USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE
ARS Office of National Programs
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AREA RESEARCH UPDATES

NORTHEAST

High-throughput phenotyping systems for greenhouses and semi-field conditions are critical for plant breeding and building image repositories that use computer vision and artificial intelligence for mapping cash crops, cover crops, and weeds. However, these high-throughput phenotyping systems are costly, resulting in limited use. A team led by Dr. Steven Mirsky at the ARS Sustainable Agricultural Systems Lab in Beltsville, Maryland, designed and built BenchBot, a fully autonomous robotic platform, in collaboration with North Carolina State University researchers. BenchBot costs less than $20,000, significantly less than most commercial and research grade systems that cost in the millions of dollars. Designs for BenchBot, published and freely available on GitHub, are now being used for high-throughput phenotyping by ARS and university scientists, including weed science programs at North Carolina State University and Texas A&M that are building a national agronomic plant image repository, which includes weeds. With BenchBot, there is now a low-cost, user-friendly technological alternative that is making high throughput phenotyping accessible for researchers.

MIDWEST

Everything good, bad, and perhaps a little ugly associated with cover crops for controlling weeds was the focus of a symposium in January at the Weed Science Society of America's annual meeting. The organizers were Erin Haramoto, weed scientist at the University of Kentucky and Steve Young, national program leader for weeds and invasive pests in the ARS Office of National Programs in Beltsville, Maryland. In recent years, understanding has improved on the mechanistic influences of cover crops on weed dynamics and how they can be integrated with herbicides. But many weed scientists and growers are still split on the contributions of cover crops to weed management in specific situations and how they fit within agroecosystems. A panel of experts both within and outside of weed science discussed these perspectives and ideas for moving forward. Through the symposium, differences in perspectives and philosophies were acknowledged, and ideas were shared on how to move the needle on cover crop adoption for weed management.

PLAINS

Invasive annual grasses such as bromes (*Bromus spp.*), ventenata (*Ventenata dubia*) and medusahead (*Taeniatherum caput-medusae*) are problematic throughout arid and semi-arid rangeland ecosystems of the western United States, with substantial impacts to ecosystem health and forage productivity. Dr. Carissa Wonkka at the ARS Pest Management Research Unit in Sidney, Montana, and collaborators are developing strategies that reduce wildfire spread and track the response of invasive annual grasses to fire in the Great Plains. Using U.S. Forest Service fire spread models, the team determined which plant traits contribute to effective green strips (linear strips of less-flammable species planted to interrupt wildfire spread) that provide fire protection and staging areas for firefighters. Field data and remote-sensing information were also combined to verify that rangeland fire management in the eastern Great Plains is compatible with strategies to limit the frequency and abundance of invasive annual grasses. These "lessons learned" from the Great Plains were included in national efforts to describe the total ARS impact on knowledge of invasive annual grass management.

PACIFIC WEST

The Pacific Northwest (PNW) region includes some of the most productive wheat, small grain and grain legume production systems in the nation. Constituting 12% of U.S. small grain acreage and almost 20% of the national total, the region exports roughly 80% of its production. The grain and legume industry of the region contributes enormously to the economies of the three states and the viability of the region's rural and urban communities. The significant achievements in market development, soil conservation, improvement in water quality and sustainability that have occurred in the PNW through adoption of no-tillage or low-tillage systems are fundamentally threatened by herbicide resistant weeds. A new PNW Herbicide Resistance Initiative has brought together ARS Research Labs in Pullman and Pendleton along with university partners to identify and overcome risks associated with herbicide resistance in cereal-based cropping systems, reduce production losses and reduce or eliminate pressure on trade limits due to contamination. The Initiative includes adding ARS weed science positions in both locations to work collaboratively with university partners and grower groups and stakeholders in the region.

SOUTHEAST

Chinese tallow is an invasive tree infesting thousands of acres in the southeast. Host range testing by Dr. Greg Wheeler and the team at the Invasive Plant Research Lab in Fort Lauderdale, Florida indicated a flea beetle and moth would be safe for release as biocontrol agents. The scientists are waiting for the issuance of a release permit from USDA-APHIS for the two biological control agents that could provide land managers and farmers with a cost-effective and sustainable means of controlling the invasive tree Chinese tallow and reduce the current reliance on herbicidal control.

OFFICE OF NATIONAL PROGRAMS
WEED SCIENCE NEWS

On November 15, 2021, the Bipartisan Infrastructure Law (BIL) was enacted, of which Title 8 Section 40804 authorized $905 million for Ecosystem Restoration over the next five years for the Department of the Interior (DOI) to implement provisions or activities, including $100 million for "invasive species detection, prevention, and eradication, including conducting research and providing resources to facilitate detection of invasive species at points of entry and awarding grants for eradication of invasive species on non-Federal land and on Federal land."

DOI prioritized strategic, collaborative efforts for investment, including advancing a National Early Detection and Rapid Response (EDRR) Framework. It is acknowledged that extensive EDRR activities are underway, from preparedness and information management to on-the-ground actions. BIL funding for invasive species enables DOI to bring together those capabilities more effectively, efficiently, and collaboratively and undertake transformational approaches to accomplish nationally coordinated EDRR outcomes that may not otherwise be achieved.

To initiate this work, in Fiscal Year 2022, DOI provided the U.S. Geological Survey (USGS) with resources to develop initial foundational components of a Framework and to do so in collaboration with others on the following topics: Horizon Scans, HotSpot Analysis, eDNA Toolbox, INHABIT Model, Information Systems, and Aquatic Invasive Species. Each of the topics are helping to advance the Framework through partner engagement and collaboration. For more information on how to get involved with **weed and invasive plant related research and management activities**, contact any of the following individuals:

- Kaylin Clements, EDRR Partner Engagement Coordinator, USGS, kclements@contractor.usgs.gov
- James English, Biosurveillance Coordinator, USGS, jjenglish@usgs.gov
- Craig Martin, Branch Chief, Aquatic Invasive Species, USFWS, craig_martin@fws.gov
- Hilary Smith, Senior Advisor for Invasive Species, DOI, hilary_smith@ios.doi.gov

RESEARCH SPOTLIGHT
DR. KRISHNA REDDY

The WSN sat down with Krishna to discuss his research on crop production systems in the Southeastern US and some of the challenges and new directions in managing weeds. Krishna is a weed scientist and research leader at the ARS Crop Production Systems Research Unit in Stoneville, Mississippi.

Krishna Reddy
Research Leader
Crop Production Systems Research Unit
USDA/ARS

WSN: Good morning, Dr. Reddy. How are you today? How is the field season going in Mississippi?

Krishna: I am doing great. Field work is going well. Our scientists and technicians are busy in collecting field samples, taking hyperspectral images, and irrigating crops as needed. Of course, we're chopping escaped pigweeds. It's getting HOT; 88 F high today. Going to be 97 F by Sunday.

WSN: Sounds like quite a team, which makes me think of the approach to managing weeds in crops. How would you describe the team concept in the research that you have done and are involved with now?

Krishna: Our field scientists and technicians work as a team – some tasks take more than 2-3 people at a time. Scientists collaborate with each other to get things done on a timely basis. The Mississippi Delta is a haven for weeds due to warm, wet, and fertile soils with long growing season – weeds germinate and establish throughout the growing season. Managing weeds is always challenging as new flushes of weeds come up after every rainfall event. In our crop productions systems (corn, soybean, and cotton), we have no choice but to employ multiple tactics (fall herbicide application, herbicide-resistant traits, cultivation, chopping escaped weeds, like we're doing today) to keep fields free of weeds. A fall application of herbicides or the use of cover crops greatly helps to suppress two of our most problematic weeds, horseweed and Italian ryegrass, from establishing in the following season.

WSN: You say management of weeds is always challenging. What changes have you seen over the years that are helping growers better address the challenges?

Krishna: From my observations for three major crops (corn, soybean, and cotton) grown in the Mississippi Delta, the current weed management tactics look a lot more like the ones used in the past, that is, the pre-HR crop era.

Herbicides continue to be the most effective and time-efficient method of weed control and the preferred choice by farmers. The mid-1990s to early 2000s was dominated by glyphosate-resistant crops and this overreliance resulted in the evolution of resistant weed biotypes, which created a niche for multiple herbicide resistant crops. Currently, farmers are planting more multiple herbicide resistant crops than when they only had glyphosate-resistant crops, which is allowing them to use new herbicide mixtures with multiple sites of actions. Considering the increasing number of resistant weed biotypes, securing diversity in weed management is a key factor for delaying evolution of herbicide resistance.

Most farmers plant into weed-free fields, and then keep fields as weed free as possible. Several weed management tactics other than herbicides that have increased are: crop rotation among major row crops, cultivation both prior to and during the growing season, planting in twin rows (vs single rows) for faster canopy closure and weed suppression, and conversations about conservation and cover crop production systems.

While cover crops can suppress weeds, the approach essentially requires growing an additional crop with no harvestable produce and higher input costs (e.g., seed, planting, and desiccation). Cover crops do offer positive attributes in terms of agronomics, but adoption is slow or negligible for economic reasons. Robotics and detect and spray technologies are still in the research phase and probably have a long way to go in our agronomic crops.

WSN: This is a great perspective and you have obviously seen a lot during your time as a weed scientist with ARS. One thing you may not get asked very often is what got you into weed science? And let's end with you sharing your advice for others thinking about a career in the field.

Krishna: My reflections on what got me into weed science: My dislike for the drudgery of hand weeding drove me to weed science. I was born and raised on the farm. I used to help my dad in farm operations while pursuing my education. Weed control in those days was purely by hand weeding and it was never ending as my dad use to grow at least two main crops a year. Weed science in those days was still in its infancy and I vividly remember talking about three herbicides: 2,4-D, atrazine, and gramoxone. My curiosity in chemical weed control as a replacement for the hard work of hand weeding led me to explore more about weed science. By the time I was ready to pursue my Ph.D., I determined that weed science was my destination. The rest is history – here I am now.

My advice to students who want to pursue weed science: Weeds have been with us since the dawn of civilization and are not likely to disappear, despite use of the best weed management tactics. In the "perpetual land of weeds" – weed scientists will always be in perpetual need and in high demand. The field of weed science is much bigger than just chemical weed control (as many widely believe). It's above and beyond herbicides. If you're interested in working with weeds, you can choose to specialize in a wide range of topics, such as weed biology, ecology; aquatics, terrestrials, invasives, herbicides, IWM, agronomics; robotics, molecular biology, genetics, drones, remote sensing imagery, AI/ML, precision weed control and the list goes on. Career paths for graduates in weed science include academia, industry, and state and federal government. Above all, one can have a personal satisfaction of ensuring food security for billions of people on the planet just be by keeping a check on weeds.

WSN: That is excellent motivation for working in weed science and some very sage advice. Thanks for your time. Great talking with you!

ARS WEED SCIENCE EVENTS, POSITIONS, AND PAPERS

ARS Meetings/Conferences/Webinars/Symposia

- **2022 WSSA-ARS Weed Science Webinar Series** – All 10 webinars from the series were recorded and are now available free for viewing. Website: https://www.ars.usda.gov/crop-production-and-protection/crop-protection-and-quarantine/docs/weed-science-webinar-series/

ARS Weed Science Positions

- Recent Hires:
    - Dr. Mark Bernards – ARS Soil Management Research Unit, Morris, Minnesota
    - Dr. James Kim – ARS Sugarbeet and Potato Research Unit, Fargo, North Dakota
    - Dr. Dale Halbritter – ARS Invasive Plant Research Lab, Fort Lauderdale, Florida

- Completed Searches:
    - Chemist – ARS Natural Products Utilization Research Unit, Oxford, Mississippi
    - Weed Scientist – ARS Crop Production Systems Research Unit, Stoneville, Mississippi
    - Research Leader – ARS Invasive Plant Research Lab, Fort Lauderdale, Florida

- Current Openings:
    - Aquatic Invasive Plant Ecologist – ARS Invasive Species and Pollinator Health Research Unit, Albany, California (6-12-23 to 7-11-23): https://arscareers.usajobs.gov/job/731291100
    - Weed Geneticist – ARS Wheat Health, Genetics, and Quality Research Unit, Pullman, Washington (6-21-23 to 7-21-23): https://www.usajobs.gov/job/732775300
    - Weed Ecologist – ARS Columbia Plateau Conservation Research Center, Pendleton, Oregon (TBD)

- Weed Scientist – ARS Northwest Sustainable Agroecosystems Research Unit, Pullman, Washington (TBD)

Select ARS Papers – recently published by researchers in weed science

- Walsh CG, AJ Sosa, F Mc Kay, M Maestro, M Hill, HL Hinz, Q Paynter, **PD Pratt**, S Raghu, R Shaw, **PW Tipping**, RL Winston (2023) Is biological control of weeds conservation's blind spot? The Quarterly Review of Biology 2023 98:(1)1-28
- Knight IA, Harms NE, Reddy AM, **Pratt PD** (2023) Multivariate evaluation of cold tolerance in domestic and foreign populations for addressing climate mismatch in biological control of *Alternanthera philoxeroides* in the USA. *Entomologia Experimentalis et Applicata* 00: 1– 15.
- **Grewell BJ**, Gallego-Tévar B, Bárcenas-Moreno G, Whitcraft CR, Thorne KM, Buffington KJ, Castillo JM (2023). Phenotypic trait differences between *Iris pseudacorus* in native and introduced ranges support greater capacity of invasive populations to withstand sea level rise. *Diversity and Distributions*, 29: 834–848
- **Gaskin, J.F.**, Cortat, G. & **West, N.M.** Vegetative versus sexual reproduction varies widely in *Convolvulus arvensis* across western North America. *Biol Invasions* **25**, 2219–2229 (2023).
- Bishwa B. Sapkota, Sorin Popescu, Nithya Rajan, Ramon G. Leon, Chris Reberg-Horton, **Steven Mirsky** & Muthukumar V. Bagavathiannan (2022) Use of synthetic images for training a deep learning model for weed detection and biomass estimation in cotton. Scientific Reports volume 12, Article number: 19580
- Singh, M., Thapa, R., Kukal, M., Irmak, S., **Mirsky, S.**, & Jhala, A. (2022). Effect of water stress on weed germination, growth characteristics, and seed production: A global meta-analysis. *Weed Science, 70*(6), 621-640.
- Hussain MI, F Araniti, M Schulz, **Scott Baerson**, Y Vieites-Álvarez, L Rempelos, P Bilsborrow, N Chinchilla, FA Macías, LA Weston, MJ Reigosa, AM Sánchez-Moreiras (2022) Benzoxazinoids in wheat allelopathy – From discovery to application for sustainable weed management. Environmental and Experimental Botany 202:104997
- Nestle R, J. Palacios, A.S. David, Q.D. Read, **G.S. Wheeler** (2023) The Brazilian peppertree biological control agent *Pseudophilothrips ichini* (*Thysanoptera: Phlaeothripidae*) displays a flexible feeding strategy between foliage and reproductive tissues. Biological Control 179: 105159
- **Halbritter DA**, **MB Rayamajhi**, **GS Wheeler** (2023) Biocontrol bites biocontrol: potential interference of the Brazilian Peppertree biological control thrips *Pseudophilothrips ichini* (Thysanoptera: Phlaeothripidae) by *Montandoniola confusa* (Hemiptera: Anthocoridae) Florida Entomologist, 106(1), 51-55
- Paul T. Madeira, Rodrigo Diaz, **F. Allen Dray**, **Min B. Rayamajhi**, **Ellen Lake** & **Melissa Smith** (2023) Population genetics comparison of *Lilioceris cheni* (Coleoptera: Chrysomelidae) colonies released onto *Dioscorea bulbifera* in Southeastern U.S.A. Biocontrol Science and Technology, 33:5, 429-447
- **Copeland, Stella M.**, David L. Hoover, David J. Augustine, **Jonathan D. Bates**, **Chad S. Boyd**, **Kirk W. Davies**, **Justin D. Derner**, Michael C. Duniway, **Lauren M. Porensky**, **Lance T. Vermeire** (2023) Variable effects of long-term livestock grazing across the western United States suggest diverse approaches are needed to meet global change challenges. *Applied Vegetation Science*, 26, e12719.
- Crist MR, Rick Belger, **Kirk W. Davies**, Dawn M. Davis, James R. Meldrum, Douglas J. Shinneman, Thomas E. Remington, Justin Welty, Kenneth E. Mayer (2023) Trends, impacts, and cost of catastrophic and frequent wildfires in the sagebrush biome. Rangeland Ecology & Management ISSN 1550-7424

- **Davies KW**, **C.S. Boyd**, O.W. Baughman, D.R. Clenet (2023) Effects of Using Indaziflam and Activated Carbon Seed Technology in Efforts to Increase Perennials in *Ventenata dubia*–Invaded Rangelands. Rangeland Ecology & Management 88:70-76
- Baughman OW, Eshleman M, Griffen J, Rios R, **Boyd C**, Kildisheva OA, et al. (2023) Assessment of multiple herbicide protection seed treatments for seed-based restoration of native perennial bunchgrasses and sagebrush across multiple sites and years. PLoS ONE 18(3): e0283678
- Davies KW, Jon D. Bates, Chad S. Boyd (2023) Is Crested Wheatgrass Invasive in Sagebrush Steppe with Intact Understories in the Great Basin? Rangeland Ecology & Management ISSN 1550-7424
- **Svejcar, L. N.**, **Davies, K. W**., & Ritchie, A. L. (2023). Ecological restoration in the age of apocalypse. *Global Change Biology*, 00, 1– 5.
- Muscha, J.M., **Vermeire, L.T.** and **Angerer, J.P.** (2023) Fire reduces Russian olive seed germination and seedling survival with increasing fuel load. Restor Ecol e13904.
- **Clements CD**, Dan N. Harmon, Robert R. Blank (2022) Seed mix performance and cheatgrass suppression on arid rangelands. Rangelands 44:129-135
- **David Archer, David Toledo, Dana M. Blumenthal, Justin Derner, Chad Boyd, Kirk Davies, Erik Hamerlynck, Roger Sheley, Pat Clark, Stuart Hardegree, Fred Pierson, Charlie Clements, Beth Newingham, Brian Rector, John Gaskin, Carissa L. Wonkka, Kevin Jensen, Tom Monaco, Lance T. Vermeire, Stephen L. Young** (2023) Invasive annual grasses—re-envisioning approaches in a changing climate. Journal of Soil and Water Conservation Feb 2023: 00074
- **Campbell, Joshua W., Michael R. Fulcher, Brenda J. Grewell, Stephen L. Young** (2023) Climate and pest interactions pose a cross-landscape management challenge to soil and water conservation. Journal of Soil and Water Conservation Mar 2023, 78 (2) 39A-44A