Montana State University: Montana Agricultural Experiment Station and Extension

REPORT FOR THE MONTANA NOXIOUS WEED TRUST FUND ADVISORY COUNCIL

JUNE 2020

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 2017–2019

Project Title, *PI*	2017	2018	2019
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 specificity testing of biocontrol agents of weedy mustards, *Jeff Littlefield*	●		
Host testing and field release of biocontrol agents for whitetop, *Jeff Littlefield*	●	●	
Host testing of a gall wasp for the biocontrol of invasive hawkweeds, *Jeff Littlefield*	●	●	●
Mass rearing, release, and monitoring of the northern tamarisk leaf beetle a biological control agent for saltcedar, *David Weaver*		●	●
Research Projects			
Effect of perennial grass seeding date on revegetation outcomes in weed-infested range and pasture, *Jane Mangold and Zach Miller*	●		●
Impacts of invasive annual grasses on forage, biodiversity, and litter decomposition rates, *Jane Mangold, Lisa Rew and Kate Fuller*	●		
Increasing herbicide and biocontrol options for integrated toadflax management, *David Weaver*	●	●	●
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*			●
Researching best strategies for managing baby's breath (*Gypsophila paniculata*) in hay field, waste areas, and CRP, *Shelley Mills, Stone Tihista, Inga Hawbaker, Bobbie Roos, and Connie Wittak*			●

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DEPARTMENTS INVOLVED WITH WEED RESEARCH AND EDUCATION

MONTANA AGRICULTURAL EXPERIMENT STATION
MSU EXTENSION SERVICE

AGRICULTURAL ECONOMICS AND ECONOMICS

Kate Fuller, *Extension Economist*

ANIMAL AND RANGE SCIENCES

Craig Carr, *Rangeland Ecology*
Pat Hatfield, *Range Sheep Nutrition*
Jeff Mosley, *Rangeland Ecology and Management*
Bret Olson, *Targeted Grazing*
Cecil Tharp, *Pesticide Education Specialist*

LAND RESOURCES AND ENVIRONMENTAL SCIENCES

Edward Davis, *Agricultural Specialist*
Jeff Littlefield, *Biological Control of Weeds*
Jane Mangold, *Integrated Invasive Plant Mgmt.*
Bruce Maxwell, *Agroecology*
Fabian Menalled, *Weed Ecology and Management*
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

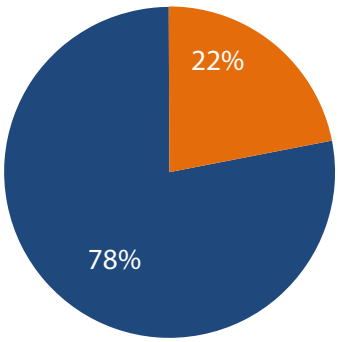
Mary Burrows, *Plant Pathology*
Bill Dyer, *Weed Physiology*
Matt Lavin, *Botany*
Ryan Thum, *Aquatic Plant Genetics and Ecology*

RESEARCH CENTERS

Clint Beiermann, *Cropping systems (started July 2020)*
Pat Carr, *Cropping systems*
Prashant Jha, *Weed Science*
Zach Miller, *Plant Ecology*
Lovreet Shergill, *Weed Science (started July 2020)*

MSU WEED PROJECT FUNDING 2017–2019

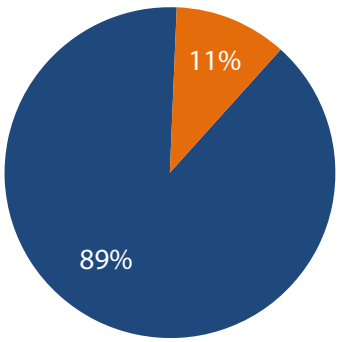
NEW AWARDS 2017



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

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

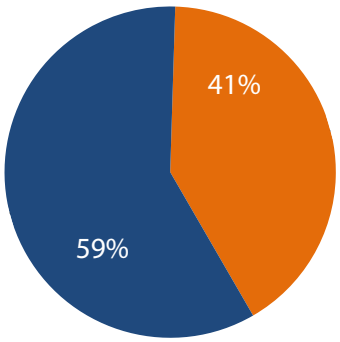
NEW AWARDS 2018



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

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

NEW AWARDS 2019



Noxious Weed Trust Fund
$351,151.....41%

Other
$501,802.....59%

OTHER FUNDING SOURCES FOR WEED RESEARCH AND EDUCATION, 2017 – 2019

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

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

MONTANA NOXIOUS WEED TRUST FUND PROJECTS 2017–2019 *(CONT.)*

Project Title, *PI*	2017	2018	2019
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			
Rock Creek Cooperative Weed Management Project, *Tracy Mosley*		●	

FUTURE PLANS: 2020 MONTANA NOXIOUS WEED TRUST FUND GRANTS

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*

Biology and host testing of a leaf mining beetle for Russian knapweed, *Jeffrey Littlefield*

Screening biocontrol agents for oxeye daisy and common tansy, *Jeffrey Littlefield*

Continued host testing of a gall wasp for invasive hawkweeds, *Jeffrey Littlefield*

Rearing and release of the hoary cress gall mite and screening of a seed pod weevil, *Jeffrey Littlefield*

EDUCATION PROJECTS:

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

RESEARCH PROJECTS:

Developing monitoring protocols for evaluating weed management outcomes, *Lisa Rew and Jane Mangold*

New solutions for old problems: identifying the best available biological and chemical and control options for the integrated management of invasive toadflaxes, *David Weaver*

MSU WEED SCIENCE ACTIVITY

Peer-reviewed journal articles: 83
Outstanding student achievement awards: 6
Regional, national & international recognition: 4
Invited book chapters: 2
Abstracts/science presentations: 59
Completed theses and dissertations: 18
Graduate students in training: 34
Extension publications: 37
TV and radio appearances: 59

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)*
Desert alyssum (*Alyssum desertorum*)
Douglas fir *(Pseudotsuga menziesii)*
Field bindweed *(Convolvulus arvensis)*
Juniper (*Juniperus* spp.)
Leafy spurge *(Euphorbia esula)*
Orange hawkweed *(Hieracium aurantiacum)*
Oxeye daisy *(Leucanthemum vulgare)*
Narrowleaf hawksbeard (*Crepis tectorum*)
Palmer amaranth (*Amaranth palmarei*)
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 HIGHLIGHTS

MSU RESEARCH TEAM RECEIVES GRANT TO STUDY INVASIVE GRASS MANAGEMENT

By Reagan Colyer, MSU News Service

Fields like this hayfield near Bozeman are currently cheatgrass-free, and MSU researchers Lisa Rew, Cathy Zabinski, Jane Mangold and Bok Sowell are working to keep it that way. Using a grant from the USDA, the team is researching integrated management practices to prevent the spread of the invasive grass. Photo by Kelly Gorham/MSU News

An interdisciplinary team of researchers from the Montana State University College of Agriculture received a grant to develop an integrated management framework for cheatgrass, an invasive species in Montana and a growing concern for agriculturalists in the Northern Rockies.

The team, made up of professors Lisa Rew, Cathy Zabinski and Jane Mangold of the Department of Land Resources and Environmental Sciences and Bok Sowell of the Department of Animal and Range Sciences, was awarded the three-year, $350,000 grant by the Western Sustainable Agriculture, Research and Education program, which is overseen by the U.S. Department of Agriculture. They will collaborate with researchers from the U.S. Fish and Wildlife Service, The Nature Conservancy nonprofit organization and local farmers and ranchers to study the spread and management of the invasive grass.

"All the models say that if you're going to stand a chance of getting rid of cheatgrass, you have to target it when it's just beginning to take hold," said Rew. "That's where we are in a lot of areas in Montana right now. But if we don't get it soon, it will be very hard if not impossible to get any land back to the way we want it to be."

Currently, Rew said, cheatgrass is spreading into Montana from states farther south and and west and is essential to address quickly as possible. Current management techniques include herbicide spraying and short stints of grazing. The grass becomes unpalatable to cattle once it goes to seed and will crowd out more desirable plants, so the need to find alternative management techniques is pressing.

"Cheatgrass germinates in the fall, when none of our native grasses have germinated yet," said Rew. "In that regard, it has a bit of an advantage over the native species, because it's already up and growing in the spring when they're just waking up."

Rew and her team will focus their research in the Centennial Valley near Dillon and partner with the Beaverhead County Weed District to develop strategies that will be applicable to producers across the state and beyond.

The team will test on-farm herbicide application and novel strategies such as applying mustard seed meal to deter cheatgrass growth and micronutrient

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supplements to promote native plants. Testing is set to begin this summer, both in the laboratory and on active producer land. As the team learns more about the different techniques, landowners have more information to tailor their approaches.

"This will help producers decide how best to manage their own land, allowing for the fact that some don't want to use herbicides, some don't have the capacity to seed and considerations like that," said Rew. "This is very much a grassroots project. They wanted to figure out how to deal with this, and our job is to help facilitate that discovery."

MSU STUDENT WINS NATIONAL AWARD FOR WEED SCIENCE

By Reagan Colyer, MSU News Service

A member of Montana State University's spring class of 2020 has been recognized for her contributions to the field of weed science during her undergraduate career.

Stacey Robbins, who graduated from the College of Agriculture's Department of Land Resources and Environmental Sciences earlier this month, was one of just nine students to receive the John Jachetta Undergraduate Research Award from the Weed Science Society of America. The nonprofit society promotes research, outreach and education regarding weed science and management nationwide, from undergraduate projects such as Robbins' to faculty and community work.

Recent Montana State University graduate Stacey Robbins was recognized by the Weed Science Society of America for her undergraduate research mapping and modeling the spread of wiregrass, a new invasive plant in Montana. Photo courtesy of Stacey Robbins.

"The whole experience has been pretty exciting for me," said Robbins, originally from Livingston. "When I learned about the opportunity to get some research funding from WSSA and present my research at their annual meeting, I immediately wrote a proposal."

Robbins' research focused on ventenata, or wiregrass, an invasive grass that grows in rangelands and natural areas and forces out more desirable native species. It is similar to better-known invasive species such as cheatgrass and medusahead.

Working with Lisa Rew, a professor in the Department of Land Resources and Environmental Sciences and a researcher in MSU's Weed and Invasive Plant Ecology and Management Group, Robbins began collecting GPS data to map where wiregrass had already taken hold in Gallatin County. She then combined that data with elevation models and other elements of the county's geography to determine where the grass was most likely to continue to spread and which areas seemed more protected.

"The project consisted of collecting that field data and then determining trends, seeing what terrain attributes were consistent with the presence or absence of the weed," said Robbins. "Then we can put it all together to predict where it may invade or continue to spread."

After high school, Robbins spent five years working before deciding to pursue a college degree. She began her time at MSU as a Gallatin College student, where she found herself intrigued by her first plant biology class.

After a year at Gallatin College, Robbins transferred to the main MSU campus began work in Rew's lab, beginning the wiregrass project during the summer of 2019. She presented her work at the WSSA's annual meeting in Hawaii in March, where she was awarded the $2,000 research award.

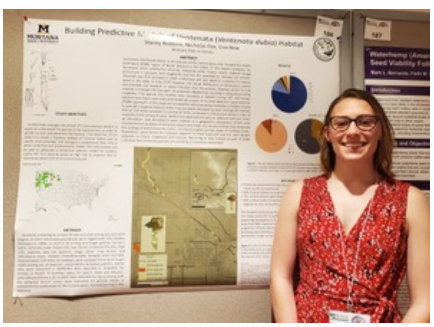
"It's a competitive award, so it's delightful that she got it," said Rew. "She did a great job doing the research and she really took it on as her own project. Stacey is very deserving of this honor."

Back home in Bozeman, Robbins was also recognized with the Land Resources and Environmental Sciences department's outstanding senior award, nominated by faculty across the breadth of her program. Professors Rew, Cathy Zabinski and Stephanie Ewing all put her name forward for the honor.

"I think it speaks to how diverse a student and researcher Stacey is that she was nominated by a plant ecologist, a restoration ecologist and a soil specialist," said Rew. "Across the board, we all think she's just great."

With Robbins' undergraduate career complete, she hopes her project will provide resources for other students to further their studies. She will put her years of hard work to use as she transitions into a position as a wetland field technician in Bozeman, a change for which she feels well prepared through her university experience.

"When I finished high school, I didn't really have a college gameplan," she said. "Starting back in a small classroom setting at Gallatin College was a really good way to get reintroduced to learning. Through my time at MSU I've come out with such a great support crew. The connections I've made have been amazing."



Recent Montana State University graduate Stacey Robbins was recognized by the Weed Science Society of America for her undergraduate research mapping and modeling the spread of wiregrass, a new invasive plant in Montana. Photos courtesy of Stacey Robbins.

MSU RESEARCH STATION AND EXTENSION HOST WORKSHOP ON INVASIVE WEED PALMER AMARANTH

By MSU News Service, October 22, 2019

BOZEMAN – Montana State University's Eastern Agricultural Research Center and MSU Extension hosted a free November half-day workshop focused on Palmer amaranth, a herbicide-resistant invasive weed that has spread through much of the Midwest in recent years. It was broadcast live online to Extension offices and Montana Agricultural Experiment Station research centers around the state for remote attendees to tune in.

The workshop, "Palmer amaranth: It's coming! What you need to know," happened Nov. 5 at the Richland County Extension

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Office in Sidney. The event was sponsored by the Montana Wheat and Barley Committee and the Western Sustainable Agriculture Research and Education program.

Palmer amaranth can grow 2-3 inches per day to a height of 6 feet or taller. The weed produces up to half a million seeds per plant and is resistant to nearly all herbicides commonly available to producers for weed management. Farmers and ranchers across Montana need to take immediate action to identify and prevent its establishment in the state, according to Frankie Crutcher, assistant professor of plant pathology at the Eastern Agricultural Research Center. The workshop provided participants with the tools necessary to do that.

The workshop featured speaker Jason Bond, a weed control specialist from Mississippi State University Extension. Bond works with the Delta Research and Extension Center and discussed the problems that Mississippi producers have faced trying to control Palmer amaranth and what they've learned in the process that can be applied in Montana. Bond was joined by Brian Jenks, a weed scientist at the North Central Research Extension Center in Minot, North Dakota; John Gaskin and Natalie West, a molecular botanist and plant ecologist with the U.S. Department of Agriculture's Northern Plains Agricultural Research Laboratory in Sidney; Tim Fine, a Richland County Extension agent; and Tim Seipel, an MSU Extension cropland specialist.

Topics included identification tips, potential biocontrol options, answers to the weed's herbicide resistance, steps Montanans can take to avoid infestations and the potential for drones in scouting for Palmer amaranth.

More at https://www.montana.edu/news/19165

NEW SURVEY SUGGESTS IMPROVEMENTS IN MONTANANS' UNDERSTANDING OF NOXIOUS WEEDS

By Reagan Colyer, MSU News Service, October 26, 2019

Farmers and ranchers in Montana are often intimately aware of dangers posed by noxious weeds, but the general public's knowledge of invasive species has also increased due to education and outreach efforts over the past 25 years, according to a recent survey.

The survey follows up an initial survey done in 1994, which determined the level of public knowledge at the time in order to gauge education needs. The 2019 survey was administered by Eric Raile of the Montana State University Human Ecology Learning and Problem Solving Lab; Jane Mangold of MSU Extension and the Department of Land Resources and Environmental Science in the College of Agriculture; and Shantell Frame-Martin of the Montana Noxious Weed Education Campaign, or MNWEC. Both surveys were funded by the Montana Noxious Weed Trust Fund, which is overseen by the Montana Department of Agriculture.

"The goal of that first survey was to gain insight into the level of knowledge that Montanans had about noxious weeds," said Frame-Martin. "We found out that there wasn't a whole lot of knowledge, so that was when the MNWEC was formed."

The MNWEC, housed in the Department of Land Resources and Environmental Sciences at MSU, is a cooperative effort among state and federal entities and non-governmental organizations that seeks to educate Montanans about noxious weeds, encouraging them to participate in integrated weed management.

Since 1994, the MNWEC has used billboards, pamphlets, educational classes, newspaper articles, and radio and television advertisements to increase knowledge across the state. Recently, it has focused has been on key audiences like recreationists and hunters who spend a lot of time in Montana's natural areas and may accidentally spread noxious weeds. They also developed educational materials for real estate professionals.

Noxious weeds infest nearly 8 million acres of Montana, said Frame-Martin, and something as simple as walking or driving through a patch of noxious weeds without washing shoes or vehicles afterward can spread the weeds to areas that haven't yet been exposed. Of particular concern are medusahead and ventenata, invasive grasses that are detrimental to rangelands because they decrease the amount of forage available for livestock and wildlife.

More than 800 Montanans responded to the newest survey. Of those, nearly half reported driving on dirt roads or across fields, 41% reported routinely hiking or backpacking, 37% work outside or in fields, 24% fish and 17% hunt. All of those are outdoor activities that, without proper awareness, can spread noxious weeds.

About half of respondents, 48%, said they have "little to no" knowledge of noxious weeds. While it seems like a large proportion, it is an improvement over the 1994 survey, when 67% of respondents indicated knowing little or nothing about noxious weeds.

However, 73% of respondents were able to name at least one species of noxious weed, and at least 80% identified loss of wildlife habitat and biodiversity, increased wildfire and loss of native plants as particularly concerning impacts of noxious weeds, showing awareness of the impacts the weeds can have.

Nearly half of respondents said they do more now to prevent noxious weed spread than five years ago, which Frame-Martin said is encouraging. While all the numbers might not yet be where researchers hoped, she said they are moving in the right direction. When it comes to environmental issues, educating people about the behaviors that contribute to the problem is critical, she said, and Montanans who know about noxious weeds are more likely to do their part to help stop the spread.

"The results that we gained are encouraging," Frame-Martin said. "The trends in our data show that knowledge has increased."

One of the less encouraging results from the survey for Frame-Martin was the trend of younger adults and female respondents tending to know less and show less interest in noxious weeds. But, she said, this finding will help the MNWEC adapt its educational efforts to engage those groups.

"Everybody has the capability and capacity to help stop noxious weeds," Frame-Martin said. "We all love Montana, and we live here because of the great recreational opportunities. We need to protect those for future generations. Making sure that knowledge is out there and that everybody can do their part is essential."

More at https://www.montana.edu/news/19145

SHANTELL FRAME-MARTIN WINS TWO AWARDS

Shantell Frame-Martin received the Montana Weed Control Association's "Weed Fighter of the Year" award at their annual meeting in Great Falls (pictured, right).

She also won an MSU Excellence in Outreach Award. Frame-Martin was nominated for her work on the campaign, which aims to increase public participation in ecologically based integrated weed management. Last summer, the program conducted a survey gauging public knowledge about noxious weeds, which returned favorable results since the implementation of outreach programming largely led by Frame-Martin.

Two of the most successful outreach projects FrameMartin has organized are the Adopt a Trailhead Montana program and the Montana Real Estate Professionals Online Noxious Weed Training. Adopt a Trailhead Montana is a cooperative volunteer program designed to protect Montana's trails from further spread of noxious weeds, and it has led to the installation of 65 boot brush kiosks at trailheads around the state, along with interactive educational booths to highlight the importance of public participation in slowing the spread of noxious weeds. The Montana Real Estate Professionals Online Noxious Weed Training was implemented to increase the knowledge of real estate agents and developers about the economic and environmental impacts of noxious weeds and the laws that govern noxious weed infestations on private properties.

MSU LRES GRAD RECEIVES NORTHERN ARIZONA UNIVERSITY PRESIDENTIAL FELLOWSHIP

Audrey Harvey, who received her M.S. in LRES in May 2019 while studying with Dr. Jane Mangold, received the Northern Arizona University Presidential Fellowship. She will be starting a Ph.D. program with Dr. Karen Haubensak in August. Haubensak's lab studies interactions and feedbacks among soils and plants to understand responses to global change and applications to restoration ecology. Audrey, from Arizona and a member of the Navajo Nation, was a Sloan Indigenous Scholar while attending MSU.

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

PARTICIPATION

- **16** Work shops/ presentations
- **525** Workshop attendees
- **43** Days Spent Collecting
- **432** Collection Day Participants
- **8730** Miles Traveled For Workshops and Collections

INSECTS

- **11** species released
- **8** Species Collected
- **10615** Acres Treated
- **35** Sites Monitored
- **41** counties & 6 out of 7 Reservations recieved insects
- **11** States Received Insects
- **1,128,750** Insects Distributed
- **$219,000** Market Value of insects

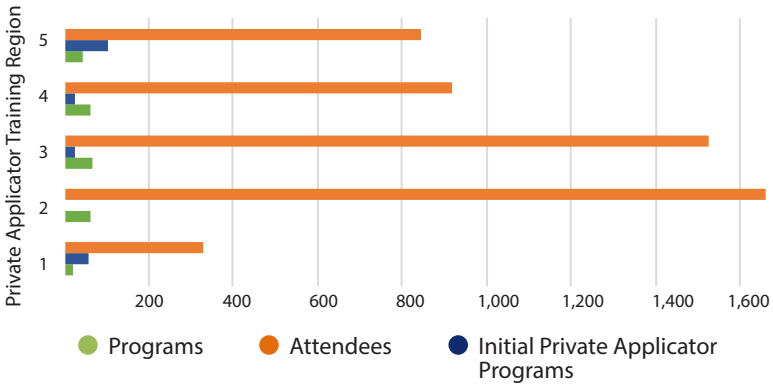
2019 BREAKDOWN

- **10%** Out of State Coordination
- **17%** Fundraising
- **15%** Workshops
- **31 %** Collections and Monitoring
- **27 %** In-state Coordination

EDUCATION IMPACTS 2017–2019

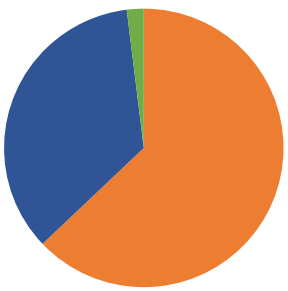
MSU EXTENSION

PESTICIDE EDUCATION DELIVERED 2019†



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

WEED MANAGEMENT CONSULTATIONS (ACRES) 2019‡



Crop land
344,635 . . . . . 63%

Non-crop land
192,550 . . . . . 35%

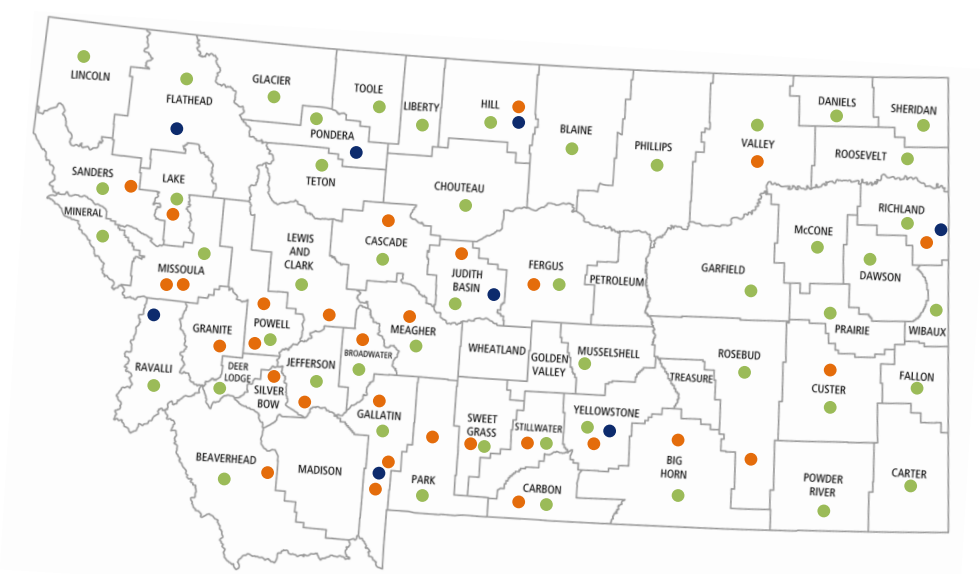
Small acreage
10,695 . . . . . .2%

‡*Data represents reporting from MSU Extension offices.*

MSU Extension Agents Contributing to Weed Education

Juli Thurston, *Sanders County* • Josh Bilbao, *Gallatin County* Wendy Becker, *Fort Peck Reservation* • Danielle Harper, *Wibaux County* Dave Brink, *Mineral County* • Emily Standley, *Fergus County* Tim Fine, *Richland County* • Jasmine Carbajal, *Hill County* • Tom Allen, *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* • Adrianne 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 Fosjord, *Musselshell and Golden Valley Counties* • Jaycee Searer, *Dawson County* • Jack Stivers, *Lake County* • Jessica Murray, *Beaverhead County* • Michael Millward, *Fallon and Carter Counties* • 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* • Bob Sager, *Meagher County* • Tracy Mosley, *Park County*• Jeff Chilson, *Roosevelt County* • Lee Schmelzer, *Stillwater County* • Mandie Reed, *Wheatland County*

MAES RESEARCHERS AND EXTENSION SPECIALISTS CONTRIBUTING TO EDUCATION AND OUTREACH



- MSU MAES Research Centers
- Off-campus MSU weed education locations 2019
- Counties which submitted plant sample(s) to MSU Schutter Diagnostic Lab in 2019

Off-Campus MSU Weed Education Programs

Programs delivered (2019): 119
Individuals reached (2019): 8,369

MSU Schutter Diagnostic Lab

Weed samples identified (2019): 1,596
Programs delivered (2019): 13
Individuals reached (2019): 5,969

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 2017–2019

JOURNAL ARTICLES AND INVITED BOOK CHAPTERS

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

ECONOMICS

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Dyer W, Burns EE, Keith B, **Bothner B**, Carey CC, Mazurie A, **Hilmer JK**, Biyiklioglu S, Burg G. 2017. Intensive herbicide use has selected for constitutively elevated levels of stress-responsive mRNAs and proteins in multiple herbicide resistant *Avena fatua* plants. *Pest Management Science* 73(11): 2267–2281.

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

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

Adhikari, S, Burkle, L, O'Neill, K, Weaver, D, Delphia, C, Menalled, F. 2019. Dryland organic farming partially offsets negative effects of highly-simplified agricultural landscapes on forbs, bees, and bee-flower networks. Environmental Entomology, 48(4), 826-835.

Adhikari, S, Burkle, L, O'Neill, K, Weaver, D, Menalled, F. 2019. Dryland organic farming increases floral resources and bee colony success in highly simplified agricultural landscapes. Agriculture, Ecosystems, and the Environment, 270, 9-18.

Adhikari, S, Adhikari, A, Weaver, D, Bekkerman, A, Menalled, F. 2019. Impacts of agricultural management systems on biodiversity and ecosystem services in highly simplified landscapes. Sustainability, 11(11,3223), 1-16.

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.

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

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

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Peterson R, Higley LG, Pedigo LP. 2018. Whatever happened to IPM? *American Entomologist, 64*, 146-150.

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

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

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.

Davis KTD, Caplat P, Pauchard A, **Maxwell B,** Nunez M. 2019. Simulation model suggests that fire promotes lodgepole pine (Pinus contorta) invasion in Patagonia. Biological Invasions, 20(Jul), 1-14.

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

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

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

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

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

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

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THESES AND DISSERTATIONS

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

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

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." Major Advisor: Lisa Rew.

Dillard S. 2019. "Restoring Semi-Arid Lands with Microtopography." MS Professional Paper. 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. Major Advisor: Paul Stoy.

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.

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RESEARCH AND EXTENSION PUBLICATIONS 2017–2019

Massey J.G. 2019. "Soil Restoration and Invasive Plants at the Block P Mill and Tailings Site, MT". Major Advisor: Bill Kleindl.

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Morford-Graziano, D. 2019. "The Impact of Elevation on Biodiversity in Mountain Ecosystems." MS Professional Paper. Major Advisor: Lisa Rew.

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

Peppel L. 2019. "Native Shrub dynamics at Restoration Plots in the Southern San Juaquin Valley, CA." MS Professional Paper. Major Advisor: Scott Powell.

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

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

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

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

WEED MANAGEMENT EXTENSION PUBLICATIONS

TARGET WEEDS

Davis S, **Mangold J.** 2019. Rush skeletonweed (MT201902AG ed., pp. 2). Bozeman: Montana State University Extension.

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

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

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

Lewis 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. http://msuextension.org/publications/AgandNaturalResources/mt201806AG.pdf

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

Mangold JM. 2014–2019. "Monthly weed posts." MSU Extension.

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

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

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

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

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

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

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

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

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

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

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

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

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

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OUTREACH PUBLICATIONS

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Davis S, Mangold J. 2019. Managing weeds after wildfire (vol. EB0230, pp. 27). Bozeman, MT: Montana State University Extension.

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

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Tharp CI. 2019. Montana Pesticide Recordkeeping Manual (EB0158A ed., 50 pages). Bozeman: MSU Extension Publications.

Tharp CI. 2019. Cold Weather Storage and Handling of Pesticides. MSU Extension MontGuide (MT201801AG ed., pp. 6). Bozeman: MSU Extension MontGuide.

Tharp C, Bowser A. 2019. Understanding Herbicide Contaminated Soil Amendments: For Greenhouses, Nurseries, and Home Gardens. (SKU4628, 6 pages). Bozeman, MT: MSU Extension.

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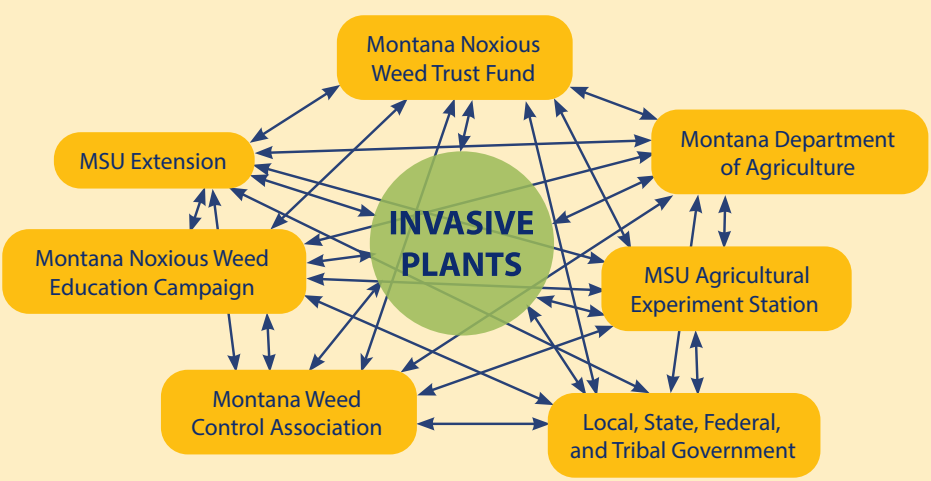
Lavin MT, Mangold J. 2019. In Katie Gibson and Whitney Tilt (Ed.), Montana Grasses App. Bozeman Montana: High Country Apps. http://highcountryapps.com/MontanaGrasses.aspx

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.

MSU EXTENSION AGENT RECEIVES EXCELLENCE IN CROP PRODUCTION AWARD

Garfield County Extension Agent Shelly Mills (right) received the 2018 Excellence in Crop Production award for her Hawksbeard outreach and education program from the National Association of County Agricultural Agents (NACAA) in Chattanooga TN, and also won the top educational poster entitled "Narrow-leaf Hawksbeard (*Crepis Tectorum L.*): Managing a new invasive weed in Montana" at the same conference out of 108 educational entries. Based on survey responses, her team's efforts saved growers in the region over 6 million dollars in a 2 year period by identifying management strategies through research plots with Ed Davis and NDSU Weed Scientist Brian Jenks.

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



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Compiled and edited by Tracy Sterling and Dan Lucas, June 2020.