 m plots. After collecting data in the third year, a subset of the plants will be destructively sampled to inspect for eggs and larvae.

In 2021, the eight sites established in 2020 will be re-monitored and monitoring sites will be expanded to include two additional sites in Montana, five in Washington, and five in Idaho.

As we search for sites with houndstongue, the weevil and non-target species, we have been able to collect information regarding presence of the weevil. Jeff Littlefield, PhD, MSU, is also conducting adventive surveys for the houndstongue root weevil. The map includes counties where the root weevil has been identified or suspected (suspicious feeding damage but no weevils) through either MSU surveys or the searches for these monitoring sites.



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

