USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

Science You Can Use *(in 5 minutes)*

SEPTEMBER 2023

The Trouble with Noxious Weeds: Predicting Herbicide Resistance

Noxious weeds plague farmers and ranchers, push out native species, and cause both economic and ecological damage. Synthetic herbicides, developed in the 1940s, are often used to control the spread of these plants. By the late 1950s, scientists noticed that some herbicides were no longer effective on certain plant species, even after a typically lethal dose. Since then, scientists have worked to understand the plant traits and management actions that lead to herbicide resistance. This work is especially important as land managers attempt to eradicate plants legally deemed "noxious" and requiring removal.

Herbicide resistance is caused by interacting factors including herbicide use (quantity, frequency, and timing), the herbicide's mode of action, and the biological traits of each weed. Due to all the possible variables, understanding herbicide resistance is complex. Rocky Mountain Research Station Research Ecologist Jacqueline Ott and her research partners, Cynthia Hartway and Nancy Grulke, hope their work can better predict which weeds are most "at risk" of becoming resistant to herbicide. Hartway is a Research Associate with South Dakota State University and Grulke is a Research Ecologist with the Pacific Northwest Research Station.

Using the Western Wildlands Threat Assessment Center's noxious weed database, the team chose 10 plant traits and developed a model (using the random forest models algorithm) to identify the plant characteristics most likely to contribute to its herbicide resistance. Currently, there are 47 noxious weeds listed as herbicide-resistant and 236 that are not. Ott explained that the team "tried to pick traits that people could identify on their own or could easily look up" that might forecast the risk of becoming herbicide resistant. The traits they examined include life form

KEY MANAGEMENT CONSIDERATIONS

- Plant lifespan, seedbank persistence, and occurrence outside of riparian/wetland habitats were the three strongest predictors for whether a weed may become herbicide resistant.
- Annuals proved more likely to be herbicide resistant than longer-lived perennials. Because annuals have higher genetic variation and shorter generation times, they may be able to adapt to herbicides and evade their effects more rapidly.
- Plants with persistent seedbanks (seeds remaining viable for more than 4 years), demonstrated a strong potential for herbicide resistance. This may be because persistent seedbanks may increase the size and genetic diversity of a population, allowing for the survival of genetic traits that are resistant. Alternately, persistent seedbanks may be simply exposed to more applications of herbicides—as plants with persistent seedbanks are often the most troublesome weeds.
- Plants in riparian/wetland habitats may be less likely to develop herbicide resistance, possibly because herbicide use is more restricted in these areas and water-approved herbicides have short residence times.

*Medusahead (*Taeniatherum caput-medusae*)—an annual grass with a moderately persistent seedbank— is likely to become resistant to herbicide according to the model. Photo by Matt Lavin.*

Noxious Weeds Most at Risk for Herbicide Resistance

The following are the twenty-five noxious weeds modeled to be most at risk for becoming resistant to herbicide. The full table can be found in the paper cited in "Further Reading."

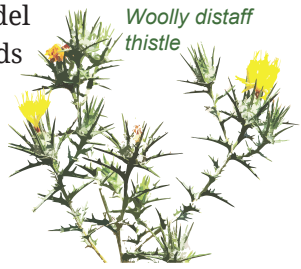
Scientific Name	Plant Family	Common Name
Aegilops cylindrica	Poaceae	jointed goatgrass
Anchusa arvensis	Boraginaceae	small bugloss
Carduus tenuiflorus	Asteraceae	winged plumeless thistle
Carthamus creticus	Asteraceae	smooth distaff thistle
Carthamus lanatus	Asteraceae	woolly distaff thistle
Carthamus leucocaulos	Asteraceae	whitestem distaff thistle
Carthamus oxyacanthus	Asteraceae	jeweled distaff thistle
Cucumis melo	Cucurbitaceae	cantaloupe
Cucumis myriocarpus	Cucurbitaceae	gooseberry gourd
Emex australis	Polygonaceae	southern threecornerjack
Emex spinosa	Polygonaceae	spiny threecornerjack
Erodium cicutarium	Geraniaceae	redstem stork's bill
Euphorbia oblongata	Euphorbiaceae	eggleaf spurge
Halogeton glomeratus	Chenopodiaceae	saltlover
Hibiscus trionum	Malvaceae	flower of an hour
Hyptis suaveolens	Lamiaceae	pignut
Ipomoea turbinata	Convulvulaceae	lilacbell
Lepidium coronopus	Brassicaceae	creeping wart cress
Microstegium vimineum	Poaceae	Nepalese browntop
Phyllanthus tenellus	Euphorbiaceae	Mascarene Island leaf-flower
Phyllanthus urinaria	Euphorbiaceae	chamber bitter
Polygonum cespitosum	Polygonaceae	Oriental lady's thumb
Taeniatherum caput-medusae	Poaceae	medusahead
Tribulus terrestris	Zygophyllaceae	puncturevine

FEATURED SCIENTIST

Jacqueline P. Ott is a research ecologist for the Rocky Mountain Research Station who works with the Maintaining Resilient Dryland Ecosystems Program in South Dakota. Her primary research in grassland and shrubland ecology focuses on the impacts of humans, fire, drought, and invasive species on plant communities and emphasizes the importance of belowground buds to plant responses to these impacts.

(e.g., forb vs. grass); life span; seedbank persistence; leaf size and properties (e.g., waxy or leathery leaves); dispersal mechanisms; and habitat.

The team tested their models on noxious weeds that are already known to be herbicide resistant and found that the best predictors of herbicide resistance were life span, seedbank, and habitat traits. More specifically, they found that species with short life spans (i.e., annuals), persistent seedbanks (seeds that survive in the soil for long periods), and those that do not occur in riparian or wetland areas have more potential to develop herbicide resistance. Their final model identified 63 noxious weeds that, currently, are not known to be herbicide resistant, but may have the potential to become resistant in the future.


Woolly distaff thistle

This project aims to create a tool to predict which noxious weeds are most at risk of developing herbicide resistance. For example, Ott explained that if a weed is "at risk," according to their model, a manager dealing with that species might choose a "different management treatment like grazing or fire to limit herbicide use" and slow or avoid the development of herbicide resistance. Ultimately, using this tool might allow for more strategic use of herbicides.

FURTHER READING

Hartway, Cynthia R.; Ott, Jacqueline P.; Grulke, Nancy E. Plant life span and persistence of soil seedbanks predict the emergence of herbicide resistance in noxious weeds. Weed Science. 70: 448–454.

The Rocky Mountain Research Station is one of seven units within USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state geography encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests, ranges and watersheds and maintains long-term research databases for these areas. Our science improves lives and landscapes. More information about Forest Service research in the Rocky Mountain Region can be found here: https://www.fs.usda.gov/research/rmrs/.