PROCEEDINGS

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These proceedings are dedicated to Dr. Phil Banks, in recognition of his unwavering devotion and invaluable contributions to the Western Society of Weed Science.

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2023

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 76

PAPERS PRESENTED AT THE ANNUAL MEETING

FEBRUARY 27-MARCH 3, 2023

Boise Centre West

Boise, Idaho

PREFACE

The Proceedings contain the written abstracts of the papers and posters presented at the 2023 Western Society of Weed Science and Western Aquatic Plant Management Society joint annual meeting plus summaries of the research discussion sections for each WSWS Project. The number located in parenthesis at the end of each abstract title corresponds to the paper/poster number in the WSWS/WAPMS Meeting Program. Authors are indexed separately. Index entries are published as received from the authors with minor format editing.

This e-document is available at the WSWS website **(www.wsweedscience.org**) or from the WSWS Business Manager, 12110 Pecos Street, Suite #220, Westminster, CO 80234 (**info@wsweedscience.org**). Print copies may be ordered from Curran Associates (**http://www.proceedings.com/agriculture-conference-proceedings.html**) 866-964-0401.

The Minutes of the Board of Directors meetings and the Business Meeting are available at the WSWS website.

The WSWS would like to thank André Lucas Simões Araujo – Colorado State University who graciously volunteered his time and talents to furnish many of the award photographs included in this publication.

Proceedings Editor: Carl Libbey

GENERAL SESSION

Introductions and Announcements. Curtis Rainbolt*; BASF, Meridian, ID (130)

Abstract not available

WSWS Presidential Address. Joel Felix*; Oregon State University Malheur Experiment Station, Ontario, OR (131)

While preparing for this Presidential Address, I read through previous president's addresses and the common theme was how WSWS members value the society and the uniqueness of this group. Members care for each other and are a welcoming lot. Another common theme was presidents talking about themselves, and I am not going to be an exception. But first, a few housekeeping items.

As you are well aware, this is a joint meeting with our colleagues from the Western Aquatics Plant Management Society (WAPMS). The Boise Centre will be our venue for the duration of the 2023 annual meeting. The Boise Centre is an excellent facility with spacious rooms and state of the art equipment to facilitate our presentations and displays. I will be remiss not to extend my sincere gratitude to the 2022/23 Local Arrangements groups led by the Committee Chair, George Newberry, assisted by Albert Adjesiwor. They did all of the legwork to inspect the facilities, send out instructions how to access the Grove Hotel (which is separate and just across from the Boise Centre), print signs, and make sure poster display boards are in place.

Thank you for trusting me with the responsibilities to serve as the WSWS leader during 2022/23. It has been a pleasure to serve as the society president and this is an experience I will always cherish. Special thanks to all members of the WSWS Board of Directors for their service to the society and for their inputs during the preparations for the 2023 meeting; Curtis Rainbolt, President-Elect and Program Chair; Sandra McDonald, Immediate Past President; Joe D. Vassios, Secretary; Phil Banks, Treasurer; Harlene Hatterman-Valenti, Research Section Chair; Jane Mangold, Education & Regulatory Chair; Grace Flusche Ogden, Student Liaison Chair; Alan Helm, WSSA Representative; Gregory Dahl, CAST Representative; Sonia Rios, Member-At-Large (Public Sector); Clarke Alder, Member-At-Large (Private Sector); Eric Gustafson, WSWS Business Manager; D. Chad Cummings, Constitution and Operating Procedures Representative; Marcelo Moretti, Research Section Chair-Elect; Nevin Lawrence, Education & Regulatory Section Chair-Elect; and Aaron Becerra-Alvarez, Student Liaison Chair-Elect.

We are indebted to the WSWS Sustaining Members whose contributions help to support various activities during the meeting. The 2023 WSWS Sustaining Members are; AMVAC Chemical Corporation, BASF Corporation, Bayer CropScience, Corteva AgriScience, FMC Corporation, Gowan Company, R&D Sprayers, Syngenta Crop Protection, UPL-Ltd., Valent U.S.A, and Winfield United. Additionally, several companies volunteered to sponsor meeting breaks, receptions, luncheon, and the business breakfast. These include BASF Corporation, Bayer CropScience, Corteva AgriScience, FMC Corporation, Gowan Company, Hubbard Ag Science, Jemmett Cons. & Research, Miller Research, Nufarm, Rolfs & Adkins Research, SePRO Corporation, Syngenta Crop Protection, The Amalgamated Sugar Company, UPL-Ltd, Valent U.S.A., VARCO, Winfield United, and WSWS.

So, with that, welcome to the 76th WSWS meeting at the Boise Centre, Boise, Idaho. The 2023 WSWS meeting marks the 2nd in-person gathering post the COVID-19 pandemic lockdown! The

2022 WSWS annual meeting in Newport Beach, California was the 1st in-person meeting out of the pandemic and by all measures it was a success. The 2022 meeting in Newport Beach marked the 75th meeting (not anniversary) of the WSWS. The theme for that meeting was to 'celebrate the past and look forward to the future'. Highlights from the 2022 General Session included; WSWS History: Building on the Past for the Future, presented by Vanelle Petersen; A future Shaped by our Past I: Teaching Weed Science in the West, presented by Andrew Kniss, University of Wyoming; and A Future by our Past II: Research and Extension in the West, presented by Jane Mangold, Montana State University (https://wsweedscience.org/wp-content/uploads/WSWS-Proceedings-2022-v2.pdf - pages 5 to 20)

The 2023 WSWS/WAPMS joint meeting has 245 registrants (176 WSWS Regular Members, 29 WSWS Students, 8 WSWS Retired or Fellows, and 32 WAPMS members). The WSWS paid members in 2023 stood at 253. The WSWS member composition has fluctuated over the years. At the inception on the society in 1938, membership and meeting participation was overwhelmingly dominated by Agencies (Federal, State, and County participants) with negligible participation from Industry and Academia personnel. However, in a turn of events, at around 1970, membership was dominated by Industry members followed by Academia and less than 20% from Agencies! This was likely a result of a boom in agricultural product development. Starting at about 1994 to the present, the WSWS membership is overwhelmingly composed of Academia staff, about 30% Industry, and about 12% Agency participants. The decline in Industry participation was likely fueled by company consolidations and possibly the decline in different company Research and Development budgets. Similarly, Agency participation declined because of reduced Federal, State, and County government funding in recent years. That said, the total number of meeting participants has grown from 24 in 1944 to 305 in 2021.

So, now, I will take a moment to describe some of my experiences and professional journey. I arose to become the 2022/23 WSWS president from a humble beginning. I was born, raised, and educated in Tanzania. My home village, Kihororo, is about 42 km (28 miles) north of Bukoba town that serves as the administrative center for Kagera region, which lies on the west coast of Lake Victoria. My involvement in agriculture goes back to the early years when my siblings and I helped at our small family farm by picking coffee, which is a major cash crop in area. I do not miss picking coffee! Picking coffee could be a laborious chore because of selective picking of ripe berries (in order to maintain high quality), but also occasional stings from wasps or hornets that build nests in bushy coffee trees! I left home to pursue college education and upon graduation I was sent to the Ilonga Agricultural Research station in the Morogoro region in Tanzania. I was assigned to the sorghum improvement section where I served as a junior Field Officer responsible with setting up experiments that were designed by senior Research Officers, recording data, preparing reports, and attending annual meetings. Ilonga is one of the 9 Agricultural Research Centers and 8 Sub Centers in Tanzania and it is situated about 10 miles east of Kilosa town in Morogoro region. The station was charged with responsibilities to lead food crops research including maize, sorghum, legumes (cowpeas, dry beans, and soybean), and sunflower. The staff included several PhDs, MSc, BSc, Diploma (equivalent to an associate degree in the United States), and Certificate in agriculture. Though in rural setting, the station had all of the necessities including piped water, electricity, and entertainment centers.

I later was awarded a scholarship to further my education in the United States. I arrived at Purdue University in West Lafayette, Indiana during the summer of 1988 and the campus was deserted! Then things got busy and fast when the fall semester commenced and students returned to campus. After earning a Bachelor of Science degree in Crop Production and Physiology, I remained at

Purdue University and embarked on a quest to earn a Master of Science degree under the guidance of Drs. James J. Vorst and Dave Mengel. Upon successful completion of my MSc degree, I was awarded a Research Assistantship position at Iowa State University in Dr. Micheal D. (Mike) Owen weed management program. Mike had a vibrant program with 12 graduate students at the time! The list included Harlene Hatterman-Valenti (now with North Dakota State University) Tony White (now with Bayer Cropscience) who are known WSWS members, and many others now in industry or academia settings. We studied weed seedbanks in different cropping systems, herbicide function (understanding the role cytochrome p450 in herbicide function and herbicide resistance was big at the time). Among notable individuals with interest and studied seedbanks at the time were Dr. Doug Buhler (at the time with USDA, Ames, Iowa), Dr. Robert (Bob) Hartzler, and Dr. Frank Forcella (at the time with USDA Morris, Minnesota). Then Dr. Matt Liebman joined the Agronomy Department and brought along his graduate student at the time, Adam Davis. Matt and Dr. Eric Gallandt had previously coined the 'many little hammers' concept to manage weeds while they were together in Maine. The many little hammer concept described how adding more weed control tactics – even if they are less effective than herbicides, can have a powerful combined effect. So, Matt and Adam largely studied non-herbicide methods to manage weeds in various cropping systems. Then Roundup Ready® corn and soybean were commercialized and it didn't take long to identify weeds that had quickly developed resistance to the herbicide. Research efforts ensued to unravel the mechanism of glyphosate resistance in weeds. Mike's lab was among the first if not the first to identify glyphosate resistance in waterhemp in Iowa! Glyphosate resistant horseweed (*Conyza* spp) had earlier been identified in Delaware by Dr. Mark VanGessel.

Upon successful completion of my study program at Iowa State University and being awarded a Ph.D. in Crop Physiology with emphasis in Weed Science, I accepted a Postdoctoral Researcher position at the Ohio State University in Wooster, Ohio. There I joined Dr. Douglas Doohan who had recently started his position as a Weed Scientist to manage weeds of vegetable crops. We researched weed management in bell pepper, processing and fresh market tomato, potato, and sweet corn. We also worked closely with Dr. John Cardina, a renowned weed scientist who studied weed management in various cropping systems.

So, the preceding paragraphs should serve as a testimony that during my educational phase and years as a postdoctoral researcher I was lucky to be mentored by exceptionally accomplished weed scientists. I look back to my years at Purdue University, Iowa State University, and the Ohio State University with fondness and cherish all my mentors who made me the weed scientist I am today.

I assumed my current position at Oregon State University Malheur Experiment Station on December 28, 2006. My program conducts research on weed management in onion, corn, wheat, sugar beet, dry beans, teff and other emerging crops. Strategies to manage yellow nutsedge (*Cyperus esculentus* L.) in onion cropping systems have dominated my research efforts as it had for my predecessors (Drs. Corey Ransom and Charles Stanger). I have had the privilege of having a very knowledgeable technician in Joey Ishida who has been at the station for many years long before my arrival. I have been fortunate to work very closely with my colleagues on campus in Corvallis, Oregon both in Crop and Soil Science and Horticulture departments as well as other weed scientists in the Pacific Northwest Region.

Finally, I would like to thank the members who are rotating off the WSWS Board including Sandra McDonald, Immediate Past President; Phil Banks, Treasurer; Harlene Hatterman-Valenti, Research Section Chair; Sonia Rios, Member-At-Large (public sector); Jane Mangold, Education & Regulatory Section Chair; and Grace Flusche Ogden, Student Liaison Chair. Last but definitely not the least, heartfelt thanks to my 'home team'. My wife and children have managed to travel

the west including enjoying the Oregon Coast (along the way passing and posing for photographs at the road sign reading '45th Parallel, HALF WAY BETWEEN THE EQUATOR AND THE NORTH POLE') and together at various meeting places including Chicago, Puerto Rico, Hawaii, and many other places. They form a big part of who I am and thankful that they have put up with me for all these years!

Thanks for your indulgence and for attending the 76th meeting of the WSWS in Boise and I hope you learn from the presentations, meet new acquaintances, socialize, and enjoy the City of Boise. I thank you!

WAPMS Presidential Address. Doug Kleweno*; Cygnet Enterprises, Inc., Camas, WA (132)

Abstract not available

Women of Aquatics Update. Amy Kay*; SOLitude Lake Management, Trout Valley, IL (133)

Abstract not available

Aquatic Ecosystem Restoration Foundation Update. Carlton Layne*; Executive Director, AERF, Marietta, GA (134)

Abstract not available

Aquatic Plant Management Society Update. (135)

Abstract not available

DC Update. Lee Van Wychen*; WSSA – Executive Director of Science Policy, Alexandria, VA (136)

Abstract not available

Challenges and Adaptive Management Opportunities in Breaking the Exotic Annual-Grass Fire Cycle. Matthew Germino*; Supervisory Research Ecologist, US Geological Survey, Boise, ID (137)

Abstract not available

Facing Water Management Challenges Throughout the West – Federal Perspective. Roland Springer and Rob Skordas*; Deputy Regional Directors, Columbia-Pacific Northwest Regional Office, Bureau of Reclamation, Boise, ID (138)

Abstract not available

POSTER SESSION

WSWS Committee Informational Posters

Necrology: WSWS Member Remembrance 2023. Rachel Seedorf*; Aero Applicators, Sterling, CO (129)

Abstract not available

Aquatics

Aquatic Photosynthetic Organisms. Luke C. Huffman*; University of Wisconsin, Madison, WI (001)

Hydrophytes, Seaweeds, and Allies: a whimsical guide to Aquatic Photosynthetic Organisms (APOs) is an informal textbook that I wrote to fill the gap of general misinformation on aquatic photosynthetic organisms, and lack of information to the general public. Much of the research going into it consisted of relevant semantics and taxonomy, ecological surveys, and basic demographic surveys. Additionally, I compiled a large amount of natural and cultural history from multiple sources on many of the aquatic plant families, genera, and species. The grant received from the WAPMS is aiding in the cost of travel to this conference as well as paying for publishing costs.

WSWS Project 1. Weeds of Range, Forestry, and Natural Areas

Annual Grass Control and Plant Community Response to Aerial Application of Indaziflam: 2-years Post-treatment. Georgia R. Harrison*, Lisa C. Jones, Eva K. Strand, Timothy S. Prather; University of Idaho, Moscow, ID (002)

Invasive annual grasses such as cheatgrass (*Bromus tectorum)* negatively impact western rangelands by outcompeting native plants and altering fire frequency and intensity. The herbicide indaziflam has a long soil residual which can deplete invasive plant seedbanks while releasing remnant native plants from competition. We established a study near Hailey, Idaho in Mountain Big Sagebrush (*Artemisia tridentata ssp. vaseyana*) plant communities to assess plant community response to indaziflam treatment. Indaziflam was applied to 19 ha at 47 L/ha by helicopter in September 2020. We stratified the study area into plant community types based on remotely sensed estimates of shrub and perennial herbaceous vegetation cover and located 32, 900 m^2 permanent assessment plots within treated and untreated areas. We measured foliar cover and fuel continuity one and two years post-treatment along 3, 30-m long transects per plot. Fuel continuity was assessed by measuring vegetation gaps greater than 20 cm. Indaziflam treatment significantly reduced annual grass foliar cover across all plant community types (mean untreated cover: 11% and 38%; treated cover: 4% and 10% in 2021 and 2022, respectively), and annual grass control was highest two years after treatment. Annual grass control was maintained even in high shrub cover. We observed higher species richness and diversity two years after treatment, but no differences between treated and untreated plots. There were no differences in vegetation gap size or abundance between treated and untreated plots. This research supports the use of indaziflam for reducing annual grasses without decreasing species richness of native plant communities.

Response of Seeded Species to Three Common Herbicides Used for Downy Brome Control. Melissa L. Landeen*[1], Kevin Gunnell[1], Weston Maughan[2]; [1]Utah Division of Wildlife Resources, Ephraim, UT, [2]Utah State University, Logan, UT (003)

Chemical control of downy brome is one of the primary tools employed to restore degraded rangelands in Western North America. However, many herbicides used to control downy brome may also inadvertently inhibit germination of desirable seeds planted following chemical treatment. We evaluated three herbicides: Imazapic (Plateau®), Indaziflam (Esplanade®), Rimsulfuron (Matrix®) and Indaziflam/Rimsulfuron in combination. We compared each product's ability to control downy brome over multiple (2) years, as well as the unintended inhibition of seeded species in treated areas one or two years after chemical application. Six common restoration species (bluebunch wheatgrass, Siberian wheatgrass, blue flax, alfalfa, Wyoming big sagebrush, and forage kochia) were seeded into treatment areas either the same year as herbicide application (single entry), one year following herbicide application (multiple entry), or immediately prior to herbicide application (sprayed after seeding). Downy brome cover and density of seeded species within each treatment was measured the following spring. While Indaziflam consistently achieved the highest and most consistent control of downy brome in both the single and multiple entry treatments, it substantially inhibited emergence of all seeded species, even two years (multiple entry) after chemical application. Imazapic achieved moderate control of downy brome in the single entry treatment, but control was not maintained in the multiple entry treatment. However, Imazapic also had the least severe inhibition on emergence of seeded species in the single entry treatment, and was similar to Rimsulfuron in the multiple entry treatment. Rimsulfuron achieved the highest control of downy brome in single entry treatments of individual herbicides, but with a corresponding high inhibition of seeded species. Rimsulfuron had similar control and inhibition on seeded species as Imazapic within the multiple entry treatment, but with some differentiation in control and inhibition among sites and species, respectively.

Managing Tall Oatgrass: It's Not the Cow, It's the How. Kelly T. Uhing*, Ryan Middleton, Ann Lezburg; City of Boulder Open Space and Mountain Parks, Boulder, CO (004)

Abstract not available

Managing Invasive Annual Grasses with an Indigenous Integrated Perspective. Ian I. McRyhew*; Montana State University, Polson, MT (005)

A complex of invasive annual grasses threaten the remnant Palouse prairie grasslands in northwestern Montana, which provide habitat for culturally important species for the local Séliš , Ksanka, and Ql?ispé Tribes, including pollinator habitat and forage for wildlife and livestock. This project tested tolerance of culturally significant species to herbicides commonly used to control annual grasses, with a goal to increase abundance of native grasses, forbs, and shrubs. We tested individually six herbicides and nine species. Treatment combinations were arranged in a strip-plot design and replicated three times at two sites on the Flathead Reservation. Herbicide treatments were applied October 2021 and seeding occurred March 2022. Canopy cover of annual grasses and density of seeded species were sampled summer 2022. Invasive annual grass cover in the non-sprayed control ranged from 20% to 57% across both sites. At both sites, rimsulfuron and sulfosulfuron had the greatest effect on annual grass cover, reducing cover to 2.8% and 3.1%, at one site, and 0.5% and 15.2%, respectively, at the other site. Propoxycarbazone, imazapic, and glyphosate had much less control on both sites; however, annual grass cover was still less than the non-treated control. Indaziflam was applied in August 2022, and its efficacy will be assessed in 2023. Seeded species were not evident the first growing season. Seeded species density and annual

grass cover will be sampled again in 2023 along with pollinator visitation to seeded species, informing restoration of ecosystem services that are vital to the future of Tribal food sovereignty systems.

Evaluating Pyraflufen-ethyl for Rangeland Weed Control. Jaycie N. Arndt*[1], Beth Fowers[2], Brian A. Mealor[3], Jane Mangold[4]; [1]University of Wyoming, Arvada, WY, [2]University of Wyoming, Sheridan, WY, [3]University of Wyoming Department of Plant Science, Laramie, WY, [4]Montana State University, Bozeman, MT (006)

Pyraflufen-ethyl is a group 14 PPO inhibitor. It is a nonselective contact herbicide commonly used on difficult to control broadleaf weeds. It is safe for riparian zone use and has no grazing restrictions. Previous research shows that pyraflufen-ethyl + 2,4-D may control leafy spurge when applied once per season for three consecutive years. We evaluated pyraflufen-ethyl control on leafy spurge (*Euphorbia esula*), Scotch thistle (*Onopordum acanthium*), houndstongue (*Cynoglossum officinale*), and on perennial grass injury. The Scotch thistle and houndstongue trials took place near Sheridan, Wyoming. The leafy spurge and perennial grass safety trials were replicated in Montana and Wyoming. We compared pyraflufen-ethyl (5.2 g ai ha^{-1}) + 2,4-D (1120 g ae ha^{-1}) and aminocyclopyrachlor (105 g ae ha^{-1}) control for Scotch thistle and houndstongue. We applied pyraflufen-ethyl + 2,4-D, aminocyclopyrachlor, picloram (1120 g ae ha^{-1}), imazapic (105 g ai ha^{-1}) + saflufenacil (25 g ai ha^{-1}), and quinclorac (840 g ai ha^{-1}) to the leafy spurge trials. We applied pyraflufen-ethyl + 2,4-D, aminocyclopyrachlor, picloram, imazapic (123 g ai ha^{-1}), and quinclorac to the grass safety trials. We applied all treatments in June 2022 and evaluated treatments throughout the 2022 summer. Pyraflufen-ethyl + 2,4-D caused no perennial grass damage. Pyraflufen-ethyl + 2,4-D provided 50% Scotch thistle and houndstongue control 7 days after treatment (DAT) and 75% and 90% control, respectively, 43 DAT. Pyraflufen-ethyl + 2,4-D showed 80-100% control on leafy spurge 2 WAT, but control diminished to 55-85% control 7 WAT, and by mid-September visual control had reduced to less than 70% at both sites. Future work will include evaluating control in 2023 and evaluating repeated applications of pyraflufen-ethyl for two more years.

Cheatgrass (*Bromus tectorum* L.) Control and Secondary Invasion at Dinosaur National Monument. Emily Spencer[1], Alexandra Stoneburner*[2], Jordan Spaak[2]; [1]National Park Service, Vernal, UT, [2]National Park Service, Fort Collins, CO (007)

Abstract not available

Testing Barrier-created Safe Sites for Revegetation Purposes in Indaziflam-treated Areas. Weston Maughan*, Corey V. Ransom; Utah State University, Logan, UT (008)

Indaziflam has proved itself an invaluable tool in managing invasive annual grasses that plague the Western US's rangelands; however, its preemergence mode of action makes revegetation seeding efforts difficult and often unsuccessful. This study explored different methods of creating safe sites around revegetation seeding rows. Siberian wheatgrass (*Agropyron fragile* var. Vavilov II) and small burnet (*Sanguisorba minor* var. Delar) were planted in 46 cm long rows with 2.5 cm spacing. Safe sites were created above seed rows using combinations of cardboard strips (0-, 2.5-, and 5-cm) and 2.5-cm wide bands of activated charcoal (0 and 448 kg ha-1) for seven total treatments. Using a spray chamber, indaziflam was applied at a rate of 44 g ai ha-1 to all treatments, save untreated control. Seedling germination counts were collected at 7, 11, 14, 18, and 21 DAT. For wheatgrass, seedling counts in the 2.5-cm safe site plus carbon and 5-cm safe site plus carbon treatments were significantly higher than the untreated control at 18 and 21 DAT ($P = 0.05$). The carbon banding only treatment was statistically similar to both of the other carbon-inclusive

treatments and the untreated control. Seedling counts in the 5-cm safe site treatment were significantly higher than the 2.5-cm safe site and indaziflam without carbon banding or herbicide exclusion throughout the trial; however, they were significantly lower than the untreated control. For small burnet, no statistical difference was found between the untreated control and any carbon-inclusive treatments.

WSWS Project 2. Weeds of Horticultural Crops

Electrical Weed Control in Organic Highbush Blueberry. Luisa C. Baccin*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (009)

Most of the United States' organic blueberry production is in the Pacific Northwest. Organically produced blueberries have fewer cost-effective weed control options. A combination of synthetic mulches, plastic weed mat, mowing, and hand pulling are commonly employed. Electric weed control (EWC) is a novel technology that delivers electric current to the weed foliage heating the plants, rupturing cell membranes, and destroying the vascular bundle, but information is needed on how to integrated EWC in organic blueberry. The objective is to evaluate the effect of speed and the number of applications on EWC efficacy in organic blueberries. Two field studies were conducted on a commercial organic blueberry farm in western Oregon in 2022. Treatments were applied using an electric weeder (Raiden, Zasso Group LLC) powered by a tractor take-off power. The unit has 6 KW power with self-adjustable voltage amperage, and electricity was applied to a 0.3 m band adjacent to the weed pat. The predominant weeds in the field were creeping fescue (*Festuca rubra*.), sharppoint fluvellin (*Kickxia elatine*), northern willowherb (*Epilobium ciliatum*) and lady's thumb (*Persicaria maculosa*). In the first study, weed biomass was reduced to 31%, 26%, and 22% compared to nontreated by a single application of an electric current of 11 amps at 1, 2, and 4 km h^{-1}, respectively. The lowest speed provided 90% weed control at 56 days after treatment. When comparing the effect of multiple applications in a second study, three applications at 4km h^{-1} controlled 83% at 42 DAT, followed by two applications at 3 and 2km h^{-1} with 79 and 78%, respectively. Treatments with a single application (1, 1.5 and 2km h^{-1}) resulted in weed control ranging between 69 to 73%, and new weed emergence was observed. Weed biomass reduction ranged from 44 to 64%, with all speeds differing from nontreated. These studies indicate electricity provided better control for broadleaves and did not affect the weed mat. Northern willowherb and lady's thumb had the best control among the species in the field. Sequential applications of EWC provided better control of tall fescue and it controlled newly emerged weeds. These results suggest that EWC is an effective tool for organic weed control.

Review of Weed Control Strategies for Desert Turfgrass. Kai Umeda*; University of Arizona, Phoenix, AZ (010)

Over the course of the year in desert turfgrasses, summer and winter annual grass weeds such as *Digitaria* spp. (crabgrasses), *Eriochola* spp. (cupgrasses), *Eleusine indica* (goosegrass), and *Poa annua* (annual bluegrass) occur as the most common problems. More recent problem grass weeds that have appeared are a summer annual, *Urochloa panicoides* (liverseedgrass), and a perennial, *Paspalum dilatatum* (dallisgrass). Few small-seeded summer broadleaved weeds such as *Chamaesyce* spp. (spurges) and *Portulaca oleracea* (purslane), and winter weeds in the families Brassicaceae (mustards, London rocket, shepherdspurse, etc.) and Asteraceae (sowthistles, wild lettuce, common groundsel) commonly invade lesser maintained turfgrasses. Some more difficult to control broadleaved weeds include *Malva* sp. (cheeseweed), *Polygonum* sp. (knotweed), *Conyza* sp. (fleabane), and *Alternanthera caracasana* ("khakiweed" or matt chafflower). *Cyperus* spp.

commonly infest desert turfgrasses and *C. rotundus* (purple nutsedge) is the most prolific and difficult to control sedge relative to *C. esculentus* (yellow nutsedge) and *Kyllinga* spp. Selective and nonselective annual grass weed control can be achieved with sequential preemergence herbicide applications plus a supplemental postemergence herbicide application against escape populations. Dinitroaniline herbicides are typically the foundation for selective preemergence grass control and other chemistries could be considered to alternate modes of action to avert the potential for development of herbicide resistance. Selective postemergence herbicides for annual grasses require timely applications to ensure successful and effective weed control in a safe manner. Broadleaved weed control can be achieved with a plethora of pre-mix products that contain various forms of phenoxies in combination with other chemistries to improve efficacy and broaden the weed spectrum. The versatile acetolactate synthase enzyme inhibiting herbicides alone or in combination offer weed control capabilities against grasses, broadleaved, and perennial weeds.

Indaziflam Resistance in Annual Bluegrass (*Poa annua* L.) from Hazelnut Orchards. Joshua W. Miranda*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (011)

Annual bluegrass (*Poa annua* L.) is a ubiquitous allotetraploid weed that has evolved resistance to 12 herbicide modes of action worldwide. During the spring and summer of 2022, we contacted hazelnut growers and field managers about annual bluegrass surviving preemergence application of indaziflam, a cellulose biosynthesis inhibitor. Eleven orchards were sampled to screen for indaziflam resistance in annual bluegrass. A seed-assay was developed for indaziflam resistance screening at concentrations ranging from 0 to 25,000 pico-Molar (pM), assessing plant survival and root elongation 10 days after assay establishment. A field study was initiated in November 2022 in a hazelnut orchard sampled to confirm seed-assay results at whole-plant level and evaluate alternative herbicide options for annual bluegrass management. Based on mortality, we determined a resistance level ranging from 10-fold to 2,337-fold the susceptible population, LD_{50} of 345 pM. All 11 annual bluegrass populations were classified as resistant to indaziflam based on the seed assay. The field study confirmed seed-assay results; the annual bluegrass population at the site survived early-POST (BBCH-1) applications of indaziflam up to 190 g ai ha^{-1} (twice the maximum labeled rate). Dichobenil, pendimethalin, diuron, flumioxazin, napropamide, pyroxasulfone, and fluridone with glufosinate as burndown applications controlled this annual bluegrass biotype. We are currently conducting whole-plant assays in all populations in the greenhouse. Resistance to indaziflam is novel, and no published information on the mechanism of resistance is available. Elucidating this mechanism is essential to develop management practices.

Evaluation of Fluridone in Christmas Trees. David R. King*, Ryan J. Hill, Marcelo L. Moretti; Oregon State University, Corvallis, OR (012)

The state of Oregon grew over 12,000 hectares of Christmas trees within almost 500 different farms in 2020, all of which together sold almost 3.5 million trees. The majority of Oregon-grown Christmas trees are Noble and Douglas Firs. Herbicides are the primary weed management strategy for Christmas tree growers, who need an increased diversity of herbicide modes of action to manage weeds and mitigate herbicide resistance selection. The objective of this study was to evaluate Christmas tree tolerance and weed control with Fluridone. Fluridone is a Group 12 phytoene desaturase inhibitor with preemergence activity. The study utilized four separate plot sites that included , two sites producing Douglas fir (*Pseudotsuga menziesii*), and two producing Nordman fir (*Abies nordmanniana)* in their second year after transplanting. The major weed species wild carrot (Daucus carrota) , rattail fescue (*Vulpia muyros*),, and false dandelion (*Hypochaeris radicata)*. Treatments were applied over the top of the trees. No affect on the growth

of leader shoots was observed with any treatment, but growth was affected by species and experimental sites averaging between 17 to 33 cm in Douglas fir and 7 to 17 cm in Nordman fir. Fluridone (450 g ai ha^{-1}) controlled 58% of rattail fescue (*Vulpia muyros*), and it did not control false dandelion (*Hypochaeris radicata)* (28%) at 120 DAT. And it was not different from the simazine plus oxyfluorfen, the standard treatment. Fluridone mixed with simazine plus oxyfluorfen improved control of false dandelion (73%) and rattail fescue (93%). Fluridone did not affect the efficacy of indaziflam, flumioxazin, or flazasulfuron compared to these herbicides used alone. The results of the study showed that fluridone (220-900 g ai/ha) applied over-the-top at planting was safe for all Christmas tree species that were evaluated and that adding fluridone to simazine and oxyfluorfen may improve weed control.

Evaluation of PPO Inhibitors Tank Mixes in California Orchards. Tong Zhen*[1], Seth Watkins[1], Brad Hanson[1], Marcelo L. Moretti[2]; [1]University of California, Davis, Davis, CA, [2]Oregon State University, Corvallis, OR (013)

According to California Department of Pesticide Regulation, over one million cumulative acres of California almond and walnut orchards were treated with oxyfluorfen in 2019. Tank mixes containing oxyfluorfen plus other active ingredients can potentially enhance weed control efficacy in orchards and provide growers with alternatives when rates of high volatile organic compound (VOC) formulations of oxyfluorfen are restricted by air quality regulations. Research conducted in orchards and fallow fields during 2012 focused on tank mixes of low VOC formulations of oxyfluorfen with other active ingredients (e.g., glyphosate and glufosinate) to enhance POST application efficacy. A fallow field trial, conducted in fall 2022 in Davis, focused on oxyfluorfen alone and in combination with carfentrazone-ethyl, flumioxazin, and saflufenacil. Treatments were evaluated up to 28 days after treatment (DAT) in 2012 and at 7, 14, 28, 60, and 98 DAT in 2022. Major weed species in the trials included hairy fleabane (*Conyza bonariensis*), field bindweed (*Convolvulus arvensis*), Italian ryegrass (*Lolium multiflorum*), filaree (*Erodium spp.*), malva (*Malva parviflora*), prostrate knotweed (*Polygonum arenastrum*), and sowthistle (*Sonchus oleraceus*). The 2012 data show that low VOC formulated oxyfluorfen tank mixed with glufosinate increased weed control efficacies against certain weed species. The 2022 data indicated that all treatments provided about 80% to 90% control of filaree and malva except 280 g a.i. ha^{-1} standalone oxyfluorfen provided a lower control.

Cranberry Response to Pyroxasulfone. David R. King, Ryan J. Hill, Marcelo L. Moretti*; Oregon State University, Corvallis, OR (014)

Oregon is among the top five cranberry producers in the United States, with 2,600 harvested acres in 2021. Herbicides are the primary weed management strategy for cranberry. Still, an increase in the diversity of herbicides is needed to help manage problematic weed species. Pyroxasulfone is a WSSA group 15 herbicide that controls grasses, sedges, and broadleaves. The present study investigated cranberry tolerance to pyroxasulfone (220-440 g ai ha^{-1}) alone or combined with sulfentrazone (420-840 g ai ha^{-1}) or flumioxazin (182– 363 g ai ha^{-1}) applied through simulated chemigation (1,500 L ha^{-1}). A study was conducted on a commercial cranberry field in Bandon, OR. Treatments were applied in February 2022, while the crop was dormant. Pyroxasulfone alone did not injure cranberry, at any rate, nor was upright shoot length affected by any treatment up to 150 days after treatment (DAT). Treatments including flumioxazin caused 5% injury in cranberry, and no injury was observed with sulfentrazone. Cranberry yield (average 2.1 kg m^{-2}) and fruit size were not affected by any treatment. Treatments containing flumioxazin controlled 60 to 82% of sphagnum moss at 150 DAT, while sulfentrazone and pyroxasulfone did not control sphagnum

moss. This research indicates that pyroxasulfone is safe for cranberry. The project will continue in 2023.

Comparing the Efficacy of Non-Selective Herbicides in Western Oregon and New Mexico. Clint M. Mattox*[1], Leslie L. Beck[2], Tim Stock[3], Bernd R. Leinauer[4], Alec R. Kowalewski[3]; [1]USDA-ARS, Corvallis, OR, [2]New Mexico State University, Los Lunas, NM, [3]Oregon State University, Corvallis, OR, [4]New Mexico State University, Las Cruces, NM (015)

In some municipalities, pesticide restrictions have resulted in the need to research herbicide alternatives; therefore, in spring 2022, a randomized complete block design field experiment replicated four times in Corvallis, OR and Las Cruces, NM took place on a mixed stand of turfgrass and broadleaf plants. Ten alternative contact herbicides and a water control were included. The experiment in Oregon took place from April 15, 2022, through June 10, 2022, and the experiment in New Mexico took place from May 25, 2022, to August 4, 2022. Applications were applied every two weeks for a total of four applications in Oregon and five applications in New Mexico using a CO_2 pressurized boom sprayer with a carrier volume of 814 liters per hectare. Images were collected using a camera mounted onto a light box and area under percent green cover progress curves (AUPGCPC) were built using the trapezoidal method. There was a significant location effect; therefore, data were analyzed separately by location. A treatment effect was significant ($P<0.001$) at each location and pair-wise comparisons were explored using Tukey's HSD. In both locations, the water control was in the group with the highest AUPGCPC. In Oregon, only the 5% mint oil + 5% sodium lauryl sulfate + 5% potassium sorbate was in the same group as the water control; however, in New Mexico, 5% mint oil + 5% sodium lauryl sulfate + 5% potassium sorbate, 1% clove oil, and 45% cinnamon oil + 45% clove oil were not different from the water control.

Delayed Preemergence Applications of Pendimethalin in New Mexico Onion. Brian Schutte*, Chris Cramer, Stephanie Walker; New Mexico State University, Las Cruces, NM (016)

Pendimethalin applied after onion germination but before onion emergence (i.e., "delayed preemergence application"; abbreviated, "delayed PRE") may be a means for controlling early season weeds in New Mexico onion. However, the efficacy and safety of delayed PRE pendimethalin in New Mexico onion is poorly understood. The objectives of this study were: 1) determine if delayed PRE pendimethalin causes crop injury and crop yield loss in New Mexico onion, 2) determine if delayed PRE pendimethalin results in residues greater than U.S. federal tolerances for pendimethalin on dry bulb onion, and 3) compare delayed PRE pendimethalin against herbicides registered for preemergence applications in New Mexico onion. To address these objectives, fall-seeded and spring-seeded onion were grown with subsurface drip irrigation on clay loam soil. Treatments included: 1) preemergence DCPA at 6.7 kg ha^{-1}, 2) preemergence bensulide at 6.7 kg ha^{-1}, 3) preemergence DCPA (6.7 kg ha^{-1}) with bensulide (6.7 kg ha^{-1}), 4) delayed PRE pendimethalin at 1.1 kg ha^{-1}, 5) delayed PRE pendimethalin at 0.53 kg ha^{-1} followed by pendimethalin (0.53 kg ha^{-1}) at onion 2-leaf stage, and 6) nontreated control. Results indicated that delayed PRE pendimethalin treatments (Treatments 4 and 5) did not cause crop injury, reductions in dry bulb onion yield, and dry bulb onions with detectable residues of pendimethalin. For fall-seeded onion, the most abundant weed species was London rocket (*Sisymbrium irio* L.). Treatments 4 and 5 (delayed PRE pendimethalin) were the only herbicide treatments that reduced weed densities relative to the nontreated control in fall-seeded onion. Pendimethalin-induced reductions in weed density at 132 d after onion seeding decreased the time required for hand weeding. For spring-seeded onion, the most abundant weed species was yellow nutsedge (*Cyperus esculentus* L.). No herbicide treatment reduced weed density or hand hoeing time compared to the nontreated control in spring-seeded onion. These results suggest delayed PRE pendimethalin is a

promising option for controlling annual weeds in New Mexico onion. Accordingly, delayed PRE pendimethalin may be suitable for registration in New Mexico onion.

Evaluation of Potential Preemergence Herbicides in California Orchard Crops. Andres Contreras*[1], Brad Hanson[2]; [1]University of California, Davis, Davis, CA, [2]University of California, Davis, CA (017)

Identification of potential tools for California orchard and vineyard weed management is an important aspect of the weed science discipline. This includes evaluating nonregistered preemergence herbicides such as pyroxasulfone and Exp-82 both inhibitors of very long-chain fatty acids (Group 15). Pyroxasulfone is registered for use in corn, soybean, and cotton in some Midwestern states of the United States. However, there is limited published literature on the use of pyroxasulfone in orchard systems. Crop safety and weed efficacy trials were carried out for the characterization of pyroxasulfone and Exp-82 under California conditions. Exp-82 was evaluated at rates of 145, 219, and 293 g ai ha^{-1} in a series of fallow ground trials initiated in fall 2020 and carried out into summer 2022. Orchard and vineyard trials were conducted in 2021 and 2022 to evaluate pyroxasulfone or Exp-82 at multiple rates compared to commercial standards in single and sequential application programs. A crop safety study was conducted to evaluate Exp-82 at 1,199 g ai ha^{-1} and S-metolachlor at 14,010 g ai ha^{-1} on 1-2 yr. old tree nut crops in spring 2021 and 2022. Pyroxasulfone and Exp-82 performed similarly to commercial standards with up to 95% control of broadleaf and grass weeds. Crop injury was not observed in the vineyard, mature orchard, or young orchard trials and there were no treatment effects on tree trunk diameter in the multi-year young tree crop safety study. These results indicate a potential opportunity for these herbicides in California vineyard and orchard systems.

Overview of Yellow Nutsedge Management in Washington State Potato Production. Rui Liu*[1], Tim Waters[2]; [1]Washington State University, Prosser, WA, [2]Washington State University, Pasco, WA (018)

Abstract not Available

WSWS Project 3. Weeds of Agronomic Crops

***Typha* Spp., Cattail, Response to Florpyrauxifen-benzyl in California Drill-Seeded Rice.** Deniz Inci*, Kassim Al-Khatib; University of California, Davis, Davis, CA (019)

Typha spp., cattail, is an aquatic weed growing up to three-meters-tall that can infest ditches, drainage and irrigation canals, lakes, marshes, ponds, rivers, and streams. *Typha* spp. has recently become an important weed in drill-seeded rice in the Sacramento-San Joaquin Delta region of California. Florpyrauxifen-benzyl is a new synthetic-auxin type rice herbicide newly registered in California. This research aimed to study the potential of using florpyrauxifen-benzyl for *Typha* spp. control. Field research was conducted at McDonald Island of the Delta region during the 2022 growing season. Treatments were florpyrauxifen-benzyl at 40 g ai/ha, triclopyr at 420 g ae/ha, florpyrauxifen-benzyl at 40 g ai/ha plus triclopyr at 420 g ae/ha, and florpyrauxifen-benzyl at 80 g ai/ha. Methylated seed oil at 584 ml/ha was added to all treatments. The study was a randomized complete block design with four replicates. Herbicides were applied on 2x2 m plots to a range of *Typha* spp. from two to three leaf growth stages up to two-meters-tall growth stages. Visual injuries were rated at 7, 14, 21, 28, 35, and 42 days after treatments using a scale where 0 means no injury and 100 means plant kill. All florpyrauxifen-benzyl treatments achieved 100% control when *Typha* spp. were up to one-meter-tall. However, when *Typha* spp. were one to two-meters-tall, the

efficacy was 75, 0, 78, and 96% for the listed treatments, respectively. This study showed that foliar applications of florpyrauxifen-benzyl would provide excellent control on *Typha* spp. up to one-meter-tall growth stages.

Rush Skeletonweed Control with Picloram Applied in Fallow with a Weed-sensing Sprayer. Drew J. Lyon*, Mark E. Thorne; Washington State University, Pullman, WA (020)

Rush skeletonweed is an invasive weed in winter wheat/summer fallow rotations in the low to intermediate rainfall areas of the inland Pacific Northwest. Picloram provides effective control of rush skeletonweed, but picloram use poses an injury risk to the following winter wheat crop. The objective of this study was to determine if picloram application with a weed-sensing sprayer in fallow could maintain rush skeletonweed control relative to broadcast applications and reduce risk for injury in the subsequent winter wheat. Field studies were conducted near Hay, WA (2019-2021) and LaCrosse, WA (2020-2022). Picloram was applied at four rates (0, 140, 280, and 560 g ae ha^{-2}) in the fall after wheat harvest or in the spring before wheat seeding with a weed-sensing or a broadcast sprayer. Rush skeletonweed density in each plot was counted in the winter wheat following picloram applications. Winter wheat was harvested for grain yield. Rush skeletonweed densities declined with increasing picloram rates applied in the fall at both locations, with no difference between application method. However, with spring applications, broadcast applications resulted in reduced rush skeletonweed densities with increasing picloram rates, whereas picloram rate had no effect on rush skeletonweed density when applied with a weed-sensing sprayer. Winter wheat yields were not reduced by fall picloram applications; however, wheat yields were reduced with spring broadcast applications. Wheat yield declined with increasing picloram rates. The weed-sensing sprayer reduced the amount of picloram applied compared to broadcast applications by 46 to 76% in the fall and 80 to 95% in the spring. Picloram applied in fallow in the fall after wheat harvest provides effective control of rush skeletonweed with little risk for injury to the subsequent winter wheat crop. A weed-sensing sprayer may reduce the risk of crop injury by decreasing the total amount of picloram applied.

Developer of Novel Adjuvant Systems for Herbicides. Chase T. Boman*[1], Jim T. Daniel[2]; [1]AgraSyst, Spokane, WA, [2]Daniel Ag Consulting, Keenesburg, CO (021)

Abstract not Available

Weed Seedbank Control in Rotational Crops for Proactive Herbicide Resistance Management. Chandra L. Montgomery*[1], Albert T. Adjesiwor[2]; [1]University of Idaho, Moscow, ID, [2]University of Idaho, Kimberly, ID (022)

Herbicide-resistant weed populations are evolving rapidly and threatening the sustainability of crop production. A 4-year crop rotation study was initiated in 2021 at the University of Idaho Kimberly Research and Extension Center to evaluate weed control and seedbank dynamics in wheat-alfalfa vs wheat-annual crop (corn and dry bean) rotations. There were three herbicide treatments: non-treated, postemergence (POST) only, and preemergence (PRE) + POST. It was observed that weed seedbank density was reduced from 1,700 viable seeds m-2 in the non-treated to as low as 578 seeds m-2 in the PRE + POST treatments. Weed seedbank density tended to be greater in the non-treated checks and there was a trend of PRE + POST treatments slightly reducing weed seedbank density compared to POST only treatment. Weed density within the crops during the growing season was influenced by the type of crop as well as the herbicide treatment. Both POST only and PRE + POST treatments reduced weed density compared to the non-treated and the PRE + POST treatments reduced weed density in each crop compared to the POST only treatment. Weed control treatments had no effect on alfalfa yield. However, herbicide application

(POST only and PRE + POST) improved corn and dry bean yield. The combination of fewer weeds and greater crop yield in the PRE + POST treatments holds promise for reducing weed seedbank and potentially improving long-term crop productivity and economics.

Study of Alternative Herbicides to Glyphosate in Fallow-Based Cropping Systems. Jennifer A. Gourlie*, Judit Barroso; Oregon State University, Adams, OR (023)

Effective weed management is a key element of successful wheat production. In an effort to maintain glyphosate (group 9 herbicide, EPSP synthase inhibitor) as a viable herbicide option for as long as possible in the wheat/fallow systems of the Pacific Northwest, we conducted trials over two years in fallow, at seeding time and post-harvest to evaluate potential good tank-mix partners and alternative herbicide options to glyphosate. The experiments were RCBD with four replications. Target weed species were primarily grasses for the fallow and seeding time trials, although broadleaf weeds were also evaluated when they were significant and uniformly distributed. Target weeds for the post-harvest trial were primarily broadleaf species like Russian thistle and lambsquarter. Studied treatments included saflufenacil (Sharpen), glufosinate (Forfeit 280), clethodim (Clethodim 2E), pyraflufen (Vida), flumioxazin+pyroxasulfone (Fierce), tiafenacil (Reviton), and combinations of some of those herbicides. Results showed no significant difference between Sharpen at the 2 fl oz/A and 4 fl oz/A rates. In the fallow trials, all treatments showed good control (75% +) of grasses, except for Vida and Reviton + Vida. In the seeding time trials, glyphosate alone and in combination with Reviton and Vida showed the best control (80% +). The post-harvest trials showed different results for 2021 and 2022. In 2022, a wet year, the control in all treatments was similar to glyphosate except for single applications of Reviton and Vita. In 2021, a dry year, only Reviton + Glyphosate and Fierce + glyphosate provided similar control than glyphosate consistently for the studied species.

Impact of Wheat Stubble Height on Russian Thistle Dispersion. Fernando H. Oreja*[1], Jennifer A. Gourlie[2], Judit Barroso[1]; [1]Oregon State University, Adams, OR, [2]Oregon State University, Pendleton, OR (024)

Salsola tragus L. is one of the most important broadleaf weed on rainfed cropping systems of Inland Pacific Northwest. With herbicide-resistant biotypes increasing in the area is necessary to adopt integrated weed management (IWM) approaches. Plant dispersion of *S. tragus* with the wind is a key process to spread infestations and practices that reduce plant movements should be considered in IWM strategies. The objective of this work was to determine the effect of stubble height and plant size on plant dispersion. An experiment was conducted in two consecutive years (2020 & 2021) at the Columbia Basin Agricultural Research Center (CBARC) (Adams, OR), in a split-plot randomized complete block design (RCBD) with four replicates. A second experiment was established in a grower field in Ione, OR using a RCBD with three replicates. Plant dispersion was evaluated by counting plants in the plots right before they were killed with freezing temperatures (end of October) and multiple times until end of April in 2021 and end of May in 2022. At CBARC, in both years, the dispersion rate was higher ($p<0.01$) with short stubble than with tall stubble, being those values 60% vs 17% on average. In Ione, plant dispersion was also higher ($p<0.05$) in trampled stubble (88%) than in standing stubble (43%). Big plants dispersed more than small plants (86% vs 48% respectively). Leaving tall stubble at harvest should be considered to reduce *S. tragus* plant dispersion. Preventing plants from growing big will also help to reduce dispersion.

Annual Grass Weed Control and Crop Tolerance with Indaziflam in Kentucky Bluegrass Grown for Seed. Traci A. Rauch*, Joan Campbell; University of Idaho, Moscow, ID (025)

Annual grass weeds are a large pest problem affecting Kentucky bluegrass production in Idaho. Grass weeds are difficult to control in Kentucky bluegrass because they are closely related, and many herbicides cannot be used in the establishment year. Indaziflam is a group 29 cellulose-biosynthesis inhibitor with no resistance reported in the PNW. In 2020, indaziflam received a supplemental label for use on established perennial ryegrass, tall fescue, smooth bromegrass and wheatgrass grown for seed and timothy for hay. Studies were initiated in the field fall 2020 and 2021 to evaluate annual grass control and Kentucky bluegrass tolerance with indaziflam applied at three application timings at three rates. Indaziflam was applied at 0.026, 0.039, and 0.052 lb ai/A early fall (preemergence), late fall, and spring. The experimental design was a randomized complete block with four replications. Annual grass control was evaluated visually where 0% represented no control and 100% represented complete weed control. In the Kentucky bluegrass tolerance studies, plots were swathed and threshed for seed yield, and seed germination was determined. In 2021, rattail fescue, wild oat, and Italian ryegrass were evaluated. Rattail fescue control was evaluated in only two replications due to a low population. All rates at both fall application times averaged 99%. Wild oat control was better with preemergence and late fall applied indaziflam compared to spring application timing. Fall application treatments range from 76 to 97 and 78 to 93% on June 11 and 24, respectively. Wild oat control with spring application treatments was 33% or less. On June 11, the early fall treatment application at the highest rate controlled Italian ryegrass 97% but did not differ from any fall application at any rate. Italian ryegrass control was 51% or less with spring applied treatments. All treatments injured Kentucky bluegrass 0 to 4 and 0 to 1% on May 13 and June 11 evaluation dates, respectively. Seed yield tended to be highest in the untreated check but ranged from 536 to 646 lb/A and did not differ among treatments. Seed germination ranged from 74 to 80% and did not differ among treatments. In 2022, downy brome and interrupted windgrass control was 92 to 99% and 94% to 98%, respectively, for all treatment rates at both fall application times. All indaziflam treatments controlled ivyleaf speedwell 91 to 99% regardless of application time. Kentucky bluegrass injury tended to be greater at the preemergence timing high rate (18%) and the two higher rates at the late fall timing (19 and 21%) but did not differ among treatments. Seed yield ranged from 735 to 887 lb/A and did not differ among treatments including the untreated check. Seed germination is in progress.

Evaluation of Group 15 Herbicide Efficacy on Pigweed Species and Injury on Sunflower. Keith A. Biggers*, Kirk A. Howatt, Joseph T. Ikley, Quincy D. Law; North Dakota State University, Fargo, ND (026)

Pigweed species (*Amaranthus* spp.) are difficult to control in sunflower (*Helianthus annuus*), as no effective foliar herbicides are labeled for control of Group 2-resistant biotypes. Pigweed management is reliant on soil residual herbicides and crop competition. *S*-metolachlor and pyroxasulfone are Group 15 herbicides currently labeled in sunflower. Acetochlor, dimethenamid-P, and flufenacet are other Group 15 herbicides that may be safe on sunflower and efficacious on pigweeds. Thus, the objectives of this research were to determine the influence of Group 15 herbicides, with and without sulfentrazone, on pigweed control, sunflower injury, sunflower yield, and herbicide residue. A randomized complete block design was utilized at three field sites with four blocks and an 8x2 factorial arrangement. Factor one included five Group 15 herbicides and three checks (non-treated, hand-weeded, and pendimethalin), and factor two included two sulfentrazone rates (0 and 0.28 kg ai ha^{-1}); treatments were applied preemergence. Sunflower injury and pigweed control were rated every 2 wk, and pigweed biomass was collected from all three sites. Harvestable flowers, sunflower yield, and test weight were measured from site 3, as was herbicide residue from non-treated and non-labeled treatments. Data were analyzed using

PROC GLIMMIX in SAS, and means were separated using Tukey's HSD (a = 0.05). At all three sites, sufentrazone increased pigweed control ($P < 0.0001$), and all Group 15 herbicides provided more control than the non-treated check ($P < 0.0001$). However, performance trends seemed to vary by site. Treatments did not affect yield ($P = 0.6925$), and no residues were detected.

Maverick™ Corn Herbicide: A New Herbicide Premix for PRE and POST Weed Control in Corn. Garrison J. Gundy*[1], Rachel J. Zuger[2], Jonathon Kohrt[3], Pat Clay[4]; [1]Valent USA, Mcpherson, KS, [2]Valent USA, Uniontown, WA, [3]Valent USA, Noblesville, IN, [4]Valent USA, Fresno, CA (027)

Maverick™ Corn Herbicide is a new three-way premix, consisting of mesotrione, clopyralid, and pyroxasulfone, developed by Valent USA LLC. Maverick Corn Herbicide has a relatively low use rate compared to many of the corn products currently available and can be applied preplant incorporated (PPI), preemergence (PRE), postemergence (POST), or as a sequential-split application. Maverick Corn Herbicide is effective on a broad range of broadleaf and grass weed species, including problematic weeds like Palmer amaranth (*Amaranthus palmeri*), common waterhemp (*Amaranthus tuberculatus*), common lambsquarters (*Chenopodium album*), and fall panicum (*Panicum dichotomiflorum*). Field research trials conducted with Maverick Corn Herbicide applied preemergence resulted in >90 % control on many of the driver weeds in corn when applied at labelled use rates. The addition of atrazine and/or glyphosate can broaden the weed spectrum and improve overall efficacy of Maverick Corn Herbicide when applied to emerged weeds. Maverick Corn Herbicide will be an important tool when developing an effective weed management program.

Late-Season Weed Control in Dry Bean with Split Application of Residual Herbicides. McKenzie J. Barth*[1], Jim Heitholt[2], Jenna Meeks[3], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Powell, WY, [3]University of Wyoming, Torrington, WY (028)

Late-season weeds are a challenge in Wyoming dry bean production during harvest and cleaning post-harvest. Standard pre-emergence (PRE) herbicides' residual effects typically dissipate too early in the season for effective late-season weed control, and available post-emergence (POST) herbicides do not provide effective residual control. A field study was conducted near Powell, Wyoming in 2021 and 2022 to compare residual herbicide application timings to reduce late-season weed density in dry bean. 'Poncho' dry bean was planted, and residual herbicides halosulfuron and dimethenamid-P were applied either at the full rate PRE or split into PRE and POST application timings. Split application of dimethenamid-P reduced density of hairy nightshade ($P = 0.001$), redroot pigweed ($P < 0.001$), and common lambsquarters ($P = 0.03$) by 52%, 58%, and 42%, respectively, compared to the full rate applied PRE. Split application of halosulfuron reduced hairy nightshade density by 57% ($P < 0.001$) compared to the full rate applied PRE. Split residual herbicide application did not influence kochia density or dry bean yield compared to the full rate applied PRE.

Hemp Response to ACCase Inhibiting Herbicides. Joseph Mettler*[1], Kirk A. Howatt[1], Michael H. Ostlie[2], Bryan Hanson[3]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Carrington Research Extension Center, Carrington, ND, [3]North Dakota State University, Langdon Research Extension Center, Langdon, ND (029)

Adequate control of weeds can increase hemp seed yield by 35%, and can result in $600 per hectare increase in net profits, compared to weedy fields. No herbicides are currently labeled for use in industrial hemp (*Cannabis sativa* L.) produced for seed in the United States. Recent research

evaluating hemp tolerance to ACCase herbicides has been variable among studies and has resulted in unacceptable hemp injury. Little is known about the influence that herbicides have on THC content and herbicide residue within the hemp seed. In 2022, experiments were conducted in Fargo, Carrington, and Langdon, ND to evaluate hemp tolerance to ACCase herbicides and their influence on THC content and seed yield. Plots were planted with 'Katani' hemp and were established in a randomized complete block design. The check and the entire study area received a weed control program of PPI ethalfluralin followed by a POST application of dimethenamid when hemp had 3 to 4 leaf pairs. ACCase inhibiting herbicides were not applied to the check. At 5 to 6 leaf pairs, treatments of petroleum oil alone, sethoxydim, quizalofop-p-ethyl, fenoxaprop-p-ethyl, pinoxaden, and clethodim were applied. Up to 15% visible hemp injury occurred as a result of the base herbicide program prior to the application of ACCase herbicides. The treatments did not result in additional injury. All THC samples collected were below the 0.3% threshold for a legal commodity. The two herbicides that resulted in significantly greater pre-harvest THC were quizalofop-p-ethyl and pinoxaden at 0.192% and 0.165%, respectively. Individual samples from hemp treated with these two herbicides reached as much as 0.27% and 0.29%. Herbicide did not affect seed yield and herbicide residue was not detected in any of the seed samples.

Weed Seed Predation in Diversified Wheat Production Systems Depends on Crop and Weed Species. Jessica E. R. Kalin*[1], Sanford D. Eigenbrode[2], Ian Burke[1]; [1]Washington State University, Pullman, WA, [2]University of Idaho, Moscow, ID (030)

Climate models predict summer drought conditions to worsen in semi-arid regions. Given these predictions, wheat producers are seeking to implement more resilient, diversified production systems. Among the challenges to doing so is increased pressure from annual weeds, which can be more difficult to control when broadleaf crops and cover crops are present in rotational schemes. The goals of this study are to determine seed removal rates of *Anthemis cotula, Bromus tectorum, Chenopodium album* in diversified wheat rotations in the inland Pacific Northwest (iPNW), as well the weed seed preference of a common invertebrate granivore in agricultural systems. Seed removal rates were assessed using bait stations within five crops for two months during 2019 growing season. Exclusion cages were used to separate the effects of vertebrate and invertebrate seed predators. Weed seeds were removed from bait stations with and without exclusion cages at similar rates. Weed seed removal was greater in fallow plots than in plots planted to a crop. Removal rates differed among four sample dates but there was no seasonal trend or interaction between sampling date and crop. The effect of crop species and fallow on seed removal rates could have several potential drivers such as microhabitat under the crop canopy or the availability of competing food sources. Three weed seed preference trials were conducted in a lab setting with live-captured *Amara spp*. (Coleoptera: Carabidae). Results from the seed preference trials indicate that *A. cotula* may be defended against seed predators. In the first experiment, *A. cotula* was consumed at significantly lower rates than *B. tectorum* or *C. album*, though when physical defenses were removed in the second experiment, *A. cotula* was consumed at higher rates than *B. tectorum*. Diversified wheat cropping systems in the iPNW either reduce or remove fallow from rotations, which could negatively impact the adoption rate of diversified cropping rotations due to lower rates of seedbank depletion and subsequent weed control in those systems.

Evaluation of POST-Herbicides for Glyphosate-Resistant Palmer Amaranth Control in Glufosinate, Glyphosate, and Dicamba-Resistant Sugar Beet. Michael D. Weber*[1], Nevin Lawrence[2]; [1]University of Nebraska, Lincoln, NE, [2]University of Nebraska, Scottsbluff, NE (031)

There are no effective PRE or POST herbicides available in sugarbeet to manage glyphosate-resistant Palmer amaranth. In the coming years, sugarbeet varieties are planned with concurrent

resistance to glufosinate, glyphosate, and dicamba. Glyphosate and dicamba are widely used herbicides across the region. Glufosinate is not commonly used in the region and may not provide similar efficacy as is observed in more eastern geographies. The objective of this study was to determine the maximum height that a naturally occurring population of glyphosate-resistant Palmer amaranth is controlled with glufosinate, glyphosate, and dicamba at rates and application requirements anticipated with future sugarbeet traits. The study was conducted in Scottsbluff, NE during the 2022 growing season, where glufosinate, glyphosate, and glyphosate plus dicamba were applied at rates of 655 g ai ha^{-1}, 1260 g ae ha^{-1}, and 1260 g ae ha^{-1} plus 563 g ae ha^{-1}, respectively. Applications were made on July 6, 8, 11, 13, and 20 corresponding to average Palmer amaranth heights of 10, 15, 28, 41, 66 cm, respectively. Two weeks after each application, Palmer amaranth above ground biomass was collected. Regression analysis was used to estimate biomass reduction across different Palmer amaranth heights. Glufosinate, and Dicamba plus glyphosate are estimated to reduce Palmer amaranth biomass by 50% at heights of 40 and 23 cm, and 75% at 37 and 12 cm, respectively. Glufosinate and dicamba with glyphosate both provided effective control of glyphosate-resistant Palmer amaranth. Glufosinate provided greater biomass reduction than glyphosate plus dicamba across all dates and heights.

Alfalfa Outperforms Alternative Cropping Sequences for Creeping Perennial Weed Suppression in Organic Small Grain Production. Greta G. Gramig*[1], Zachary Pull[1], Pat Carr[2]; [1]North Dakota State University, Fargo, ND, [2]Montana State University, Moccasin, MT (032)

Organic small grain producers often use a multi-year alfalfa phase to suppress creeping perennial weeds. Although this approach is effective, producers in the precipitation-limited Northern Great Plains (NGP) of the United States may benefit from alternative crop sequences that provide market and operational flexibility while also providing perennial weed suppression. As part of a larger study, we compared the following three-year cropping sequences: (i) three years of alfalfa (ALF), (ii) lentil/sweet clover + hard red spring wheat (HRSW)/sweet clover (LENCL), and (iii) 9-species cover crop polyculture/HRSW/9-species cover crop polyculture (CCPLY) for their ability to suppress Canada thistle, field bindweed, and perennial sowthistle at two sites in North Dakota: Turtle Lake and Absaraka. Both alternative cropping sequences and alfalfa were followed by a final year in HRSW. At peak emergence, Canada thistle shoot densities at Turtle Lake were greatest under LENCL and least under ALF (14 vs. 5 shoots per m^{-2}, respectively), while CCPLY was associated with an intermediate infestation (9 shoots m^{-2}). At Absaraka, Canada thistle density associated with ALF was reduced compared with both LENCL and CCPLY (1 vs. 5 and 5 shoots m^{-2}, respectively). At Turtle Lake, ALF was associated with reduced field bindweed emergence compared with LENCL and CCPLY (9 vs. 23 and 20 shoots m^{-2}, respectively). At Absaraka, ALF was associated with reduced perennial sowthistle emergence compared to LENCL and CCPLY (6 vs. 17 and 14 shoots m^{-2}, respectively). Canada thistle peak growth biomass was reduced in ALF compared to LENCL, with an intermediate response in CCPLY (8.4, 82.5, and 55.7 g m^{-2}, respectively). At Absaraka, perennial sowthistle peak growth biomass was reduced in ALF compared to both LENCL and CCPLY (27.5, 8.8, and 14.3 g m^{-2}, respectively). At Turtle Lake, field bindweed biomass was minimized in ALF compared with CCPLY and the response in LENCL was intermediate (31.4, 59.9, and 42.8 g m^{-2}, respectively). At peak vegetative growth, Canada thistle and perennial sowthistle densities associated with ALF were reduced compared with both alternative cropping sequences. Our results suggest that alfalfa remains the best choice for creeping perennial weed suppression. However, none of the weed species increased substantially in LENCL and CCPLY, and the final year HRSW yield did not differ among cropping sequences. Therefore, these two alternative sequences may have utility for farmers looking for crop diversification options along with creeping perennial weed management.

Dry Bean and Sunflower Response to Preplant Dicamba. Greg Endres*[1], Joseph T. Ikley[2], Brian Jenks[3], Nathan H. Haugrud[2], Michael H. Ostlie[4]; [1]North Dakota State University, Carrington, ND, [2]North Dakota State University, Fargo, ND, [3]North Dakota State University, Minot, ND, [4]North Dakota State University, Carrington Research Extension Center, Carrington, ND (033)

Preplant-applied (PP) dicamba is a useful, low-cost tool for burndown of selected early season broadleaf weeds. Dicamba label restrictions include 120-day delay between application and planting dry bean and sunflower to minimize potential crop injury. A field study was conducted in 2021-22 by North Dakota State University to evaluate pinto bean and oilseed sunflower response to a low-dose rate of PP dicamba based on planting interval and precipitation after application. Dryland trials were conducted at Prosper and Minot, and irrigated (center-pivot) trials were conducted at Carrington. DGA dicamba at 0.12 lb ai/A was applied during May 7-17, 2021 and May 27-June 3, 2022. Crops were planted 2-7 days and 14-20 days following application of dicamba. Rainfall ranged from 0-0.8 inch between dicamba application and first planting dates, and total water as rain and irrigation was 0.6-3.0 inches at the second planting dates. Pinto bean plant injury (visually evaluated 1-2 wk after emergence [WAE]) from dicamba across site-years ranged from 23-91% with the first planting dates, and 0-46% with the second planting dates. Sunflower plant injury from dicamba ranged from 0-23% with the first planting dates, and 0-9% with the second planting dates. Plant injury generally was reduced 3-4 and 6-8 WAE. Pinto bean seed yield on dicamba-treated soil with the first planting dates was similar to untreated checks at three of four site-years but was reduced 9.3 cwt/A with dicamba at Prosper in 2022. Bean yield was similar between untreated checks and dicamba with the second planting dates. Sunflower yield was similar between untreated checks and dicamba among four site-years and planting dates. In summary, pinto bean generally had moderate to high plant injury with first planting dates and low to moderate injury with second planting dates. Bean yield was not impacted with dicamba with second planting dates but loss is possible with no rain and prompt planting after application of dicamba. Sunflower had no to moderate plant injury from dicamba with first planting dates and no to low injury with second planting dates. Sunflower yield was not impacted by dicamba.

Influence of Planting Date and Fall-Applied Soil Active Herbicides on Weed Control in Chickpea. Akamjot S. Brar*[1], Qasim Khan[2], Fabian Menalled[1], Zach Miller[1], Clint W. Beiermann[1], Kent McVay[2], Lovreet S. Shergill[3]; [1]Montana State University, Bozeman, MT, [2]Southern Ag Research Centre, Montana State University, Huntley, MT, [3]Montana State University, Huntley, MT (034)

Chickpeas are poor competitors with weeds due to their low establishment and slow early growth leading to huge yield losses that are common. Fall application of herbicides can increase crop stand establishment and development by providing early season weed suppression. Planting date can also influence weed management by affecting crop-weed competition at the time of emergence. A field trial was conducted at the Southern Agricultural Research Center, Huntley, MT in 2021-2022 to evaluate the effect of planting date and fall-applied soil active residual herbicides for crop safety and weed control in spring-planted chickpea. Early planting of chickpeas was done at start of May and late planting 2 weeks after that. Fall application of dimethenamid at 950 g ha^{-1} + pendimethalin at 2.13 kg ha^{-1} and carfentrazone + sulfentrazone at 238 g ha^{-1} provided 66.67% reduction in number of *Kochia scoparia* and *Amaranthus retroflexus*, compared to untreated control at crop establishment. A single post application of bentazon at 280 g ha^{-1} reduced the weed biomass by 80% in the plots with dimethenamid + pendimethalin and carfentrazone + sulfentrazone compared to untreated control. No visual injury was observed from any of the herbicide treatments. Due to

low weed density, no yield penalty was observed. Similarly, planting date did not influence the weed abundance, probably due to low weed pressure (P = 0.1939). However, the later planting provided better grain yield than early planted crop (P <0.0001). These are the preliminary results, and the trail will be repeated next year at multiple locations.

Effect of Soil Residual Herbicides on Sugar Beet Yield in Conventional and Minimum Tillage Systems in Southern Idaho. Clarke Alder*[1], Albert T. Adjesiwor[2]; [1]Amalgamated Sugar, Boise, ID, [2]University of Idaho, Kimberly, ID (035)

Agronomists and Consultants in the Snake River Sugar growing area are approached each year by growers concerned by potential carryover from herbicides applied to previous crops. As sugarbeets are an integral part of crop rotations in southern Idaho, growers are not so quick to disc in a sugarbeet crop to plant another. This study was established to answer common questions posed by growers regarding potential yield loss due to certain chemistries carrying over in the soil and to evaluate possible differences in residual activity due to tillage practices. Seven herbicides comprising five modes of action were applied in a split block design to two different types of tillage the summer before planting sugarbeets to analyze the effects of herbicide carryover on sugarbeet yield under differing tillage types. Four of seven herbicides were detectable in the soil 10 months after application. Tillage significantly affected final stand count of sugarbeets planted. Imazamox, terbacil, and metribuzin had the greatest impact on yield reduction and final stand count of sugarbeets. None of the herbicides applied affected sucrose content. Sugarbeets are sensitive to imazamox and terbacil at very low levels in the soil. Following crops whre imazamox or terbacil was applied the previous season will likely result in severe sugarbeet crop loss regardless of tillage type used. Metribuzin will also result in nearly 25% yield reduction regardless of tillage type.

Curious and Concerning False Cleavers (*Galium spurium*) Response to Quinclorac. Breanne D. Tidemann*[1], Shaun M. Sharpe[2], Charles M. Geddes[3]; [1]Agriculture and Agri-Food Canada, Lacombe, AB, Canada, [2]Agriculture and Agri-Food Canada, Saskatoon, SK, Canada, [3]Agriculture and Agri-Food Canada, Lethbridge, AB, Canada (036)

Curious and Concerning False Cleavers (*Galium spurium*) Response to Quinclorac Breanne D. Tidemann[1], Shaun M. Sharpe[2], Charles M. Geddes[3] [1]Agriculture and Agri-Food Canada (AAFC), Lacombe, Alberta. [2]AAFC, Saskatoon, Saskatchewan. [3]AAFC, Lethbridge, AB In 1996, a biotype of false cleavers (hereafter cleavers) was discovered in Alberta that exhibited resistance to acetolactate synthase inhibitors, as well as the auxin mimic quinclorac. While it was a concern, further studies determined that the resistance gene to quinclorac was recessive, and as a selfing species, it was unlikely that quinclorac resistance in cleavers would become a significant problem. In 2021, 25 populations of cleavers were collected from across Alberta, Saskatchewan and Manitoba pre-harvest for use in a common garden study in 2022. Additionally in 2022, a small, unreplicated screening trial was set-up at Lacombe, AB and Saskatoon, SK for each of the populations to be sprayed with the field rate of quinclorac. Quinclorac was therefore applied at 101 g ae ha^{-1} when the majority of cleavers in the plots were 2-3 whorls. Populations were evaluated for visual control at 1, 2, 4 and 8 weeks after treatment, biomassed at maturity, and threshed to determine seed weight. Control was better in Lacombe compared to Saskatoon, however, for most populations the 80% control threshold was not reached, even in Lacombe. Based on visual ratings, biomass weight and seed weights, at least 6 populations (2 Alberta, 3 Manitoba and 1 Saskatchewan) are highly suspicious in terms of their lack of control for putative resistance, however field rate tolerance in numerous populations is also a concern. Research to be conducted in 2023 includes a replicated field trial to evaluate tolerance to the registered field rate of

quinclorac, as well as a greenhouse dose response with the suspicious populations to determine if herbicide resistance can be confirmed. While resistance would not necessarily be a surprising find, it would be surprising to find it over such a large geographic range and in so many populations in such an unstructured sampling of populations

Effect of Seeding Rate and Herbicide Applications on Weed Management and Yield Potential of Chickpea. Het S. Desai*[1], Fabian Menalled[1], Tim Tim Seipel[2], Lovreet S. Shergill[3]; [1]Montana State University, Bozeman, MT, [2]Montana State University, LRES, Bozeman, MT, [3]Montana State University, Huntley, MT (037)

Heavy weed infestation could result in a 70% yield loss in chickpea (*Cicer arietinum* L.); therefore, there is an increased interest in integrating chemical and cultural weed management practices for optimum yield. We hypothesize that the integration of increased chickpea seeding rates and appropriate herbicide programs provides effective season-long weed control. Field experiments were conducted in a two-factorial randomized complete block design with four replications at Bozeman and Huntley in 2022. Seeding rates [32 plants/m^2 (recommended), 43 plants/m^2 (1.3 × recommended), and 54 plants/m^2 (1.6 × recommended)] were assigned to the main plots. Four chemical weed control treatments plus an untreated control were assigned to the subplots. No differences were detected in weed biomass and chickpea yield in the three seeding rates. Treatment 5 [flumioxazin (30.3 g ai/ha) (PRE) followed by (*FB*) pyridate (525 g ai/ha) + bentazon (560 g ai/ha) + clethodim (280 g ai/ha) (POST)] provided 100% and 80% weed biomass reduction compared to untreated in Bozeman and Huntley, respectively. Treatment 2 [glyphosate (1540 g ae/ha) + saflufenacil (25 g ai/ha) (PRE) *FB* pyridate (525 g ai/ha) + bentazon (560 g ai/ha) + clethodim (280 g ai/ha) (POST)] provided 76% and 92% weed biomass reduction compared to untreated in Bozeman and Huntley, respectively. Chickpea yield increased by 136% and 131% compared to untreated in treatment 2 in Bozeman and Huntley, respectively. Our results suggest that while the seeding rate did not impact weed abundance and chickpea yield, appropriate herbicide programs could be designed to secure production goals.

Evaluation of Oat Tolerance to Soil-applied Herbicides Applied Preemergence and Early Postemergence. Caleb D. Dalley*[1], Brian Jenks[2], Daniel Guimaraes Abe[1]; [1]North Dakota State University, Hettinger, ND, [2]North Dakota State University, Minot, ND (038)

In North Dakota, oats (*Avena Sativa*) are grown primarily as a feed crop. Weed control in tame oat is hindered by the lack of labelled herbicides, especially for weedy grasses such as green and yellow foxtail and barnyardgrass. Preliminary trials were conducted from 2017-2021 in Hettinger, Minot, and Carrington, ND to identify herbicides with potential tolerance in oats. These herbicides were applied preemergence (PRE) and early postemergence (EPOST) to 1-leaf oats. From these trials, metolachlor and pendimethalin were identified as having acceptable tolerance in oats when applied PRE or EPOST. Oats were also shown to have good tolerance to EPOST application of dimethenamid, topramezone, and tembotrione. Oats showed variable tolerance to pyroxasulfone when applied EPOST, with tolerance related to environmental conditions, especially rainfall amounts. In 2022, a trial was conducted in Hettinger, ND to evaluate oat response to herbicides applied PRE and EPOST (1-leaf oats) at 1X and 2X typical use rates: metolachlor, PRE and EPOST, 1790 and 3580 g ai ha^{-1}; pendimethalin, PRE and EPOST, 1600 and 3200 g ai ah^{-1}; pyroxasulfone, EPOST, 180 and 360 g ai ha^{-1}; dimethenamid, EPOST, 940 and 1880 g ai ha^{-1}; topramezone, EPOST, 25 and 50 g ai ha^{-1}; and tembotrione, EPOST, 90 and 180 g ai ha^{-1}. Oats "Leggit" were seeded on May 23 using a no-till drill at a depth of 5 cm using 135 kg seed ha^{-1}. The field had been farmed under no-till cropping practices for more than 20 years prior. PRE treatments were applied after seeding using a tractor-mounted sprayer. EPOST treatments were applied on

June 3. Rainfall measuring 21 mm was recorded in the week after PRE application. Rainfall measuring 45 mm was recorded in the week following EPOST application. An additional 30 mm rainfall was recorded the following week. At 2 weeks after crop emergence (WAE), no visual injury response was observed following PRE application of metolachlor or pendimethalin at 1X and 2X rates. A visual response was observed following EPOST application of pyroxasulfone (3 and 7%), topramezone (10 and 14%), and tembotrione (4 and 12%) at the 1X and 2X rates, respectively. At 3 WAE, severe injury resulted from the EPOST application of pyroxasulfone (72 and 83%, respectively, at the 1X and 2X rates). Moderate injury resulted from EPOST application of dimethenamid (24 and 62%, respectively, at the 1X and 2X rates). Minor injury resulted from EPOST application of metolachlor (15% at 2X) and pendimethalin (7 and 11% at 1X and 2X, respectively). Other treatments resulted in injury of 5% or less. At 6 WAE, injury was 5% or less in all treatments except EPOST pyroxasulfone (61 and 73% at 1X and 2X), EPOST metolachlor (6% at 2X), and dimethenamid (12 and 48% at 1X and 2X). Oat height was reduced compared with the untreated control (68 cm) following EPOST 1X and 2X application of pyroxasulfone (55 and 52 cm), EPOST metolachlor at 2X (65 cm), and EPOST dimethenamid at 1X and 2X (64 and 57cm). Oat yield was reduced 42 and 73% by 1X and 2X EPOST application of pyroxasulfone. Other treatments did not reduce oat yield compared with the untreated control. This trial demonstrated that both metolachlor and pendimethalin could be safely used PRE in oats. It also demonstrated that metolachlor, pendimethalin, topramezone, and tembotrione can be safely applied EPOST in oats. While there was no yield reduction following EPOST application of dimethenamid, the level of injury would be concerning. Under the environmental conditions in this trial, injury to oats resulting from EPOST application of pyroxasulfone would eliminate its potential for use in oats.

Acifluorfen Selectivity in Sugarbeet in Nebraska and Wyoming. Nevin Lawrence*[1], Andrew R. Kniss[2]; [1]University of Nebraska, Scottsbluff, NE, [2]University of Wyoming, Laramie, WY (039)

Weed control remains one of the top production issues Western Sugar growers face. There are currently no effective pre-emergence (PRE) or post-emergence (POST) herbicide options to control either glyphosate-resistant kochia or Palmer amaranth. Acifluorfen received several state registrations for use in sugar beet in 2021. Field studies were conducted in Nebraska and Wyoming in 2021 and 2022 to evaluate acifluorfen for crop safety and weed control efficacy in sugar beet. Crop safety trials were established in Scottsbluff, NE and Sheridan, WY in 2021 and in Scottsbluff, NE, Lingle, WY, and Powell, WY in 2022. Crop safety studies were kept weed-free and acifluorfen was applied to the crop to evaluate injury potential. Weed efficacy studies were conducted in Lingle, WY in 2021 and at Scottsbluff, NE in 2021 and 2022. In all studies, acifluorfen was applied at rates between 0 and 560 g/ha. At the recommended field use rate of 280 g/ha, Palmer amaranth control ranged from 42 to 94%, depending on the year. When applied at the 6 true-leaf sugar beet stage, the 280 g/ha rate reduced sugarbeet biomass by 26 to 75%, depending on year and location.

Weed Management Options in Dormant-Seeded Safflower. Earl Creech*, Rodney Nelson, Corey V. Ransom, Matt Yost; Utah State University, Logan, UT (040)

Abstract not Available

The Economics of Wild Oat (*Avena fatua* L.) in Small Grains Production in Utah. Cody J. Beckley*, Corey V. Ransom; Utah State University, Logan, UT (041)

Wild oat (*Avena fatua* L.) is a common cool season annual grass weed of Utah cereal crop production. Wheat and barley yields are reduced considerably by wild oat presence during critical periods of growth and maturation. Even so, producers may be reluctant to apply herbicide to

control wild oat due to logistical or cost restraints. Various research trials aimed at controlling wild oat in small grains provide evidence that producers risk lower yields and return on investment (ROI) when wild oat is not controlled in cereal crops. Trials were conducted in Cache Valley UT in 2016, 2017, 2019, 2020, and 2022 to evaluate postemergence herbicide application for wild oat control in irrigated barley and dryland wheat. Treatments consisted of various postemergence herbicides labeled for wild oat control in cereal crops applied to plots measuring 3 by 9 m arranged in a randomized block design, replicated four times. Plots treated with herbicide had an increase in average yield across all years. The average yield increase in 2022, 2020, 2019, 2017, and 2016 was 131%, 187%, 118%, 4%, and 11%, respectively. Similarly, almost all herbicide treatments had an increase in ROI. While in 2022, 2020, 2019 and 2016 the ROI increase was 69%, 35%, 38%, and 17%, respectively, in 2017 there was a decrease of 1% due to low wild oat density within the treatment area. The average yield and ROI increase across all trials was 91% and 30% respectively. Trial results suggest that increases to yield and ROI are achieved when heavy infestations of wild oat are controlled in cereal crops. Even slight increases to yield and ROI are seen when wild oat density is low. Future research which accounts for wild oat densities would provide additional insight into economic benefits of wild oat control at various degrees of infestation and provide producers with valuable insight into the economic drawbacks of leaving wild oat untreated.

Impacts of Deep Tillage and a Deversified Herbicide Program on Palmer Amaranth Control in Enlist and XtendFlex Cotton in Arizona. Jose Luiz Carvalho de Souza Dias*, Bryan Pastor, Inana Schutze, Yossue Trejo; University of Arizona, Maricopa, AZ (042)

Abstract not Available

Selectivity of Broadcast Applied Broadleaf Herbicides on Guayule (*Parthenium argentatum*) in Arizona. Jose Luiz Carvalho de Souza Dias*, Bryan Pastor, Inana Schutze, Yossue Trejo; University of Arizona, Maricopa, AZ (043)

Guayule is a drought tolerant perennial shrub that has been studied as an alternative source of natural rubber for the past 150 years. The interest for large scale guayule farming in AZ has increased in the last decade due to its potential environmental benefits and low water use requirements. However, effective weed management during the establishment phase can be challenging due to its slow growth rate and limited selective herbicide options. Field experiments were conducted in 2022 to determine guayule tolerance to two sequential over-the-top broadcast applications of herbicides commonly used in other crops in Arizona. The effects of herbicide treatments on guayule visual estimates of injury (%), height (cm), stand (plants/ha) and aboveground biomass (kg DM ha^{-1}) were investigated at the University of Arizona Maricopa AG Center, AZ on a Casa Grande clay loam (pH=8.5, 0.75% OM, 32.5% clay); and near Eloy, AZ on a Marana silt loam (pH=8.2, 0.38% OM, 30.5% clay). Herbicide treatments consisted of both systemic and contact herbicides from two different sites of actions (SOAs; PPO- and PSII-inhibitors), at 1- and 2-X maximum labels rates (based on other model crops in AZ), and included: prometryn (1,793 and 3,586 g ai ha^{-1}), atrazine (1,120 and 2,240 g ai ha^{-1}), bentazon (1,120 and 2,240 g ai ha^{-1}), flumioxazin (58 and 116 g ai ha^{-1}), saflufenacil (50 and 100 g ai ha^{-1}), and acifluorfen (560 and 1,120 g ai ha^{-1}). An untreated control and one industry standard control (carfentrazone 28 g ai ha^{-1}) were also included for treatments comparison. All herbicide treatments contained NIS (0.25% v/v) and were applied in mid-June and mid-July (1st and 2nd application, respectively) when Spring planted guayule plants were on average 7.5 and 15 cm tall (1st and 2nd application, respectively). All PSII-inhibitor herbicides tested in this study provided greater visual estimates of guayule injury ($\geq$ 30%) at 56 days after the 1st broadcast application (DAT) compared

to carfentrazone (28 g ai ha^{-1}; our industry standard) at both locations. On the other hand, only both rates of saflufenaci, among the PPO-inhibitor herbicides treatments, provided greater injury than carfentrazone. Guayule height was also affected by herbicide treatments at 56 DAT at both locations. Treatments that provided significant reductions in guayule height included the higher rates of prometryn and bentazon, both rates of atrazine, as well as saflufenacil (100 g ha). Very similar responses were observed for guayule stand at 90 DAT as only prometryn (3,584 g ai ha^{-1}), atrazine (1,120 and 2,240 g ai ha^{-1}), bentazon (2,240 g ai ha^{-1}) and saflufenacil (100 g ai ha^{-1}) resulted in lower stands compared to carfentrazone. Only the PPO-inhibitors canfentrazone (28 g ai ha^{-1}), flumioxazin (58 g ai ha^{-1}), and oxyfluorfen (560 g ai ha^{-1}) did not significantly reduced guayule biomass at 90 DAT compared to the untreated plots. Results from this study indicate that seedling guayule appears to tolerate the PPO-inhibitor herbicides flumioxazin (58 g ai ha^{-1}) and oxyfluorfen (560 g ai ha^{-1}), even after two sequential over-the-top broadcast applications. Differently than carfentrazone, flumioxazin and oxyfluorfen exhibit both foliar and soil activity; thus, the addition of these two chemistries to the available guayule herbicide portfolio would significantly improve overall guayule chemical weed management programs. Finally, the possibility of employing broadcast applications of flumioxazin or oxyfluorfen during the establishment phase would broaden the spectrum of control of broadleaves weeds compared to the currently only POST broadleaf herbicide option (carfentrazone).

Selectivity of Post-Directed Applied Broadleaf Herbicides on Guayule (*Parthenium argentatum*) in Arizona. Jose Luiz Carvalho de Souza Dias*, Inana Schutze, Bryan Pastor, Yossue Trejo; University of Arizona, Maricopa, AZ (044)

Guayule is a perennial shrub native to the Chihuahuan Desert that is presently being targeted as supplemental source of high-quality natural rubber in the US. Despite all potential environmental and economical incentives to large scale guayule farming in AZ, effective postemergence (POST) control of broadleaf weeds is a major concern due to the limited number of selective herbicide options. Field experiments were conducted in 2022 to determine guayule tolerance to two sequential POST-directed applications of broadleaf herbicides used at layby in other crops in the state. The effects of herbicide treatments on guayule visual estimates of injury (%), aboveground biomass (kg DM ha^{-1}) and aboveground cover (%) were investigated at the University of Arizona Maricopa AG Center, AZ on a Casa Grande clay loam (0.75% OM, 32.5% clay, 34.7% sand); and at two sites near Eloy, AZ on a Sasco silt loam (0.38% OM, 12% clay, 19.2% sand). Herbicide treatments consisted of both systemic and contact herbicides from five different sites of actions (SOAs), at 1- and 2-X maximum labels rates (based on other model crops in AZ), and included: imazamox (53 and 105 g ai ha^{-1}), imazethapyr (105 and 210 g ai ha^{-1}), pyrithiobac (106 and 212 g ai ha^{-1}), flumioxazin (58 and 116 g ai ha^{-1}), acifluorfen (560 and 1,120 g ai ha^{-1}), atrazine (1,120 and 2,240 g ai ha^{-1}), prometryn (1,793 and 3,586 g ai ha^{-1}), linuron (840 and 1,681 g ai ha^{-1}), glyphosate (941 and 1,894 g ae ha^{-1}), and glufosinate (986 and 1,972 g ai ha^{-1}). An untreated control and one industry standard control (carfentrazone 35 g ai ha^{-1}) were also included for treatments comparison. All herbicide treatments contained NIS (0.25% v/v) and were applied in mid-August and mid-September (1st and 2nd application, respectively) when Spring planted guayule plants were on average 15 and 23 cm tall (1st and 2nd application, respectively). Although guayule injury (%) was affected by herbicide treatments at both evaluation timings (28 and 56 days after 1st application; DAT) at all locations; the only treatments that resulted in greater injury 56 DAT compared to the industry standard (carfentrazone 35 g ha^{-1}) were imazethapyr (210 g ha^{-1}), atrazine (2,240 g ha^{-1}), glyphosate (2,240 g ha^{-1}) and glufosinate (75, 57, 52 and 45% injury, respectively). Aboveground guayule cover varied across locations 56 DAT; however, imazamox (105 g ha^{-1}), imazethapyer (105 and 210 g ha^{-1}), atrazine (1,120 and 2,240 g ha^{-1}), prometryn (3,586

g ha^{-1}), glyphosate (1,894 g ha^{-1}) and glufosinate (1,972 g ha^{-1}) deceased cover as compared to the untreated plots at all locations. Similarly, most treatments provided less than 20% biomass reduction (compared to the untreated) 90 DAT and only imazethapyr (210 g ha^{-1}), atrazine (both rates), glyphosate (1,894 g ha^{-1}) and glufosinate (both rates) resulted in lower biomass production compared to the carfentrazone treatment pooled across locations. Results from this study indicate that there are multiple herbicide options, from different SOAs, that have the potential to be safely adopted in sequential post-directed applications in guayule. The addition of guayule to the Section 24-C label of the most selective herbicide treatments evaluated in this study has not only the potential to significantly improve the effectiveness of currently guayule's chemical weed management program, but it would also allow growers to use multiple effective SOA in their integrated weed management program, delaying the selection of future herbicide resistant weed biotypes.

Indaziflam Use During Seedling Establishment of Kentucky Bluegrass Grown for Seed. John F. Spring*[1], Darrin L. Walenta[2]; [1]Central Oregon Agricultural Research & Extension Center, Oregon State University, Madras, OR, [2]Oregon State University Extension, La Grande, OR (045)

Annual grass weeds are problematic in Kentucky bluegrass grown for seed across eastern Oregon. Indaziflam provides pre-emergent control of many grass weeds, and is registered for use in established stands of several other grass species grown for seed. Applying indaziflam to seedling stands of Kentucky bluegrass could offer several advantages over use in established stands, although the crop safety of early post-emergent indaziflam on perennial grass seedlings is effectively unknown. Field trials were conducted at 4 locations in eastern Oregon in 2021 and 2022 to test the crop safety of indaziflam (15, 30, or 45 g ai·ha^{-1}) applied to several seedling stages (3-5 leaf, 3-5 tiller, or 10+ tiller) of irrigated Kentucky bluegrass grown for seed. Crop injury generally increased with application rate, and at earlier application timings. At 3 of 4 sites, applications to 3-5 leaf seedlings were highly injurious (3 to 100% median yield reduction relative to non-treated), 3-5 tiller applications were moderately injurious (4 to 40% median yield reduction), and 10+ tiller applications caused slight to moderate injury (0 to 26% median yield reduction). At a 4th site, injury from 3-5 leaf applications was slightly to moderately injurious (13 to 21% median yield reduction), 3-5 tiller applications moderately injurious (20 to 36% median yield reduction), and 10+ tiller applications were moderately to highly injurious (12 to 73% median yield reduction). Inconsistent patterns of injury across growth stages are speculatively attributed to soil moisture conditions, with higher injury associated with lack of full soil surface drying at and shortly after application. Yield reduction from herbicide injury can be tolerated at relatively high levels in grass seed crops if key weed seed contaminants are controlled. Thus, the range of crop injury observed at lower indaziflam rates on some growth stages in these trials could be acceptable given the excellent efficacy expected on key grass weeds. Observations suggest that surface soil moisture conditions at and shortly following application play an important role in potential for crop injury. Further investigation is needed to better characterize the relationship between soil moisture dynamics, seedling size, and crop injury, and the potential to reduce crop injury with proper application timing relative to these factors.

WSWS Project 4. Teaching and Technology

Pilot Safety and Aerial Application Proficiency Training Utilizing an Air Tractor Simulator. Jeffrey Golus*[1], Tom May[2]; [1]University of Nebraska, North Platte, NE, [2]Flying M Enterprises, Holdrege, NE (046)

Many crop protection products are applied aerially to control insects, weeds, fungal diseases and other pests. Agricultural pilots do not always have many opportunities to practice application situations which they may encounter (such as engine failure, obstruction avoidance, etc). An updated Air Tractor 502 simulator is located at the University of Nebraska West Central Research, Extension and Education Center in North Platte, Nebraska to provide such an opportunity. The simulator consists of an Air Tractor cockpit and a 235 degree wraparound screen with multiple projectors, giving the pilot a realistic viewpoint, and also contains a modern engine performance system and gauges. Emergency scenarios, such as engine failure, changing weather conditions, etc., can be induced during a flight to allow the pilot to encounter potentially dangerous situations in a safe environment. Field scenarios will also provide the pilot the opportunity to receive training feedback regarding application techniques and practice alternative methods to improve product efficacy and spray drift management. The trainer can also provide valuable feedback to the pilot regarding their management of these scenarios. Courses are available with the goals of increasing application accuracy and effectiveness, increasing pilot knowledge of airplane operation, and exposure to and management of emergencies.

WSWS Project 5. Basic Biology and Ecology

Weed Survey in Colorado Sugar Beet Farms Reveals Resistance to Dicamba and Glyphosate. Andre Lucas Simoes Araujo*[1], Eric P. Westra[2], Todd A. Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Utah State University, Logan, UT (047)

A new genetically engineered trait for sugar beets is under development that will confer resistance to glufosinate, glyphosate, and dicamba. The research objective was to perform a resistance survey to evaluate the trait efficacy for Colorado. Sugar beet fields were visited in the Fall of 2021, and three weed species were surveyed: kochia (*Bassia scoparia*), common lambsquarters (*Chenopodium album*), and Palmer amaranth (*Amaranthus palmeri).* From each collection site, plants were screened as followed: glyphosate (840 g ae ha^{-1} + AMS 20 g L^{-1}), glufosinate (590 g ai ha^{-1} + AMS 1.2 kg ha^{-1}), and dicamba (280 g ae ha^{-1} + NIS 0.25% v/v) at the spray volume of 187 L ha^{-1}. Populations were graded as susceptible (0% to 2% survival), low resistance (2% to 20% survival) and resistant (20% to 100% survival). Resistance mechanisms were investigated in kochia populations. Increased EPSPS gene copy number assays were performed. IAA16 degron region was sequenced to investigate the presence of G127N previously reported. Glyphosate survivals were identified in all three weed species. Dicamba survivals were identified in kochia and Palmer amaranth, but not in Common lambsquarters populations. Glufosinate survivals were not identified. EPSPS increased copy number was identified in all kochia survivals. G127N substitution was identified in one population. Several mutations and a deletion were identified in one population. Concerns about the long-term utility of this technology should be considered. Integrated pest-management approaches such as the use of cover crops should be implemented to mitigate resistance evolution in the Central Great Plains.

Monitoring Herbicide Resistant Weeds in Sugarbeet Cropping Systems in SE Montana. Lovreet S. Shergill*[1], Het S. Desai[2], Todd A. Gaines[3]; [1]Montana State University, Huntley, MT, [2]Montana State University, Bozeman, MT, [3]Colorado State University, Fort Collins, CO (048)

Abstract not Available

Impact of Repeated Weed Exposure on the Competitive Ability of Wheat. Albert O. Kwarteng*; University of Idaho, Moscow, ID (049)

Plants are subjected to several forms of stress and have evolved mechanisms to cope with these stressors. Studies have shown that plants can store and recollect memory of previous stress exposure which may affect their reponse to future stresss. This research is aimed at understanding how multigenerational weed exposure affects phenotypic plasticity, hormonal and gene expression, and DNA methylation in wheat. Wheat was planted in the center of 3L plastic pots surrounded by either 8 kochia (*Bassia scoparia*), 8 Italian ryegrass (*Lolium multiflorum*), 8 wheat, or no surrounding plants. Treatments were arranged in a completely randomized design with 15 replications. Seeds harvested from the first generation were used to plant the second generation, and the process was repeated under the same conditions to obtain the second, third, fourth, and fifth generations. Relative to wheat with no surrounding plants, wheat-kochia, wheat-ryegrass, and wheat-wheat treatments reduced seed yield by 7, 26, and 43%, respectively, in the first generation; 90, 93, and 89%, respectively, in generation two; 63, 85, and 84%, respectively, in generation three, 80, 82, and 80%, respectively, in generation four, and 79, 90, and 69%, respectively in the fifth generation. The number of seeds per plant in the wheat only treatment increased from 50 seeds in generation one to 110 seeds per plant in the fifth generation. These results suggest a potential maladaptive impact of transgenerational memory of weed stress on wheat. The biochemical, transcriptomic, and epigenetic data would provide a better understanding of the mechanisms involved in these observations.

WSWS PROJECT 1: WEEDS OF RANGE, FORESTRY, AND NATURAL AREAS

Biodiversity and Geo-referenced Density Sampling Methods for Determining Native Specie's Responses to Long-term Cheatgrass Control with Indaziflam. James R. Sebastian*[1], Joe Swanson[1], Derek J. Sebastian[2]; [1]Boulder County Parks and Open Space, Longmont, CO, [2]Envu Vegetation Management, Greeley, CO (057)

Boulder County Open Space (BCPOS) manages properties that include high plains, foothill's shrub steppe, and mountain ecosystems in Colorado. These properties provide critical wildlife and pollinator habitat within highly diverse ecosystems. Of major concern is the loss of critical wildlife habitat, diversity of native plants, and specialized ecosystems, due to cheatgrass and cheatgrass-fueled wildfires. Invasive winter annual grasses, such as cheatgrass (Bromus tectorum L.) are considered serious threats to regional biodiversity. Cheatgrass competes directly with short-lived native annual, biennial, and short-lived perennial species. Indaziflam (Rejuvra, Envu) which has been labeled for open space, natural areas, and grazing, has been adopted by land managers to help control cheatgrass infestations. Field studies at Colorado State University have demonstrated that indaziflam provides superior long-term BROTE control (3 plus years) with no documented injury to native perennial species. With cheatgrass control, the resulting voids and gaps that are created in the landscape, allow remnant native plants to take full advantage of these sites. BCPOS has monitored species diversity and has geo-referenced native species densities at 12 large-scale (5-40 acre), highly diverse sites, 4 to 6 years after treatment. All 12 sites have a B1 Natural Heritage Society (NHC) global significance, high diversity, and rarity rankings. BCPOS evaluated the presence or absence of each native species using belt-diversity sampling in indaziflam treated sites versus adjoining non-treated sites. This has been critical for monitoring species on sites with a broad diversity of soils, aspects, slopes, and ecosystem regimes that would be difficult to measure with small plots and quadrats. One concern of indaziflam is the long-term impacts it may have on short-lived native plants which depend upon successful seed reproduction for regeneration. BCPOS monitored 27 different annual, monocarpic, biennial, and short-lived perennial native

species at 12 sites. This monitoring also includes long-term impacts indaziflam may have on species that are rare, of special concern and/or communities that the NHC have listed as having global, state, or local significance. BCPOS collected density numbers of rare and short-lived species within 1 to10-acre grid areas, to determine each species population trends and distribution. Large geo-referencing grid blocks were used to complement the belt-diversity sampling method. Using GPS, 7 rare and/or species of special concern at these 12 sites (1 to 6 years after treatment) and short-lived species at 3 separate sites, were geo-referenced. While no decrease in density or diversity of rare or short-lived species has been documented, extreme caution should be used when considering the use of indaziflam where native annual grass, or rare species exist. Additional geo-referencing work has also been done with forked three-awn (*Aristida basiramea*) a rare GS5S2 species of concern, to establish baseline population data. As annual grass species tend to be sensitive to low rates of indaziflam we will continue to monitor long-term impacts cheatgrass and indaziflam may have on forked three-awn and other short-lived, rare grass species. These studies will continue in 2023. Belted grid and geo-referencing monitoring techniques have demonstrated to be valuable for monitoring long-term cheatgrass impacts to native species diversity and density trends over large-scale areas. Our findings reinforce the conclusive evidence from other field managers, that cheatgrass and other invasive annual grasses pose a significant threat to native species diversity. For land managers, this management tool provides a long-term control option to begin the restoration process on large-scale areas infested with cheatgrass.

Cheatgrass (*Bromus tectorum*) Increases Perennial Grass Flammability - a Missing Component of Fire Behavior Models. Georgia R. Harrison*, Lisa C. Jones, Eva K. Strand, Timothy S. Prather; University of Idaho, Moscow, ID (058)

Flammability of the invasive annual grass cheatgrass (*Bromus tectorum*) increases fire risk and causes plant community shifts in the Great Basin (USA), yet no studies have quantified its flammability in comparison to and in combination with native perennial grasses. To address this knowledge gap, we conducted burn experiments with cheatgrass and two native perennial bunchgrasses (Bluebunch wheatgrass, *Pseudoroegneria spicata* and Columbia needlegrass, *Achnatherum nelsonii*) across a range of typical fire season fuel moistures (5-55%) with a standard 20 g of perennial grass and increasing amounts of cheatgrass. Grasses were field collected, oven dried and then rehydrated to desired fuel moistures. Flammability was assessed by recording temperature, flame length, and mass consumption throughout each burn. Cheatgrass sustained high ignitability and mass consumption even at the highest moisture levels, suggesting that this species increases ignition and fire spread probability even before plants have senesced. The addition of cheatgrass increased perennial grass flammability. When mixed with perennial grasses, cheatgrass's impact did not differ by fuel moisture, suggesting that cheatgrass poses a threat throughout the season, not only under dry conditions. Additionally, we tested for nonadditive effects, which compared actual flammability of a combined species mixture to expected flammability from individual species trials. Nonadditive effects of flammability were greater with needlegrass, suggesting cheatgrass contributes more to flammability of the combined species biomass than expected. Our experimental results support previous qualitative observations of cheatgrass altering fire behavior and can inform risk thresholds for cheatgrass presence on a landscape throughout the fire season.

Chemical and Bioherbicides for Control of Exotic Annual Grasses in Sagebrush Steppe Ecosystems: Evaluation of Efficacy, Longevity, and Non-target Effects. Brynne E. Lazarus*, Matthew J. Germino; USGS, Boise, ID (059)

Selective herbicide application is a common strategy to control exotic invaders that interfere with native plant recovery after wildfire. Whether spraying with pre-emergent or bio-herbicides releases native plants from competition with exotics ("spray-and-release" strategy) and makes communities resistant to reinvasion by exotic annual grasses (e.g., cheatgrass, medusahead), without risks to non-target native plants or secondary invasion, is a major question for land managers of semiarid plant communities. Additionally, how these treatments affect plant-soil feedbacks is important and poorly understood. We applied chemical herbicides (imazapic, rimsulfuron) and weed-suppressive bacteria (*Pseudomonas fluorescens* strains MB906 and D7) after fire to three sagebrush-steppe communities that spanned a climate gradient. We measured plant cover prior to burning and for 5 years post-treatment and soil mineral N, potential net N mineralization, and CO_2 respiration, in the second year after treatment. Both chemical herbicides significantly reduced exotic annual grass cover in all communities in the first post-spraying year, but rimsulfuron plots were re-invaded after 1-2 years, while imazapic plots continued to resist re-invasion 5 years post-spraying. Rimsulfuron was more damaging than imazapic to shallow-rooted perennial bunchgrasses (*Poa secunda* and *Poa bulbosa*). Preliminary results showed both chemical herbicides resulted in increased mineral N in proportion to their reductions in total plant cover. Weed-suppressive bacteria treatments had no significant effects on cover of any functional group, but preliminary results showed decreased potential net N mineralization and increased CO_2 respiration two years after their application. While short-term effects of chemical herbicides were relatively consistent and predictable, longer-term effects were specific to the herbicide and plant community. Herbicide treatments can exacerbate pulses of mineral nutrients, which previous studies have shown can weaken ecosystem resistance to invasion. Restoration strategies that increase the likelihood that desired plants such as native perennials can capture mineralized nutrients after herbicide application will likely be more successful.

Testing Ventenata Control Treatments on the Crow Reservation in Southeastern Montana.
Zach Fighter*[1], Scott Powell[1], Jane Mangold[1], Robert Demery[2], David Hopkins[2]; [1]Montana State University, Bozeman, MT, [2]Bureau of Indian Affairs, Billings, MT (060)

Ventenata dubia (ventenata) is a non-native winter annual grass of concern in southeastern Montana. Ventenata can impact rangelands by lowering forage production and displacing native species. The objective of this study was to test herbicides and a soil amendment for the management of ventenata in southeastern Montana on the Crow Reservation. At four sites, we tested two herbicides at two water carrier rates and two rates of a soil nutrient amendment using a split-plot randomized block design with four replications. Water carrier rates were meant to mimic aerial and ground applications. Indaziflam (Rejuvra®) and soil amendment treatments were applied mid-August 2021, while the imazapic (Plateau®) treatment was applied in early November 2021. Herbicides were applied using a hand-held boom sprayer pressurized by carbon dioxide. Soil amendment was hand-broadcasted. In June 2022, vegetation was sampled by randomly placing 3, 20 cm x 50 cm frames in each split-plot and estimating cover by species and bare ground. Indaziflam and imazapic provided the highest control of ventenata. Water carrier rate did not affect herbicide performance. Across the four sites, imazapic and indaziflam reduced ventenata cover to < 4%; cover in the control was 38%. Soil amendment reduced ventenata cover by about 50% at two sites but had no effect at the other two sites. Herbicide treatments provided the best control of ventenata regardless of water carrier rate, suggesting that aerial application may provide similar control as ground application. This is encouraging for the Crow Reservation where ventenata is widespread across relatively inaccessible land.

Long-term Downy Brome (*Bromus tectorum* L.) Control with Indaziflam in Sagebrush-Grasslands in Sublette County Wyoming: Research Synthesis and Future Directions. Jacob Courkamp*[1], Paul Meiman[2]; [1]Colorado State University, Fort Collins, CO, [2]University of Nevada-Reno, Elko, NV (061)

Invasive winter annual downy brome (*Bromus tectorum* L.) has invaded vast expanses of sagebrush-grassland in western North America, and the fine fuel associated with invasion increases the frequency of wildfire such that native plants struggle to persist. Rangeland managers and scientists have long been aware of this annual grass-fueled "downward spiral", but developing tools with the capacity to effectively manage invasive annual grasses remains critical to preventing further conversion of native rangeland to fire-prone annual grass-dominated plant communities. The herbicide indaziflam (Rejuvra®, Envu), recently labeled for use in grazed areas, provides multi-year annual grass control with minimal harm to established perennials. In September 2016, we established several indaziflam studies in Sublette County, Wyoming to evaluate the long-term effectiveness of this promising new tool and the potential for non-target impacts to native plants. Our studies included large aerial treatment and control plots (approx. 2 ha) established to evaluate the effects of aerial indaziflam treatment (helicopter; 73 g ai ha-1 with 47 L ha-1 of water carrier), and smaller-scale comparisons of one and two applications (45 months between treatments) of multiple indaziflam application rates (51, 73 and 102 g ai ha-1) and a standard imazapic rate (Plateau®, BASF; 123 g ai ha-1). We will briefly synthesize our research findings, highlighting key insights and focusing on data collected in 2021 and 2022, 57 and 69 months after treatment (MAT), respectively. Data collected in the aerial plots indicated that treatment did not impact established native perennials, and in some cases a single indaziflam treatment reduced cheatgrass cover and density to very low levels at least 57 MAT. Indaziflam can help achieve weed management objectives that are not feasible using other herbicides, and will likely be a powerful tool for land managers tasked with mitigating the impacts of invasive annual grasses in grazed areas.

Effects of Grazing Deferment Following Invasive Annual Grass Control with Indaziflam in Northeast Wyoming. Walker T. Billings*, Brian A. Mealor; University of Wyoming, Sheridan, WY (062)

Annual grasses such as cheatgrass (*Bromus tectorum*) and ventenata (*Ventenata dubia*) are native to Mediterranean Europe but have invaded western North America. These weeds displace native species and can cause severe damage to ecosystems. Ventenata was first confirmed in northeast Wyoming in 2016 and is expected to be an extremely competitive weed in the Great Plains ecoregion. Indaziflam is a cellulose biosynthesis inhibitor herbicide labeled for control of annual grasses that shows long-term soil activity. Management recommendations from some government agencies include grazing deferment for one to multiple growing seasons following indaziflam application to promote regeneration of perennial plant communities. We focused on understanding the effects of grazing exclusion following indaziflam application on perennial plant communities across two ecological sites at four locations in northeast Wyoming. At each site - all of which were treated with 123 g ai ha-1 indaziflam applied in 18.9 L ha-1 from a helicopter in 2019 - we excluded grazing using electric fencing during the growing season and allowed ambient grazing in an adjacent, paired plot. We collected plant community data via ocular cover estimates, line point intercept, and perennial grass gap measurements from 2019-2022 and analyzed vegetation data using a 3-way analysis of variance with grazing, ecological site, and year as factors of interest; and year as a repeated measures variable. Preliminary results indicate that grazing exclusion had no

effect on multiple plant community attributes, suggesting that grazing exclusion may not be necessary to meet vegetation goals.

Three Years Later: Plant Community Resilience to Annual Grass Control in Sagebrush Steppe. Lisa C. Jones*, Georgia R. Harrison, Timothy S. Prather; University of Idaho, Moscow, ID (063)

Invasive annual grasses negatively impact sagebrush steppe by decreasing native plant diversity and shortening fire return intervals. Indaziflam, a longer residual herbicide, effectively controls annual grasses yet there is concern that such an herbicide can delay plant recruitment from the seed bank. Large-scale treatment that considers soil-surface droplet coverage was explored with indaziflam and indaziflam + imazapic (70 and 84 g/ha, respectively) applied aerially across a range of herbicide droplet coverage. Applications occurred in a mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*)-dominated pasture near Hailey, ID in fall 2019 (pre-emergent). We monitored vegetation composition annually for three years post-treatment. Three years post-treatment, herbicide applications controlled *Bromus tectorum* by 57-100% (mean 85%) compared to plots without herbicide. Treated plots averaged 6% cheatgrass cover compared to 41% cover in untreated plots. In 2022, deep-rooted perennial grass cover increased as herbicide droplet coverage increased, suggesting release from competition. Sandberg bluegrass (*Poa secunda*) cover increased with increasing droplet coverage, but the effect was stronger for indaziflam than indaziflam + imazapic, suggesting injury from imazapic. Perennial forb cover differed by herbicide used: cover was greatest in indaziflam plots (mean 78%, sd 25%) compared to indaziflam + imazapic plots (mean 65%, sd 20%), indicating imazapic's non-target impact on forbs, though cover values were still high. Three years post-treatment, we observed recruitment from the seedbank in the treated plots at the same level as in the untreated plots, indicating that herbicide application has not substantially impeded natural recruitment. Notably, recruited plants included 22 forb species that are preferred forage of greater sage grouse. We will continue to monitor plots to assess long-term annual grass control and plant community response.

Community Response to Dyer's Woad Control Efforts. Erin Hettinger*[1], Corey V. Ransom[1], Tom Monaco[2]; [1]Utah State University, Logan, UT, [2]USDA-ARS, Logan, UT (064)

Dyer's woad (*Isatis tinctoria* L.) is a non-native forb, invasive in ten Western states. Due to its biennial life cycle, control of dyer's woad often requires repeat herbicide applications which can damage surrounding desirable vegetation. Our study objectives were twofold: 1) to determine the effectiveness of preemergence herbicide, indaziflam, alone and in conjunction with three common postemergence herbicides to control dyer's woad populations and 2) to assess community response to herbicide treatments. Two sites were established in Newton and Collinston, Utah to test seven herbicide treatments with a fall or spring application timing. Plots were three by nine meters arranged in a complete randomized block design with four replicates. Point-line transect data was assessed using an observation-level random effects model. Results showed that dyer's woad cover was significantly less in plots treated with imazapic and metsulfuron alone and when these treatments were combined with indaziflam. Dyer's woad cover was not reduced by 2,4-D alone, however, the addition of indaziflam reduced cover at Collinston. Although metsulfuron alone decreased dyer's woad cover, annual grass cover increased. At Newton, the fall indaziflam treatment and indaziflam combined with metsulfuron had less annual grass cover than untreated plots. In Collinston, all treatments with indaziflam, as well as imazapic alone, had significantly less annual grass cover than untreated plots. Weedy forb cover was lower in plots treated with

imazapic and indaziflam compared to those treated with only imazapic or metsulfuron. Perennial grass cover was not affected by any treatments, possibly due to continued drought conditions.

Do Reduced Rates of Herbicide in Basal Bark Treatments of *Prunus padus* Decrease the Frequency of Non-target Impacts? Gino Graziano*; UAF Cooperative Extension Service, Anchorage, AK (065)

Basal bark treatments of *Prunus padus* in Alaska are intended to reduce drift and non-target impacts. Other direct treatments such as frill, cut stump, and injection have the same goal, however basal bark can be more time efficient. Invasive plant managers have noted some non-target impacts following these treatments. We previously reported non-target impacts on trees receiving basal bark treatments of Milestone® (active ingredient aminopyralid) with incidences occurring on about half the treated trees. Aminopyralid is desirable to use for its low toxicity to fauna, and it tends to be very effective at doses far lower than other herbicides. We will present preliminary results from control trials that compared full and half label rates of Milestone® and Garlon 4® on the control of *Prunus padus* at infestations in Anchorage and Fairbanks. These control trials compare efficacy of control, document non-target impacts, and use bioassays and analytical detection to document herbicide residues in soil.

Long-term Plant Community Response to Cheatgrass Management in High-elevation Sagebrush Steppe. Colter Mumford*, Jane Mangold, Catherine Zabinski, Matthew Lavin, Lisa J. Rew; Montana State University, Bozeman, MT (066)

Cheatgrass (downy brome, *Bromus tectorum*) is a widespread non-native plant management challenge across the western United States. Historically, cheatgrass has been less competitive in the northeastern region of the sagebrush biome due to ecological constraints. Anecdotal evidence suggests cheatgrass abundance is increasing on steep, south-facing slopes in southwestern Montana. This study quantified plant community and cheatgrass response to two consecutive fall applications of post-emergent herbicide (ai imazapic, Plateau ®). Over four years we sampled 12 sites across two regions differentiated by their soil types: the Antelope Peak (AP) region with a silty clay/loam soil and the Eastern Sandhills (ES) with sand. Sampling occurred at two spatial scales: local scale for a highly infested, non-sprayed control, and a sprayed area directly adjacent (10 x10m); and landscape scale, sitewide (~4ha), within the sprayed area and an adjacent non-sprayed, lightly infested reference community. Cheatgrass abundance was reduced for three years post-application, but by year four returned to pre-treatment levels in both regions at the landscape scale, and at the local scale in the AP region. Cheatgrass remained suppressed for the study duration in the ES region's local scale sprayed treatment. Landscape scale sprayed treatments had similar diversity to the reference by year three in the ES region and year four in the AP region. Conversely, the local scale non-sprayed treatment had greater richness, evenness, and diversity, regardless of region. Herbicide effectively reduced cheatgrass abundance, however, its impact on the plant community varied over time and space, emphasizing the importance of long-term vegetation monitoring.

Frequent Flyover: Using High-Frequency, Moderate-Resolution Multispectral Imagery to Map Invasive Annual Grasses. Chloe M. Mattilio*, Brian A. Mealor; University of Wyoming, Laramie, WY (067)

Introduced annual grasses represent an unprecedented threat to native plant communities in rangeland ecosystems by displacing native vegetation, altering fire regimes, affecting wildlife

species, and causing significant economic costs. Remote sensing allows for landscape-scale monitoring of invasive annual grasses by capitalizing on phenological differences to distinguish invasive species from native vegetation in a mixed-grass prairie in Sheridan County, Wyoming. Our research goal was to evaluate the ability of frequently collected multispectral (blue, green, red, near infrared, and Normalized Difference Vegetation Index (NDVI)) imagery and machine learning to detect invasive annual grass species. Imagery was collected weekly from May 10 to August 23, 2021 at 4m x 4m spatial resolution. Our research questions were: 1) Can frequently collected imagery detect invasive annual grasses? 2) Do phenological differences help to distinguish among non-native species? Extensive ground mapping of vegetative cover was used to train classification models for >30% cover of ventenata (*Ventenata dubia*), invasive annual grasses (ventenata, medusahead (*Taeniatherum caput-medusae*), cheatgrass (*Bromus tectorum*), and Japanese brome (*Bromus japonicus*), and all invasive grasses (ventenata, medusahead, cheatgrass, Japanese brome, and bulbous bluegrass (*Poa bulbosa*). Ventenata was best represented in our training data and by classification models and accuracy indices (class accuracy = 78.6%, Area Under the Curve = 0.801). Invasive annual grasses and all invasive grasses were identified with 63.5% and 62.8% class accuracy, respectively. Misclassifications may be due to asynchronous senescence of target invasive grasses across the landscape, and small and/or sparse annual grass invasions may be missed with limited spectral and spatial resolution.

Long-term Efficacy of Indaziflam to Suppress Ventenata and Response of Other Vegetation. Lilly L. Sencenbaugh*, Jane Mangold, Lisa J. Rew; Montana State University, Bozeman, MT (068)

Ventenata (*Ventenata dubia*) is a problematic non-native annual grass in northwestern pastures and rangelands, and effective management strategies are needed. Fall applied pre-emergent herbicides are preferred for annual grasses in grassland ecosystems. However, impacts on desired vegetation may occur. Herbicide treatments should be monitored following application to quantify long-term impacts on target species and the community. The pre-emergent herbicide indaziflam (Rejuvra) has been recommended for use on ventenata, with reported residual control of three years. We monitored the response of ventenata and other vegetation to indaziflam compared with a non-sprayed control, four other grass herbicides (ai imazapic, rimsulfuron, propoxycarbazone-sodium, and glyphosate), and indaziflam combined with each of the other herbicides, for six years after a single application in a pasture in Springhill, Montana. The first year after treatment ventenata cover in all herbicide treatments was lower than the control, with varying degrees of efficacy from the treatments (0-68% cover). However, richness and diversity were lower in the indaziflam treatments than in the non-sprayed control. After 6 years, the ventenata cover remained lower than the control in all treatments that contained indaziflam, in contrast the other herbicide treatments showed ventenata recovery (control 0-32%, indaziflam 0-5%, others 0-42% cover). There was no difference in richness or diversity for any herbicide treatment relative to the control (mean richness 3). Indaziflam may be a useful tool for long-term management of ventenata in pastures without causing declines in desired species richness and diversity. This highlights the importance of monitoring vegetation communities long-term following herbicide application.

Recent Winter Annual Grass Control Trials in the Intermountain Region of California. Thomas J. Getts*; University of California Cooperative Extension, Susanville, CA (069)

Winter annual grasses are problematic throughout California, from red brome in the south to medusahead in the north. In Northeastern California the three main species of concern are cheatgrass, medusahead, and ventenata. These grasses have invaded millions of acres and

numerous ecosystems from perennial bunchgrasses, to shrublands and forests. Increasing fire frequency, reducing native biodiversity, and reduced forage are just a handful of these winter annual grass impacts. Over the past decade research from Colorado and throughout the Western United States has investigated a relatively new herbicide, indaziflam, for annual grass control. Trials have found multiyear control of cheatgrass and other annual grass species while safely releasing established perennials from competition when using indaziflam. Beginning in 2016 multiple trials were initially implemented in Northeastern California testing indaziflam which gave excellent multiyear control of medusahead. Since 2016 numerous additional small plot trials have been implemented and monitoring larger-scale firebreaks has been conducted to investigate indaziflam for annual grass suppression while releasing desirable perennial plants. The results from the second wave of trials have been inconsistent, with some sites offering excellent multiyear control of annual grasses, and other sites only offering suppression. Applications of 73 g ai/ha in September of 2020 at three sites resulted in 45, 82 and 95 percent annual grass control one year after treatment. Annual grass control at the three sites increased to 76, 92, and 98 percent control, respectively, two years after treatment. Control was acceptable at two of the sites, but this was the first instance in California trials where annual grass control was not greater than 90 percent following an application of indaziflam. This presentation will give an overview and highlights from the results of all these trials and case studies which may help shed light to the effectiveness of indaziflam for annual grass suppression in Northeastern California ecosystems, with potential lessons for other regions.

Impact of Native Vegetation on Cheatgrass Fitness: A Neighborhood Study. Erin B. Teichroew*, Bruce Maxwell, Lisa J. Rew; Montana State University, Bozeman, MT (070)

Plant community composition and spatial arrangement must affect the fitness of a target plant, but they are rarely assessed in competition studies. Neighborhood studies allow for the effect of individual plant responses and include spatial proximity factors influencing the target plant. We evaluated competitive interactions between cheatgrass (downy brome, *Bromus tectorum*) and species in the surrounding community (neighborhood). We characterized neighborhoods centered around a randomly selected target cheatgrass individual, at two semi-arid grassland sites in Montana. We measured the percent cover and density of all neighboring species, and categorized them by life-forms (grasses, forbs, or cheatgrass) in four neighborhoods (10, 20, 30, 40 cm diameter) surrounding the target plant. We used linear models to analyze the impacts of the neighbors' covers and densities on the cover of the target. Neither cover nor density of the neighbors accurately predicted the cover of the target cheatgrass. However, AIC model comparison suggested that increasing neighborhood size increased model performance. We also evaluated the impact of the most common species in the 40 cm neighborhoods and found that Sandberg bluegrass (*Poa secunda*) cover was associated with a decrease in target cheatgrass cover at the more intact site, while western wheatgrass (*Pascopyrum smithii*) and neighboring cheatgrass covers were associated with an increase in target cheatgrass cover at the more disturbed site. This suggests that site differences may have a larger impact on cheatgrass fitness than life-forms or individual neighboring species.

Exploring the Utility of Penoxsulam in Western U.S. Forestry Vegetation Management. William L. Hatler*[1], Byron B. Sleugh[2], Craig M. Alford[3], Jodie A. Crose[4], Scott Flynn[5]; [1]Corteva Agriscience, Meridian, ID, [2]Corteva Agriscience, Carmel, IN, [3]Corteva Agriscience, Ankeny, IA, [4]Corteva Agriscience, Tulsa, OK, [5]Corteva Agriscience, Lees Summit, MO (085)

Sapphire® herbicide (penoxsulam) is a Corteva Agriscience™ product currently labeled for control of broadleaf weeds and certain sedges in turf and non-crop areas. Research has been ongoing to determine its suitability for applications in forest vegetation management in the western U.S. Trials conducted in the spring of 2022 were specifically designed to compare the efficacy of Sapphire at 44-66 g ai/ha with that of CleanTraxx® herbicide (penoxsulam + oxyfluorfen) at 2270-2560 g ai/ha on key Ceanothus species. Three trial sites were established in California and Oregon at the spring site preparation timing, prior to planting Douglas fir (*Pseudotsuga menziesii*) or Ponderosa pine (*Pinus ponderosa*). Initial results indicate good crop tolerance for Sapphire at all rates tested on Douglas fir and Ponderosa pine at 21-27 weeks after application (WAA). Across all Ceanothus species tested, including Deerbrush (*Ceanothus integerrimus*), Chaparral whitethorn (*Ceanothus leucodermis*), Prostrate ceanothus (*Ceanothus prostratus*), and Snowbrush (*Ceanothus velutinus*), control ranged from 85-95% with Sapphire alone at 21-27 WAA. Control with CleanTraxx alone across the same species ranged from 91-99% and was not statistically different than Sapphire, indicating that penoxsulam is the principal active ingredient for control of Ceanothus spp. Based on the results from these and previous studies, Sapphire will be a very useful product for use in western U.S. forestry, and a potential alternative to CleanTraxx on some key species. Registration for use of Sapphire on forest sites will be pursued, as it is not currently labeled for this use pattern.

Surveying Resistance to ALS-inhibiting Herbicides in Intermountain West Kochia Populations. Weston Maughan*[1], Corey V. Ransom[1], Megan Nielson[1], Kimberly Thornsted[2], Shaun Bushman[2]; [1]Utah State University, Logan, UT, [2]USDA, Logan, UT (086)

Kochia (*Bassia scoparia*) is a common invasive plant across Utah; however, studies regarding this species' ability to rapidly evolve herbicide resistance has not been well studied, much less reported, in the state's populations. This study sought to document the extent of ALS-resistant kochia in Utah and analyze mutations in the ALS gene to determine which mutations are suspect in the increase in ALS resistance. Samples from 84 Utah populations were collected from across the State and subjected to 17.5 g ai/ha of chlorsulfuron at the 3-4 leaf stage to determine population survival rates. The greenhouse screens showed 62% of the kochia populations showed some level of resistance, with some demonstrating zero mortality. Eight individual plants from populations that exhibited different survival rates were clonally propagated and screened to determine GR50's. Genetic sequencing of the ALS gene revealed mutations at the Ile72, Pro81, Pro197, Gly261, Pro264, Asp376, Asn427, and Trp574 sites, as well as a 12bp indel in a non-coding region. Genotype analysis showed strong correlations between population survival rates, GR_{50}'s, and mutations at the Trp574 and Pro197 sites. Trp574Met endowed resistance independent of any other mutations. Trp574Leu also showed a high correlation to resistance when accompanied with resistant mutations in the Pro197 and Asp376 sites. Pro197Arg, Pro197Glu, and Pro197Leu showed survival rates comparable to Trp574Met; however, the margins of error were exceptionally large. Asp376Glu correlated with higher levels of resistance only when accompanied with other resistant mutations. All other sites showed little correlation with ALS-inhibition resistance.

Western U.S. Forestry Site Preparation with Florpyrauxifen-benzyl + Aminopyralid. Jodie A. Crose*[1], William L. Hatler[2], Byron B. Sleugh[3], Craig M. Alford[4], Sam Ingram[5], Scott Flynn[6]; [1]Corteva Agriscience, Tulsa, OK, [2]Corteva Agriscience, Meridian, ID, [3]Corteva Agriscience, Carmel, IN, [4]Corteva Agriscience, Ankeny, IA, [5]Corteva Agriscience, Savannah, GA, [6]Corteva Agriscience, Lees Summit, MO (087)

TerraVue® (Rinskor™ + aminopyralid) is a new herbicide developed by Corteva Agriscience™ for control of broadleaf weeds, including invasive and noxious weeds, and certain woody plants in non-crop areas. Research has been ongoing to determine its suitability for forestry site preparation applications in the western U.S. Extensive testing was conducted with TerraVue alone at 129 g ai/ha and in combination with tank mix partners on production forest sites in California, Oregon, Washington, and Idaho in 2021. Seven trials were established in September or October of 2021, at the typical pre-plant site preparation timing. Results indicate overall good crop tolerance on Douglas fir (*Pseudotsuga menziesii*), Ponderosa pine (*Pinus ponderosa*), Western larch (*Larix occidentalis*), and Western redcedar (*Thuja plicata*) at 36-54 weeks after application (WAA). Weed control with TerraVue alone was good to excellent (81-100%) at 36-54 WAA on key species, such as California snowbush (*Ceanothus cordulatus*), oxeye daisy (*Leucanthemum vulgare*), miner's lettuce (*Claytonia perfoliata*), fringed willowherb (*Epilobium ciliatum*), rose clover (*Trifolium hirtum*), and common mullein (*Verbascum thapsus*). Mean control across all weeds with TerraVue alone at 36-54 WAA was 75% and improved to 89% when tank mixed with CleanTraxx® herbicide (penoxsulam + oxyfluorfen) at 2560 g ai/ha. Based on these results, TerraVue will be a very effective tank mix partner for use in western U.S. forestry site preparation. Registration for use of TerraVue on forest sites will be pursued, as it is not currently labeled for this use pattern.

Integrated Management of Canada Thistle: Evaluating the Efficacy of the Rust Pathogen *Puccinia punctiformis*. Caitlin Henderson*[1], Kristi Gladem[2], Karen Rosen[2], Steve Young[3], Dan Bean[2], Robert Schaeffer[1]; [1]Utah State University, Logan, UT, [2]Colorado Dept. of Agriculture, Palisade, CO, [3]USDA-ARS, Beltsville, MD (088)

Canada thistle (*Cirsium arvense*) is a problematic invasive plant that threatens agricultural and natural landscapes worldwide. Chemical control has been the primary management method used for this weed, along with tillage and mowing. Unfortunately, *C. arvense* has an extensive root system, making control difficult, particularly in natural environments. *Puccinia punctiformis* (Canada thistle rust fungus) is a pathogen capable of infecting *C. arvense*, resulting in the reduction of root mass and shoot growth, both important for clonal spread. *Puccinia punctiformis* has shown promise as a biocontrol agent for Canada thistle; however, its efficacy when integrated with other methods remains unclear. Here, we evaluated different combinations of control methods (herbicide, mowing, tillage, and *P. punctiformis*) and their compatibility with one another, with experiments performed at two sites (Colorado and Utah) from 2020-2022. Pre-treatment measures of thistle density and coverage and rust incidence occurred in fall 2020, with subsequent monitoring occurring in spring, summer, and fall before treatment application (fall 2020 and 2021). Preliminary analyses reveal that herbicide application, both alone and combined, can generate the greatest immediate effect on *C. arvense*, reducing stem density at both sites in both years by 90-100%. Furthermore, all other treatments appeared to generate some impact on *C. arvense* density, including *P. punctiformis* treatments. Interestingly, *P. punctiformis* treatments appear to have a greater impact in Colorado than in Utah. However, signs (e.g., telia) of pathogen infection were few, suggesting that the pathogen may be impacting the thistle more than we can visibly observe.

Micronutrient Fertilizer Impacts on Cheatgrass and Desirable Species. Danielle B. Johnston[1], Kevin Gunnell*[2], Melissa L. Landeen[2]; [1]Colorado Parks and Wildlife, Grand Junction, CO, [2]Utah Division of Wildlife Resources, Ephraim, UT (089)

Cheatgrass (*Bromus tectorum*) is a serious obstacle to ecosystem restoration in western North America. NutraFix™ is a micronutrient-heavy fertilizer that can limit cheatgrass while promoting

the growth of some desirable plants. We sought information on appropriate application rates and germination impacts via 3 studies. Beginning fall 2019, we compared NutraFix (392 kg/ha) to imazapic (70 g ai/ha; 4 oz/ac Plateau®), applied prior to seeding at one Colorado site. In both 2020 and 2021, cheatgrass density was lower with NutraFix than imazapic. However, seeded grass density in 2021 was also lower with NutraFix than with imazapic. At another Colorado site, we compared NutraFix (392 kg/ha), indaziflam (73 g ai/h ; 5 oz/ac Rejuvra®), and control in conjunction with a germination trial. Cheatgrass density was lower with NutraFix than indaziflam. However, NutraFix reduced bitterbrush (*Purshia tridentata*) and squirreltail (*Elymus elymoides*) seedling density relative to control. In fall 2020, we began a rate trial study comparing control, low, medium, and high rates on mature vegetation at 10 locations in Colorado and Utah. In 2021, the low and medium rates did not satisfactorily limit cheatgrass cover. The high rate (336 kg/ha) limited cheatgrass cover at most sites. NutraFix remains a promising tool for ecosystem restoration as we continue to refine our understanding of how best to use it.

New Weeds Arriving in the West: How Are We Keeping Track? Kelsey C. Brock*; University of Wyoming, Laramie, WY (090)

Early detection and rapid response (EDRR) is often touted as the most cost-effective approach to weed management. However, preparing for new incursions requires sufficient infrastructure to verify plant identifications and communicate information on new species' locations. This talk details my experience in attempting to "horizon scan" for future invaders in west-central North America by first compiling a simple species list of non-native plants using 1) non-native plant checklists curated by each state, and 2) occurrence records of specimens housed in herbaria. I found that assembling a list was hindered by tremendous variation in the quality, completeness and accessibility of checklists curated by individual states. Compiling this list from occurrence data alone was a poor substitute, as some specimens have not yet been digitized and uploaded into easy-access databases, resulting in many species being excluded. Attempting to solve this problem using non-specimen-based resources added so many species that accurate identification was drawn into question. This study shows that we lack the infrastructure to track plant invasions in the west, even at coarse resolutions such as the state level. Thus, our ability to coordinate EDRR actions is reliant on word-of-mouth communication, which is likely inadequate, especially at large spatial scales.

Evaluating Bulbous Bluegrass Control by Various Herbicides. Jaycie N. Arndt*[1], Brian A. Mealor[2], Beth Fowers[3]; [1]University of Wyoming, Arvada, WY, [2]University of Wyoming, Laramie, WY, [3]University of Wyoming, Sheridan, WY (091)

Bulbous Bluegrass (*Poa bulbosa*) is an invasive perennial grass that was intentionally introduced to the US in 1906. Bulbous bluegrass was tested as a turf grass but performed poorly. Then it was momentarily used in restoration seed mixes to compete with cheatgrass in southern Idaho. Now bulbous bluegrass is considered an invasive short-lived perennial. It is adapted to areas with dry summers, mild winters, and winter-dominated precipitation. Although it is widespread throughout the West, research on bulbous bluegrass control methods is limited. We evaluated the efficacy of various herbicides in controlling bulbous bluegrass. We present results from two field sites, one treated with 11 herbicides + glyphosate in April of 2018 and monitored every year for 4 years after treatment (YAT), and one treated with 10 herbicides in November of 2021 and monitored one YAT. We estimated control (%) of bulbous bluegrass, damage (%) to perennial species and cover (%) by species for both field sites. We also collected biomass in 2, ¼ m^2 quadrats for each treatment in the 2021 field site. Indaziflam + imazapic showed greater initial control and better

long-term control of bulbous bluegrass. Imazapic, sulfometuron methyl + chlorsulfuron, and rimsulfuron provide good control in the first year after treatment, but control diminished by 4 YAT. Perennial grasses at 1 YAT were only impacted by herbicide treatments that included rimsulfuron or imazapic. Further research should evaluate efficacy under various application timings and non-target effects in treatment areas.

Monitoring Biodiversity Response to Invasive Annual Grass Control Across Several Western Ecoregions. Shannon Clark*[1], James R. Sebastian[2], Rachel Mealor[3]; [1]Envu Vegetation Management, Sheridan, WY, [2]Boulder County Parks and Open Space, Longmont, CO, [3]Private contractor, Sheridan, WY (109)

Invasive annual grasses (IAG), such as *Bromus tectorum*, *Bromus japonicus*, *Ventenata dubia*, and *Taeniatherum caput-medusae*, threaten rangeland biodiversity and productivity throughout the western US. Focusing efforts on managing IAG in intact rangelands can have immediate impacts to biodiversity and productivity. We conducted a study to evaluate impacts to vegetation communities with IAG treatments across several western ecoregions. At all sites, plots were established in areas treated with either indaziflam 73 g ai ha^{-1} or indaziflam 73 g ai ha^{-1} + imazapic 88 g ai ha^{-1} and a paired non-treated control. Sampling was conducted at 1 to 3 years after treatment. For each plot, a center point was established and quadrats were used for sampling on paced transects at 0, 120, and 240 degrees. Eleven quadrats were sampled per transect for a total of 33 quadrats per plot. Species frequency, dry weight rank, and line point intercept sampling methods were used. Within the High Plains ecoregion, non-treated plots ranged from 33 to 100% frequency of IAG, while treated plots ranged from 0 to 36% frequency. The top three species by dry weight within non-treated plots were *Bromus tectorum*, *Sporobolus cryptandrus*, and *Hesperostipa comata*, averaging 22.4, 11.3, and 10.3% of the dry weight production across sites, respectively. In the treated plots, the top three species by dry weight rank were *Agropyron smithii*, *Bouteloua gracilis*, and *Sporobolus cryptandrus*, contributing to 15.6, 15.1, and 14.9% of the dry weight production across treated sites, respectively. Across the Northwestern Great Plains sites, plots in non-treated sites ranged from 58 to 100% IAG frequency, while treated plots had 0 to 18% IAG frequency. The top three species by dry weight rank in the non-treated plots were *Bromus tectorum* (21.8%), *Hesperostipa comata* (16.9%), and *Agropyron smithii* (14.2). In the treated plots the top three dry weight species were A*gropyron smithii* (25.5%), *Hesperostipa comata* (22.7%), and *Pseudoroegneria spicata* (11.9%). Overall, across ecoregions treatments reduced IAG and promoted native species compositions in terms of production by dry weight.

Evaluating Differences in the Ecology of Small, Non-native Annual Mustards and the Need for Management in Grasslands. Lisa J. Rew*, Jordan Meyer-Morey, Matthew Lavin; Montana State University, Bozeman, MT (110)

Three alyssum species (*Alyssum alyssoides, A. desertorum* and *A. simplex*) are found in disturbed land within the sagebrush biome and other areas of the west. The species are difficult to distinguish among without a hand-lens and ecological information is scant. We used herbarium data to evaluate for differences in climate niches, assessed seed germination over a temperature gradient (5 - 40 ^{O}C), and their competitive ability with each other and a non-native annual grass. The species overlap in most climate variables but *A. alyssoides* prefers higher precipitation and lower elevation sites than the other two species. All three species had good germination, but *A. desertorum* had the narrowest temperature range, the other two species were similar. All were weak competitors to the non-native grass. So, what is their role in the ecosystem? Non-native plants can reduce biodiversity and disrupt essential ecosystem services and functions. For most non-native plant species however,

quantitative evidence of negative effects is lacking. To address this, we recorded vegetation at six sites along an elevation gradient within lightly disturbed mountain sagebrush (*Artemisia tridentata* ssp. *vaseyana*) habitats, within Yellowstone National Park. We observed *A. desertorum* at four and *A. simplex* at two sites, no *A. alyssoides* was found. The presence of either *Alyssum* species did not affect species richness nor Shannon's diversity, and functionally similar native annual forbs were not displaced in invaded areas. Our study suggests that while there are subtle differences in these species' ecology they are relatively weak competitors within the mountain sagebrush steppe.

Phragmites Control and Wetlands Restoration: The Struggle to Increase Plant Community Diversity in Metal-Contaminated Ecosystems. Stephen G. Hayes*[1], David J. Leptich[2], David Van de Riet[2], Steve Sluka[2]; [1]Alta Science and Engineering, Spokane Valley, WA, [2]Idaho Fish and Game, Coeur D'Alene, ID (111)

We provide a preliminary report following the fourth year of a 5-year *Phragmites* control and wetland restoration field experiment in the Lower Coeur d'Alene Basin, Idaho. We are using an adaptive management approach to develop a set of *Phragmites* control protocols and to evaluate the effect native species planting and natural regeneration have on wetland restoration at *Phragmites* control sites. Our restoration efforts are stymied by the presence of extensive metal pollution in the Lower Basin. We are using a split-split plot design to examine the effects 4 herbicide treatments, 2 treatment frequencies, and 2 seeding strategies on visual obstruction, *Phragmites* relative importance value (RIV), and non-*Phragmites* plant community diversity. Predictions from fitting the split-split mixed effects models on visual obstruction indicate that plots treated once with glyphosate contain the greatest amount of residual *Phragmites* vegetation, supporting the notion of an herbicide treatment by application frequency interaction on this response. Large main effects of herbicide treatment on RIV, species richness, and Shannon diversity are emerging, but interactive effects of herbicide treatment, seeding, and spray frequency are not. After 4 years, treatments continue to be effective in reducing *Phragmites* below baseline conditions, but we have observed waning of herbicide effectiveness, especially in the glyphosate-treated plots. We suspect the weak native plant community response is due to a combination of residual *Phragmites* thatch, low soil moisture, and a lack of aggressive, metal-tolerant pioneer species in our planting mix. This starts to suggest that future restoration efforts in the Lower Coeur d'Alene Basin should focus on site preparation and species selection when attempting to reestablish the native plant community in these highly contaminated environments.

WSWS PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Weed Control in Desert Turfgrass Has Been Effective and Successful So Far, How Long Can it Last? Kai Umeda*; University of Arizona, Phoenix, AZ (112)

The dinitroaniline herbicides, prodiamine and pendimethalin, along with dithiopyr have been used historically for effective preemergence weed control in most turfgrasses in the desert southwest United States. Annually, multiple applications offer control of summer and winter annual grass weeds such as *Digitaria* spp. (crabgrasses), *Eriochola* spp. (cupgrasses), *Eleusine indica* (goosegrass), and *Poa annua* (annual bluegrass). The same applications frequently provide control of small-seeded broadleaved weeds such as *Chamaesyce* spp. (spurges) and *Portulaca oleracea* (purslane), and winter weeds in the families Brassicaceae (mustards, London rocket, shepherdspurse, etc.) and Asteraceae (sowthistles, wild lettuce, common groundsel). Typically, the application timings coincide with the winter and summer rainfall patterns when the weeds

commonly emerge. Usually sequential applications in February-March ahead of the first emergence of the summer weeds are followed by another application in July when monsoon rains facilitate the continued emergence through the summer. For winter weeds that emerge with cooling soil temperatures and winter rains, an October application is followed by a later December application for season-long control. Since the early 1990's, the acetolactate synthase (ALS) enzyme inhibiting herbicides gained popularity for a multitude of weed control and turfgrass management functions. Several products have been extremely useful for removal of overseeded perennial ryegrass to hasten spring transition of bermudagrass turf. Many of the same products have been effective in a strategy to control *Cyperus rotundus* (purple nutsedge) during the summer in turfgrasses. For *P. annua* management, the ALS herbicides could be in the fall immediately before ryegrass overseeding and after overseeding to cleanup and help define golf course fairway edges from the rough areas. For the future, the outlook for effective and successful weed management in desert turfgrasses is promising as other chemistries with different modes of action are investigated for selectivity and rotated into preemergence programs. Pre-mix preemergence herbicide products also offer multiple modes of action to address multiple weed problems during winter and summer seasons. Complementing the preemergence herbicides are newer postemergence herbicides that have proven to be effective when applied in a timely manner.

Herbicide Injury in Hazelnut - Risk and Prevention. Ryan J. Hill*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (114)

Control of hazelnut basal sprouts is necessary to maintain a single-trunk tree form, typically accomplished in with 4-8 applications of herbicides per year. Frequent and widespread reports of trunk injury in orchards pose questions concerning the safety of the practice, particularly in juvenile trees. Trunk guards and latex paint are commonly used as physical barriers to shield the trunk from direct contact with herbicides but no studies have been conducted to assess efficacy of either method in reducing trunk injury. To address this question 'Jefferson' hazelnut trees were planted at the Lewis-Brown Horticultural Research Farm in 2018 with three trunk protection methods: unshielded, coated with latex paint, or covered in an opaque plastic trunk guard. These trees were treated with glufosinate-ammonium (Rely 280) at 1x, 2x, and 4x the label rate (1,150 g ai/Ha) in 2019 and 2020 with one, two, or three applications per season. Results showed injury was induced at the 4x rate on unshielded and painted trunks, with no injury in trunk guard trees. Injured bark surface area and internal trunk injury were reduced by 50% in painted trunks, relative to unshielded trunks. There was no herbicide injury on trunk guard trees but wood density measurements showed a 2-3% reduction relative to unshielded and painted samples. We conclude that both latex paint and trunk guards provide good protection from herbicide injury, but higher cost and reduced wood density make trunk guards less attractive. More work must be done to provide precise recommendations to growers on how to properly protect their plants from injury while mitigating the consequences of the methods chosen.

European Hazelnut (*Corylus avellana* L.) and Canada Thistle (*Cirsium arvense* L.) Response to Florpyrauxifen-benzyl. Joshua W. Miranda*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (115)

Canada thistle is difficult to control due to its root system that can extend two meters in depth and five meters horizontally. Clopyralid is the only effective option for Canada thistle control in hazelnut; however, its use is limited to a single application per season. Florpyrauxifen-benzyl is a synthetic auxin herbicide with potential suitability in hazelnuts, however, its effect on hazelnut and Canada thistle is unknown. Two field studies were initiated in 2022 to assess hazelnut tolerance to four repeated basal-directed applications of florpyrauxifen-benzyl (29 to 116 g ai ha^{-}

[1]). Greenhouse studies were conducted to evaluate the efficacy of florpyrauxifen-benzyl to control Canada thistle at two growth stages, rosette and small bolting, as well as comparing its efficacy with current benchmarks. In 2022, four applications of basal-directed florpyrauxifen-benzyl did not injure hazelnut trees nor affected hazelnut yield or growth at either location. Regardless of the rate, number of applications, or growth stage of Canada thistle, florpyrauxifen-benzyl exerted 75-96% control over Canada thistle. Florpyrauxifen-benzyl at 29 g ai ha^{-1} provided similar Canada thistle control as clopyralid 280 g ai ha^{-1} and glyphosate 1,680 g ae ha^{-1}. Florpyrauxifen-benzyl at 8, 16, 29, or 38 g ai ha^{-1} as one application or as sequential application reduced Canada thistle root biomass by 96-99% when applied at the rosette stage, and 80-97% when applied at the small bolting stage. Florpyrauxifen-benzyl at 29 g ai ha^{-1} reduced Canada thistle root biomass by 97% similar to clopyralid, glyphosate, and clopyralid plus florpyrauxifen-benzyl, flazasulfuron, or glufosinate.

Liquid-applied Cellulosic Mulches for Weed Suppression in Day-neutral Strawberry. Greta G. Gramig*[1], Waqas Ahmad[1], Dilpreet Bajwa[2], Lisa DeVetter[3], Andrew Durado[2], Alice Formiga[4], Suzette Galinato[5], Sharon Weyers[6]; [1]North Dakota State University, Fargo, ND, [2]Montana State University, Bozeman, MT, [3]Washington State University, Mount Vernon, WA, [4]Oregon State University, Corvallis, OR, [5]Washington State University, Pullman, WA, [6]USDA-ARS, Morris, MN (116)

Polyethylene (PE) plastic mulch is widely used in organic horticultural systems to suppress weeds and promote crop performance through optimization of soil temperature and moisture. Unfortunately, disposal of this non-biodegradable material is associated with negative environmental impacts that are misaligned with goals of organic agriculture. We are developing biodegradable sprayable alternative mulches (hydromulches, HM) that will effectively suppress weeds while helping to mitigate plastic pollution. During 2021 and 2022, we developed and tested several cellulosic HM formulations via lab and greenhouse experiments. Subsequently, field trials of the most promising HM formulations were conducted in ND and WA in day-neutral strawberry during 2022. Hydromulch consisted of shredded newsprint mixed with water and formulations included additions of guar gum and psyllium husk at rates of 2 or 6% of the total dry matter (DM). These HM formulations were compared with 1 mil thick PE mulch, an industry standard. The sprayable HM slurry consisted of 35.7 g DM L^{-1} H_2O. Hydromulch was applied using an engine-driven centrifugal pump to 1 x 4.6 m^2 raised beds at 454 g DM m^{-2} through a 1.9 cm brass nozzle. Bare root 'Albion' variety strawberry plants were planted by hand after HM application. Weed density was quantified at peak weed emergence (PWE) and peak weed vegetative growth (PWVG). Weed total DM was quantified at PWVG. Total and marketable berry yield from both weedy and weed-free subplots were quantified via weekly harvests. Across both sites at PWE, weed density associated with guar gum HM formulations was 500% less than that associated with other formulations (10 vs. 60 weeds m^{-2}, respectively). At PWVG for ND, the same pattern persisted and weed densities ranged from 1 to 12 weeds m^{-2}, but at the WA site weed density did not differ among HM formulations and ranged from 48 to 98 weeds m^{-2}. At both sites, PE mulch was associated with zero weeds (excluding those in planting holes). At ND, mulch deterioration over the season was reduced for guar gum HM formulations and PE compared with other formulations (approximately 2 to 7% vs. 14 to 18%, respectively). At WA, mulch deterioration for all HMs was greater than for PE (approximately 1 to 2% vs. 6 to 14%, respectively). At WA, total berry yield did not differ among HMs or PE in weedy or weed-free subplots, and ranged from approximately 200 to 275 g $plant^{-1}$. Conversely, at ND in weed-free subplots, all HM formulations were associated greater berry yield than PE mulch (approximately 40 to 120 g $plant^{-1}$ vs. 2 to 5 g $plant^{-1}$). At ND in the weedy subplots, guar gum HM formulations were associated with greatest

yield (70 to 90 g plant^{-1}) compared with PE mulch (2 to 5 g plant^{-1}). Marketable yield followed similar patterns to total yield at both sites. Our results suggest that cellulosic HMs, especially those including guar gum tackifier, may be a suitable replacement for PE mulch in day-neutral strawberry production.

Novel Weed Control with Low Doses of Electricity. Erik A. Lehnhoff*, Paul Neher, Andres Indacochea; New Mexico State University, Las Cruces, NM (117)

Alternatives to manual and chemical weed control are desired by homeowners and organic producers. Weed management via electricity is becoming a more viable option, but commercial electrical weeding systems are expensive and generally not suitable for home or small-scale use. We have developed a safe and effective system for pre-emergent weed management in xeriscaping, prevention of climbing vines, and potentially managing weeds in high-value crops. In a xeriscaping weed control experiment, electric weed control was integrated into landscaping gravel and compared to gravel alone, and electric weed control reduced weed cover by 90% compared to the gravel control. In an experiment to test the ability of electricity to prevent vine weeds from climbing structures, electricity was shown to be 100% effective at prevention, while in the control weeds climbed readily and covered 45% of the structures. In a crop production setting, our electric weed management system has been shown to be effective in minimizing weed cover compared to untreated controls. Our results indicate that electricity is a viable alternative to manual, mechanical or chemical methods for pre-emergent weed control in xeriscaping and in prevention of climbing weeds, and preliminary results indicate the system has potential to manage weeds in select cropping systems.

Efficacy of Preemergence Herbicides for Puncturevine Control Between Plastic Mulch Rows in Cucurbits. Cody D. Zesiger*[1], Corey V. Ransom[2], Cody J. Beckley[2], Dan Drost[2]; [1]Utah State University, Ogden, UT, [2]Utah State University, Logan, UT (118)

In June 2022, four field trails were established in three Utah counties to evaluate preemergence herbicide efficacy for puncturevine (*Tribulus terrestris*) management. Up to 9 treatments including an untreated check were applied to pumpkins (Box Elder and Davis counties), cantaloupe (Box Elder County), and watermelon (Weber County) using a pressurized CO^2 backpack sprayer. Plots measured 6 by 20-feet and were replicated four times. Treatments included five herbicides (clomazone, ethalfluralin, halosulfuron, pendimethalin, and trifluralin) that were applied alone or in combination at coarse or fine soil rates. Both sites in Box Elder County were not evaluated following the application of the treatments. In Weber and Davis counties, the treatments were applied between rows of plastic mulch prior to puncturevine emergence. Because of exceptionally dry conditions, herbicides were incorporated mechanically. Treatments were evaluated eight weeks after application by collecting total dry biomass from each plot. Additionally, puncturevine plants were tallied in each plot to assess whether a small number of plants escaping control could produce significant biomass that negate management efforts. Puncturevine control from both sites was not statistically significant for all but three treatments in comparison with the untreated check. Treatments, containing ethalfluralin alone or in combination with halosulfuron performed better than all other treatments. However, statistically significant puncturevine control in 2022 was relatively disappointing in comparison to the herbicide's efficacy observed in 2021 trials. Although we are uncertain of the actual cause, it is possible that mechanical incorporation, dry soils, or warm soils coupled with application timing reduced herbicide efficacy. Given the likelihood of drought during future applications of herbicides, the 2022 trails will be repeated in 2023 using irrigation for herbicide incorporation.

Pendimethalin Integration into Onion Early Season Weed Management. Harlene M. Hatterman-Valenti*, Avery Shikanai, Collin Auwarter; North Dakota State University, Fargo, ND (119)

Weed control in seeded, dry-bulb onion (*Allium cepa* L.) is challenging. A slow growth rate, poor competitive ability, and the scarcity of registered herbicides can all converge to limit yield. Additionally, commonly used herbicides in onion production can be costly. Given these challenges, North Dakota State University has sought to optimize early-season weed control to preserve yield, while maintaining profitability. Herbicide programs assessed application timings (PRE, delayed PRE, loop, 1-leaf, and 2-leaf), number of early season applications (one or two) and herbicide active ingredients. Programs were centered around pendimethalin, but dimethyl-tetrachloroterephthalate, ethofumesate, bromoxynil, and glyphosate were also evaluated in either tank mixes or sequential applications. In total, 46 herbicide programs were evaluated across two sites and three years in a multi-environment trial. A hierarchical, linear, mixed-effect model was used to determine the best linear unbiased estimates of herbicide treatment effects. With timely application and irrigation, average weed control was generally excellent (>90%) regardless of the program. Yield was significantly affected by herbicide program. Among pendimethalin-only programs, delayed PRE applications at the highest labeled rate generally resulted in the greatest yield. Addition of another herbicide applied in sequence or as a tank-mix generally resulted in greater yields than pendimethalin-only programs. Taken together, pendimethalin can be an effective component of a weed control program for dry-bulb onion with timely application and appropriate irrigation.

Metobromuron Potato Crop Safety and Weed Control. Pamela J.s. Hutchinson*[1], Joel Felix[2], Brent Beutler[1]; [1]University of Idaho, Aberdeen, ID, [2]Oregon State University, Ontario, OR (120)

Trials to determine weed control and potato crop variety tolerance with metobromuron were conducted at the University of Idaho Aberdeen R&E Center and Oregon State University Malheur Experiment Station in 2022. Weed Control Trial: Russet Burbank and Ranger Russet were planted at Aberdeen and Malheur, respectively. Treatments consisted of metobromuron at 0.9 or 1.34 lb ai/A or s-metolachlor at 0.95 or 1.27 lb ai/A alone or in tank-mix combinations of the two rates, as well as linuron at 0.75 and metribuzin at 1 lb ai/A applied preemergence to the potatoes and weeds after a hilling operation, then sprinkler incorporated with irrigation water. A nontreated, weedy control was also included for treatment tuber yield and quality comparisons. Visual control ratings were performed early-, mid-, and end-of-season with 0 being no control and 100 being total control. All treatments provided 90 to 100% season-long control of redroot pigweed (*Amaranthus retroflexus*) (AMARE) at both locations and green foxtail (*Seteria viridis*) (SETVI) and barnyardgrass (*Echinochloa crus-galli*) (ECHCG) at Aberdeen and Malheur, respectively. Other than the 60 and 73% control of common lambsquarters (*Chenopodium album*) (CHEAL) by the low and high s-metolachlor rates, respectively, control was 90 to 100%. Hairy nightshade (*Solanum physalifolium*) (SOLPS) was present at both locations, however, control results could not be combined. SOLPS was controlled 90% or greater by all treatments at Malheur while control of this weed at Aberdeen was less than 50% by metribuzin and was 85 to 87% by both s-metolachlor rates and the low rate of metobromuron. Crop injury during the season was negligible at both locations. Although U.S. No. 1 and total tuber yields in the herbicide treatments were variable, all were greater than those of the nontreated weedy control. Overall, metobromuron controlled AMARE, SETVI, and ECHCG season-long. SOLPS control by s-metolachlor can be enhanced when tank mixed with metobromuron. CHEAL control by metobromuron alone or tank-mixed with s-metolachlor was greater than by s-metolachlor alone. Potato Variety Tolerance:

Atlantic, Chieftain, Dark Red Norland, and Shepody were planted at both locations. Representing 1 and 2X rates, metobromuron at 1.34 or 2.68 lb ai/A was applied preemergence and sprinkler incorporated. Similarly applied tank mixtures of 1X with s-metolachlor at 1.27 or 2X with s-metolachlor at 2.53 lb ai/A were included in the trial. A nontreated weed-free control for each variety was included. The variety x rate x location interaction was significant for injury and yields, so data were sorted by variety, and treatments analyzed within variety at each location. Regardless of herbicide treatment, injury consisting of chlorosis and some stunting, was not greater than 10% except with Atlantic at Malheur where injury was 20 to 29%. There were no differences in U.S. No. 1 and total tuber yields for Chieftain at either location; for Atlantic or Dark Red Norland at Aberdeen; or for Shepody at Malheur. Although significant injury differences were not observed at Aberdeen in Shepody, yields of the metobromuron 2X alone and tank-mixed with s-metolachlor were less than yields of the nontreated weed-free control and the 1X alone and tank mixed treatments. The same differences in Dark Red Norland tuber yields occurred at Malheur. While treatment yields of Atlantic at Malheur were different, they did not correlate with rates. Concerning potato variety tolerance, tank mixing metobromuron with s-metolachlor did not cause more injury and yield loss than when metobromuron was applied alone, rather, differences were due to the rates. Chieftain tolerated all treatments and rates at both locations. Atlantic tolerated metobromuron alone or mixed with s-metolachlor at Aberdeen but not at Malheur. Dark Red Norland and Shepody seemed to be impacted by the 2X rate of metobromuron alone or with s-metolachlor but not the 1X alone and tank mixture.

Cover Crops for Pest Suppression in Chile Pepper. Brian Schutte*[1], Akash Bajagain[1], Asmita Nagila[2], Caroline Toth[1]; [1]New Mexico State University, Las Cruces, NM, [2]Texas A&M University, Uvalde, TX (121)

Previous research indicated weeds in chile pepper were inhibited by an overwinter mustard cover crop that was mowed and incorporated in soil in spring. Although this suggests overwinter mustard cover crops can be components of weed management programs for chile pepper, mustard cover crops may cause additional pest problems as they potentially provide habitat for beet leafhoppers (*Circulifer tenellus*) that transmit a curtovirus responsible for beet curly top disease in chile pepper. To further develop overwinter cover crops as a weed management tactic for chile pepper, we evaluated weed suppression from mustard (*Brassica juncea*) cover crops terminated at different times before beet leafhopper flights in spring. We also assessed mustard and barley (*Hordeum vulgare*) cover crops for beet leafhopper abundance and weed suppression in chile pepper. These objectives were addressed with two field studies conducted at university research farms in the Rio Grande Valley of southern New Mexico. For the first study, treatments included mustard cover crops terminated and incorporated in soil at 56, 42 or 28 d before chile pepper seeding and a no cover control. For the second study, treatments included mustard, barley, a mixture of mustard and barley, and a no cover control. Results from the first study indicated mustard cover crops terminated 42 d before chile pepper seeding (17 to 30 d before the onset of beet leafhopper flights) reduced weed densities through the first 28 d of the chile pepper season. Mustard cover crops terminated 28 and 56 d before chile pepper seeding did not suppress weeds. Results from the second study indicated adult beet leafhoppers were found in the mustard cover crop and the mixture of mustard and barley. Adult beet leafhoppers were not found in the barley cover crop. At 4 wk after chile pepper seeding at one study site, plots that were formerly barley had fewer weeds than plots that did not have a cover crop (no cover control). The results from these two studies suggest overwinter cover crops can be selected and managed to limit local increases in beet leafhopper abundance and possibly suppress weeds in chile pepper.

WSWS PROJECT 3: WEEDS OF AGRONOMIC CROPS

Simulating Postemergence Optical Spot Spraying Applications Following Acuron Applied Preemergence. Jason W. Adams[1], R Joseph Wuerffel[2], Rob Lind[3], Taylor Glenn[4], David Belles[5], Marty Schraer*[6]; [1]Syngenta Crop Protection, Vero Beach, FL, [2]Syngenta Crop Protection, Gerald, MO, [3]Syngenta Crop Protection, Jealotts Hill, United Kingdom, [4]Syngenta Crop Protection, Orlando, FL, [5]Syngenta Crop Protection, Greensboro, NC, [6]Syngenta, Meridian, ID (071)

Optical spot spraying technology is becoming more common in the marketplace. Understanding how this technology may perform in integrated weed management systems is important; however, access to research equipment is currently a challenge. Therefore, the objective of this study was to evaluate if high resolution drone imagery can be used to simulate postemergence applications using an optical spot sprayer following preemergence applications. Bicep II Magnum® or Acuron® were applied to corn plots preemergence. Following the preemergence application, drone flights were performed at the V1, V3, and V5 corn growth stages. Images from each flight were then converted and analyzed using a Syngenta modeling tool to simulate postemergence optical spot spray applications. The simulated post sprays indicated greater weed control from Acuron® compared to Bicep II Magnum®. The resulting simulated postemergence spray volume savings aligned well with previous field results. The results from these trials indicate that the use of high-quality drone imagery can be used to simulate postemergence optical spot spraying applications. Furthermore, these data indicate that early season weed management will remain critical to weed management in a future where optical spot sprayers are used.

Harvest Weed Seed Control: A Potential Non-Chemical Weed Management Tool for Cereal and Corn/Soybean Rotations in SE Montana. Het S. Desai*[1], Fabian Menalled[1], Tim Tim Seipel[2], Lovreet S. Shergill[3]; [1]Montana State University, Bozeman, MT, [2]Montana State University, LRES, Bozeman, MT, [3]Montana State University, Huntley, MT (072)

With the evolution of multiple herbicide resistance in agroecosystems, there is an increased need to develop additional non-chemical weed management practices [e.g., harvest weed seed control (HWSC)]. At crop harvest, HWSC disrupts the dispersion of weed seeds from the combine and minimizes the weed seedbank replenishment. However, understanding weed seed retention at crop harvest is essential to identify potential weed species for HWSC. During 2021 and 2022, field experiments were conducted to evaluate seed retention and seed-shattering phenology of wild oats (*Avena fatua* L.) in spring wheat, feral rye (*Secale cereale* L.), and downy brome (*Bromus tectorum* L.) in winter wheat, and kochia [*Bassia scoparia* (L.) A. J. Scott], common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), and green foxtail [*Setaria viridis* (L.) Beauv.] in soybean and corn. *Avena fatua* retained 70-100% seeds at spring wheat physiological maturity. *Secale cereale* and *B. tectorum* retained 85-95% and >75% seeds in winter wheat, respectively. In corn and soybean, all tested weed species retained 85-90% seeds at crop physiological maturity, except *C. album*, which retained 75-80% seeds. High seed retention (70-100%) of all tested weed species at winter wheat, spring wheat, corn, and soybean physiological maturity makes them suitable candidates for HWSC. Our results will aid in future research, which aims to evaluate different HWSC systems such as chaff-lining, narrow windrow burning, and impact mill.

Field Testing of a Physical Impact Mill in Western Canada. Breanne D. Tidemann*[1], K. Neil Harker[1], Hugh Beckie[2]; [1]Agriculture and Agri-Food Canada, Lacombe, AB, Canada, [2]University of Western Australia, Perth, Australia (073)

Field Testing of a Physical Impact Mill in Western Canada Tidemann, B.D.[1], Harker, K.N.[2], Beckie, H.J.[2] [1]Agriculture and Agri-Food Canada, Lacombe, AB. [2]Retired. Alternative weed control strategies are necessary for management of herbicides resistant weeds. Physical impact mills are an originally Australian strategy that have been developed to prevent weed seedbank additions at harvest. A physical impact mill, the original Harrington Seed Destructor, was tested from 2017-2020 in 20 producer fields within an approximately 50km radius of Lacombe, AB. In each producer field a dense weed patch was identified, mapped, and divided into three replicates. Each replicate contained an untreated check treatment, and a treatment where the Harrington Seed Destructor was used at harvest. Treatments were applied for three harvests, 2017, 2018 and 2019, with pre-harvest weed density assessments conducted, as well as pre-spraying seedling weed densities the following spring (2018, 2019 and 2020, respectively). Soil seedbank samples were also collected in spring of 2020. ANOVA statistical analysis of 2020 seedling density and total weed population was conducted for the most abundant weeds in each field using Proc. GLIMMIX in SAS 9.4. Limited significant differences between weed densities were observed between the regular harvest and the Harrington Seed Destructor treatments. Exploratory PCA analyses were conducted for seedling and seedbank weed densities, but show limited separation between treatments, although 95% confidence interval ellipses are showing some shape differences. Limitations to the study design that may have limited the ability to detect differences between treatments included a short timeframe of the study, high weed seedbank densities, non-optimal combine settings, unmeasured seed losses at harvest and high weed density variability. Investigation into some of these factors could help to more accurately assess the potential of for physical impact mills to be incorporated into IWM strategies in western Canada.

A23980B: Corn Weed Control from Four Complimentary Active Ingredients. Seth A. Strom[1], Mark J. Kitt[2], Thomas H. Beckett[2], Benjamin C. Westrich*[3]; [1]Syngenta Crop Protection, Monticello, IL, [2]Syngenta Crop Protection, Greensboro, NC, [3]Syngenta Crop Protection, Greeley, CO (074)

A23980B is a new selective herbicide coming soon for weed control in field corn, seed corn, popcorn, and sweet corn containing s-metolachlor, pyroxasulfone, mesotrione, bicyclopyrone, and the safener benoxacor. The combination of four active ingredients in A23980B was designed to deliver residual control of difficult to manage weeds. Field trials were conducted to determine the benefit of two Group 15 herbicides and two Group 27 herbicides in a premix for long-lasting residual weed control. Results demonstrated that the active ingredients in A23980B work better together to deliver consistency and efficacy resulting in control of key weeds such as *Amaranthus* spp. and grasses. Overall, A23980B provides the foundation needed for growers facing the most problematic broadleaf and grass weeds in corn agronomic cropping systems.

A23980B: A Step Change for Residual Weed Control in Corn. Jafe Weems*[1], Scott Cully[2], Mark J. Kitt[3], Thomas H. Beckett[3]; [1]Syngenta Crop Protection, Kennewick, WA, [2]Syngenta Crop Protection, Marion, IL, [3]Syngenta Crop Protection, Greensboro, NC (075)

A23980B is a new selective herbicide coming soon for weed control in field corn, seed corn, popcorn and sweet corn. A23980B contains ratios of S-metolachlor, pyroxasulfone, mesotrione, bicyclopyrone, and the safener benoxacor that will provide extended residual weed control in corn. Field trials were conducted to evaluate A23980B for residual weed control compared to Acuron®, Acuron Flexi and other corn herbicide premixes in one pass and two pass weed control programs. Results show that A23980B will provide more consistent and longer lasting residual control of difficult to control weeds like *Amaranthus palmeri*, *Amaranthus tuberculatus* and other problematic broadleaf and grass weeds in corn.

Maverick Corn Herbicide™: Valent's New Herbicide for Broad-Spectrum Weed Control in Corn. Garrison J. Gundy*[1], Rachel J. Zuger[2], Pat Clay[3], Jonathon Kohrt[4]; [1]Valent USA, Mcpherson, KS, [2]Valent USA, Uniontown, WA, [3]Valent USA, Fresno, CA, [4]Valent USA, West Des Moines, IA (076)

Maverick™ Corn Herbicide is a new three-way premix, consisting of mesotrione, clopyralid, and pyroxasulfone, developed by Valent USA LLC to be used in field corn, seed corn, silage corn, and yellow popcorn. Maverick Corn Herbicide has a wide application window and can be applied preplant incorporated (PPI) or preemergence (PRE) at 18 - 32 fl oz acre^{-1}, or postemergence (POST) at 14 fl oz acre^{-1} on up to 18-inch height or through V6 corn, whichever occurs first. Results from field trials conducted from 2018 to 2022 showed that Maverick Corn Herbicide is effective on a broad range of broadleaf and grass weed species, including problematic weeds like Palmer amaranth (*Amaranthus palmeri*), common waterhemp (*Amaranthus tuberculatus*), common lambsquarters (*Chenopodium album*), and fall panicum (*Panicum dichotomiflorum*). The addition of atrazine and/or glyphosate can broaden the weed spectrum and improve overall efficacy of Maverick Corn Herbicide when applied to emerged weeds. With a low use rate, exceptional control of many driver weeds, flexible application window, and excellent crop safety, Maverick Corn Herbicide is an excellent tool for vital weed management in corn.

Weed Control Benefits and Soil Response to Sweep Tillage. Grace Flusche Ogden*[1], Jason G. Warren[2]; [1]Oklahoma State University, Lubbock, TX, [2]Oklahoma State University, Stillwater, OK (077)

Tumble windmill grass (*Chloris verticillata*) is a native, perennial bunch grass invading no-till cropping systems in Oklahoma. Tumble windmill grass is difficult to control with herbicide once established and no-till producers in Oklahoma have faced difficulty controlling this weed. Prompted by producer concerns, two studies were conducted near Stillwater and Wakita, Oklahoma to determine if sweep tillage could be a tool to control tumble windmill grass and the resulting soil response to this tool. The first study compared disking alone, sweep tillage + herbicide, and no-till + herbicide for tumble windmill grass control and the resulting soil response. The second study investigated one, two, or three passes of sweep tillage throughout the fallow season compared to no-till + herbicide. In both studies, sweep tillage was conducted with a 1.5 m sweep blade that undercut the top 7-10 cm of top soil, while disk tillage was performed with a 1.8 m tandem disk. Weed control was evaluated by visual weed control ratings and biomass collection. Soil response was measured by soil aggregate stability and CO2 burst analysis. Sweep tillage + herbicide provided greater weed control than no-till + herbicide 6 weeks after herbicide application. Similarly, sweep tillage applied alone one, two, or three times offered greater tumble windmill grass control than herbicide alone. Soil aggregate stability was similar between sweep and no-till treatments at 0-5 cm and 5-15 cm soil depths in both sample locations. Sweep tillage is an effective tool to manage tumble windmill grass with minimal soil response.

Impact of Kochia Size on Carfentrazone-ethyl Susceptibility. Shaun M. Sharpe*; Agriculture and Agri-Food Canada, Saskatoon, SK, Canada (078)

Kochia is a problematic tumbleweed on the Great Plains. In Canada, kochia has evolved resistance towards ALS-inhibitors, synthetic auxins, and glyphosate. Group 14 herbicides are important for resistance management but foliar-applied herbicides have contact activity only. The study objective was to evaluate relative escape risk based on kochia growth stage at carfentrazone-ethyl application. The experiment was conducted three times between 2019 and 2022 in controlled environments in Saskatoon, SK. The experimental design was a two-factor factorial arranged as a

randomized complete block with four blocks. The first factor was carfentrazone-ethyl application (18 g ai ha^{-1}) and the second factor was kochia growth stage at application. Plant height, branch number, and leaf number were recorded prior to herbicide application. Herbicide injury, reproductive maturity, plant height and branch number were recorded at four weeks after application. Four relative escape risk metrics were calculated and averaged to account for various escape considerations. There was significant correlation between the average relative escape risk metric and plant height at application ($R=0.83$, $p<0.01$), stem number at application ($p=0.80$, $p<0.01$), and leaf number at application ($R=0.79$, $p<0.01$). Approximately 30% relative escape risk was observed for kochia sprayed at 10 cm height. Consistent control was only observed for plant heights = 5 cm. Kochia control with contact-based foliar applied herbicides may be challenging when staging naturally varies in the field. Targeting smaller growth forms will help maintain efficacy short-term but chemical control should be integrated with other control strategies to reduce selection pressure on herbicides.

Diflufenican: a Tool for Managing *Amaranthus* Species in Corn and Soybean Cropping Systems. John Buol, Ryan Rapp*, Carl Coburn, Richard Leitz, Eric Riley, Ananda Datta; Bayer, St. Louis, MO (079)

The continued development and spread of herbicide resistance constitutes a major threat to the efficiency and profitability of corn and soybean production. Weeds such as some *Amaranthus* species have developed resistance to multiple herbicide modes- and sites- of action and are among the most challenging broadleaf weeds in North America. Bayer CropScience is developing an herbicide platform that features the use of diflufenican, a new site of action for *Amaranthus* spp. control in corn and soybean production systems in North America, pending registration with the U.S. EPA and Canada PMRA. Diflufenican functions as a phytoene desaturase inhibitor classified by HRAC as a group 12 herbicide and has been used outside of the U.S. for control of broadleaf weeds in cereals, peas, lentils, lupins, clover pastures, and oilseed poppy. Given the increasing challenge of managing herbicide-resistant weeds, diflufenican is being evaluated in field trials in North America for residual activity on *Amaranthus spp*. and crop selectivity in soybean and corn. Pending registration with the U.S. EPA and Canada PMRA, diflufenican would enable a new weed management tool that should be used in combination with other weed management practices as part of an integrated weed management plan.

Palmer Amaranth Yield Interference in North Dakota Corn and Soybean. Quincy D. Law*, Joseph T. Ikley; North Dakota State University, Fargo, ND (080)

Palmer amaranth (*Amaranthus palmeri*) was first identified in North Dakota in 2018. Yield losses due to Palmer amaranth interference have been reported as high as 91% in corn (*Zea mays*) and 79% in soybean (*Glycine max*). However, it is unknown how Palmer amaranth will interfere with corn and soybean grown in North Dakota. The objectives of this research were to quantify the yield loss associated with Palmer amaranth in corn and soybean in North Dakota. Separate corn and soybean field trials were conducted near Valley City, ND in 2022. Each trial was a randomized complete block design with four blocks and six Palmer amaranth densities (i.e., treatments): 0, 0.5, 1, 2, 4, and 8 plants m^{-1} of row. Corn and soybean were planted with a 76-cm row spacing, and plots were four rows wide by 7.6 m long. Corn and soybeans were planted at 87,700 and 383,000 seeds ha^{-1}, respectively, on 6 June 2022. Using puff plugs, Palmer amaranth plants were initiated in the greenhouse on 10 June and then transplanted into research plots at intended densities on 30 June (soybeans) and 1 July 2022 (corn). Plots were hand weeded weekly to maintain intended densities. Corn and soybeans were harvested on 18 Oct. 2022. Yield loss was calculated for each plot based on the mean weed-free yield. For soybean, a rectangular hyperbola model estimated a

57% yield loss as weed density nears infinity. However, Palmer amaranth density did not affect corn yield loss (P = 0.1617).

Cover Crops and Herbicide Combinations for Season-Long Weed Control in Dry Beans. Ryan Johnson*[1], Jenna Meeks[2], Jim Heitholt[3], Nevin Lawrence[4], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming, Torrington, WY, [3]University of Wyoming, Powell, WY, [4]University of Nebraska, Scottsbluff, NE (081)

Herbicides remain an important weed management tool in dry edible beans but reducing reliance on herbicides through integrated weed management practices is important. The objective of this study was to evaluate the effect of cover crops in combination with herbicide applications on weed suppression in dry bean. If cover crops effectively suppress weeds, reliance on herbicides may be reduced and economic benefits may be possible. Field studies were conducted in 2021 and 2022 near Lingle and Powell, WY. A small grain cover crop (winter wheat) was planted in March (early) and in April (late), with a control treatment of no cover crop. Pinto beans were planted in early June and the cover crop was terminated with glyphosate on the day of bean planting. Each cover crop whole-plot was divided into four split-plots consisting of the following herbicide treatments: no herbicide, preemergence (PRE) herbicide application only (pendimethalin + dimethenamid-P), postemergence (POST) herbicide application only (bentazon + imazamox), and sequential PRE and POST herbicide applications. Spring-planted winter wheat cover crop combined with herbicides had a beneficial effect on dry bean yield in 3 out of the 4 studies. The Lingle 2022 site was a complete failure due to herbicide-resistant weeds, mainly kochia, and yield was unable to be collected for that year. POST herbicide had a greater impact on protecting dry bean yield than PRE herbicides or cover crops. Cover crop helped to reduce kochia and lambsquarter density, but failed to reduce hairy nightshade density.

Safety of PPO-inhibiting Herbicides Applied Preemergence in Dry Bean. Joseph T. Ikley*, Nathan H. Haugrud; North Dakota State University, Fargo, ND (082)

Dry beans (*Phaseolus vulgaris*) are an edible legume crop and North Dakota is its leading producer in the United States. Controlling ALS-inhibitor resistant weeds in dry bean is heavily reliant on preemergence herbicides as the only effective POST herbicide labeled for controlling ALS-inhibitor resistant waterhemp (*Amaranthus tuberculatus*) in dry bean is fomesafen whose use is limited in western states. Group 14 herbicides such as sulfentrazone (under a section 24c label indemnification) are labeled for preemergence control of waterhemp in North Dakota, but more herbicide options are desired by producers. Two field experiments were conducted in 2022 on a sandy loam soil near Hillsboro, ND and a silty clay loam soil near Prosper, ND. The first experiment focused on safety and efficacy of Group 14 herbicides applied PRE and the second experiment focused on increasing rates of saflufenacil and tiafenacil applied PRE. Treatments in the first experiment were non-treated, sulfentrazone at 158 g ha^{-1}, fomesafen at 210 g ha^{-1}, flumioxazin at 72 and 107 g ha^{-1}, lactofen at 333 g ha^{-1}, acifluorfen at 420 g ha^{-1}, saflufenacil at 25 g ha^{-1}, and tiafenacil at 25 and 50 g ha^{-1}. The treatments in the second experiment were non-treated, saflufenacil at 25, 50, 75, and 100 g ha^{-1} and tiafenacil at 25, 50, 75, and 100 g ha^{-1}. In the first experiment, pinto bean was planted and all PRE-applications were made on May 25. In the second experiment, dry bean, sunflower, and soybean were planted and PRE-applications were made on May 26. At least 25 mm of incorporating rainfall was received within five days after planting in both experiments. Visible injury and redroot pigweed/Powell amaranth control were evaluated 14, 28, and 42 days after application. Results from the first experiment 28 DAT indicated flumioxazin was most injurious to dry bean at 10%, followed by fomesafen, saflufenacil, and acifluorfen at 5%, while all other herbicides were not different from non-treated. Redroot pigweed control was

greatest from lactofen, fomesafen, and flumioxazin which provided 89 to 99% control 42 DAT. Results from the second experiment 28 DAT indicated tiafencil at 25, 50, 75, and 100 g ha^{-1} caused 5, 8, 13, and 28% dry bean injury respectively. Comparatively, saflufenacil at 25, 50, 75, and 100 g ha^{-1} caused 48, 89, 92, and 99% dry bean injury respectively. Tiafenacil at 25 g ha^{-1} resulted in negligible dry bean injury and redroot pigweed control in both experiments, but shows potential as a burndown herbicide in dry bean.

Irrigation Timing Influenced Weed Control Efficacy and Dry Bean Response to Soil-Applied Herbicides. Prayusha Bhattarai*[1], Albert T. Adjesiwor[2]; [1]University of Idaho, Moscow, ID, [2]University of Idaho, Kimberly, ID (083)

Field experiments were conducted in 2021 and 2022 to evaluate the effect of irrigation timing on EPTC, flumioxazin, pyroxasulfone, and flumioxazin plus pyroxasulfone weed control efficacy and safety in dry bean. There were 14 treatments arranged in a randomized complete block with four replications. Treatments comprised of a weedy and hand-weeded check, and EPTC (3,430 g ai ha^{-1}), flumioxazin (53.6 g ai ha^{-1}), pyroxasulfone (119 g ai ha^{-1}), and flumioxazin + pyroxasulfone (70.4 + 89.3 g ai ha^{-1}) incorporated with overhead irrigation at 1, 4, and 8 days after herbicide treatment (DAT). Activation timing did not affect the phytotoxicity of flumioxazin. Delaying activation until 8 days after herbicide application resulted in 11 and 19% phytotoxicity in the pyroxasulfone and flumioxazin + pyroxasulfone treatments, respectively, but the crop recovered within 5 weeks after treatment. Activation timing did not affect the efficacy of flumioxazin, pyroxasulfone and flumioxazin + pyroxasulfone. Flumioxazin + pyroxasulfone provided better weed control compared to flumioxazin or pyroxasulfone applied alone, irrespective of the activation timing. Delaying EPTC activation until 8 days after treatment reduced weed control by 48 to 59% compared to 1 day after treatment activation timing. Herbicide treatment and activation timing did not reduce dry bean yield. Seed yield was 223 kg ha^{-1} in the weedy check and 1,420 to 2,657 kg ha^{-1} in herbicide-treated plots which were statistically similar to the hand-weeded check. Uncontrolled weeds in the weedy check reduced dry bean yield by 91% compared to the hand-weeded check.

Impacts of Herbicide and Application Timing on Hoary Cress Seed Viability. Robert O. Finley*[1], Brian A. Mealor[2]; [1]University of Wyoming, Dubois, WY, [2]University of Wyoming, Laramie, WY (084)

Impacts of Herbicide and Application Timing on Hoary Cress Seed Viability Abstract When inspecting hay production fields for Wyoming's weed free forage program, apparently-mature hoary cress (*Cardaria draba* L. (Desv.)) seed heads have sometimes been observed in fields where herbicide had been applied earlier in the growing season. While the seed heads were present, it was unknown if any viable seeds were produced. We conducted a field study at two sites in Wyoming to evaluate effects of herbicide and timing of application on hoary cress seed viability. We applied metsulfuron (43 g ai ha^{-1}), aminopyralid (123 g ae ha^{-1}), and the two herbicides combined at vegetative, late bud, and full flowering stages to hoary cress in a RCBD with four replicates at two sites in Fremont County, WY. We collected hoary cress seed heads near the time of first hay harvest. We hand-cleaned and separated 50-seed lots from each plot, except where seed production did not reach 50 seeds. We placed seed lots on filter paper disks wetted with a distilled water and pyraclostrobin solution (to prevent mold), and placed in a germination chamber at 20°C, 12hrs light/dark, and counted germinated seeds after 26 days. We tested non-germinated seeds for viability using a 1% TZ solution soak for 20 hours. Herbicide treatments reduced seed viability ($p < 0.01$), partially driven by lack of seed production in herbicide-treated plots. We observed

apparent trends in application timing, but more work is needed before conclusions can be made. We plan to repeat the full study on two more sites in spring 2023.

Application Rates and Timings of Pyroxasulfone Containing Products at Carbon Seeding in Perennial Ryegrass. Kyle Roerig*; Pratum Co-op, Salem, OR (092)

In Western Oregon grasses grown for seed are a high value, broad acreage crop. In addition to yield, seed purity is very important to the economic viability of the crop. Seed dealers and end users demand high seed purity in seed lots. Grass weeds, such as annual bluegrass and rough-stalk bluegrass, are of greatest concern to seed dealers and end users. Seed lots contaminated with grass weed seeds must be cleaned until purity standards are met. Excessive cleaning to remove weed seeds can result in significant losses of marketable crop seed. It is essential to protect seed lots against excessive loss at the seed cleaner by producing grass seed that is not excessively contaminated with grass weeds. Herbicides are the pillar of grass weed control in grasses grown for seed, however it is difficult to achieve selectivity with herbicides when controlling grass weeds in a grass crop, especially during the establishment stage of a perennial grass. For several decades the primary method to control grass weeds during the establishment of perennial grasses grown for seed is to plant with a narrow band of activated carbon over the seed row followed by a broadcast application of diuron. The extensive use of a single herbicide has, not surprisingly, led to widespread resistance to diuron in the key grass weed species. In response to widespread diuron resistance, research was conducted, and several new herbicides were registered for the carbon seeded use pattern, including indaziflam, EPTC, and a pyroxasulfone-flumioxazin premix. Pyroxasulfone-flumioxazin is the most effective herbicide for control of the key grass weeds of interest but has the perception among growers of reducing grass seed yield, especially at later planting dates. These trials were conducted to assess whether rate or timing of planting and application affected perennial ryegrass seed yield. Contrary to popular belief, later timings and higher rates resulted in higher yields, even though crop injury was visible late into the growing season.

Dissipation of Three Pendimethalin Formulations in Water After an Application Onto a Water-Seeded Rice System. Aaron Becerra-Alvarez*, Kassim Al-Khatib; University of California, Davis, Davis, CA (093)

Water-seeded rice is the predominant method for rice production in California. A continuous flood is typically maintained throughout the growing season. Water-holding periods after herbicide applications are common in flooded rice to reduce off-target exposure and influence herbicidal activity. Along with chemical characteristics, herbicide formulation type may affect the persistence in water. Three pendimethalin formulations, a capsule suspension (CS), emulsifiable concentrate (EC), and granule (GR), were applied onto flooded rice field plots at three rates. Then, water samples were collected sequentially at 1, 3, 5, 10, and 15 days after treatment (DAT) and analyzed for pendimethalin residue via high performance liquid chromatography-mass spectrometry. Rate and sampling time had an effect on the dissipation of pendimethalin in the flood water. Formulation alone did not have an effect on dissipation, however, interaction across formulation and sampling time was observed. At 1 DAT, on average, the EC formulation recorded 135 µg L^{-1}, the CS formulation recorded 15 µg L^{-1}, and the GR formulation recorded 5 µg L^{-1} of pendimethalin residue at the 3.57 kg ai ha^{-1} rate. Dissipation kinetics demonstrated half-lives at 2.35 to 2.85 days for the CS, 0.50 to 0.71 days for the EC, and 4.05 to 7.07 days for the GR across the three rates, respectively for each formulation. The GR formulation had a prolonged dissipation in the flood water. Results may suggest a water-holding period of three to five days after a pendimethalin application onto a flooded rice field, but may be extended if the GR formulation is applied.

Italian Ryegrass Seed Shatter in Winter and Spring Wheat. Mark E. Thorne*, Drew J. Lyon; Washington State University, Pullman, WA (094)

Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot) is a serious weed in the Palouse region of eastern Washington and northern Idaho. Italian ryegrass is very competitive with all crops and has developed resistance to many group 1 and 2 herbicides. Herbicide resistance increases the need for alternative management strategies, including diverting weed seeds going through combines into chaff lines, bales or chaff piles, or pulverizing with mills attached to the back of combines. For these to be effective, weed seeds must remain on the plant until crop harvest. Italian ryegrass seeds are known to shatter, but timing and extent of shatter up to harvest is not well understood. We collected Italian ryegrass plants weekly starting at seed fill but before shatter and continuing until crop harvest. Italian ryegrass plants were collected from winter wheat in 2017, 2018, and 2019, and spring wheat in 2019 and 2020. Three field sites were sampled in 2017 and two in each of the following years. At each weekly collection, ten plants were collected from a north/east facing slope, a south/west facing slope, and a flat draw bottom. Number of culms per plant, spikelets per culm, and seeds per spikelet were counted. Italian ryegrass seed fill was congruent with the milk stage of both winter and spring wheat. Seed shatter began a week or two after seed fill and reached 50% about a week prior to crop harvest and 60 to 70% by the beginning of harvest. Slope position had only slight effect on shatter timing and rate; however, high temperatures and wind speeds were observed to always promote shattering. Italian ryegrass seed weight did increase from seed fill up to about a week before harvest. Most Italian ryegrass seeds are shattered by harvest, but the heaviest seeds remain on the plants.

Herbicide Resistance in Downy Brome from Winter Wheat Fields in Eastern Oregon. Victor Ribeiro*[1], Caio A. Brunharo[2], Carol Mallory-Smith[1], Judit Barroso[3]; [1]Oregon State University, Corvallis, OR, [2]Pennsylvania State University, University Park, PA, [3]Oregon State University, Adams, OR (095)

Herbicide resistance in downy brome (*Bromus tectorum* L.) is of increasing concern in wheat (*Triticum aestivum* L.) systems in Eastern Oregon. The objectives of this study were to (1) conduct a survey of wheat growers to understand downy brome management practices and (2) determine if downy brome populations collected from wheat fields were resistant to acetolactate synthase (ALS)- and acetyl-coenzyme A carboxylase (ACCase)-inhibiting herbicides and glyphosate. Survey questions included crop rotation, tillage, irrigation, and herbicide program. Greenhouse screenings were conducted using a completely randomized design with three replications. Herbicide rates (g ai ha^{-1}) ranging from 0 to 2X were tested for imazamox (X=35), mesosulfuron-methyl (X=15), propoxycarbazone-sodium (X=44), pyroxsulam (18), sulfosulfuron (X=35), clethodim (X=136), quizalofop-P-ethyl (X=92), and glyphosate (X=841), where X is the labeled rate. Downy brome populations were visually assessed as dead or alive 21 days after treatment. Winter wheat-summer fallow rotation (71%) was the most predominant cropping system. All but one of the surveyed fields were no-till systems and none were irrigated. Pyroxasulfone/carfentrazone (10%) and metribuzin (26%) were the most used PRE and POST herbicides in winter wheat, respectively. Glyphosate (77%) was the most frequently used herbicide in fallow. Downy brome resistance to ALS inhibitors (81%) was prevalent. All populations were susceptible to ACCase inhibitors and glyphosate. Widespread ALS-resistant downy brome populations limit effective POST herbicide options in wheat. Use of quizalofop-P-ethyl may become a viable control option for ALS-resistant downy brome with the incorporation of herbicide-resistant wheat varieties, such as CoAXium, in an integrated weed management plan.

Evaluation of Dichlorprop-p Plus Bromoxynil for Management of Kochia in Small Grains. Daniel Beran*[1], Bob Bruss[2]; [1]Nufarm, Eldora, IA, [2]Nufarm, Morrisville, NC (096)

Dichlorprop-p is a group 4 phenoxy herbicide being developed by Nufarm that has recently shown potential for the management of herbicide resistant plants. Efficacy studies conducted from 2019-2021 have indicated promising levels of control of kochia (*Bassia scoparia*) with dichlorprop-p, including biotypes resistant to 2,4-D, dicamba and fluroxypyr. A premix herbicide with dichlorprop-p plus bromoxynil has been submitted for registration for postemergence weed control in wheat and barley. In 2021 field trials conducted in MT, SD, and ND, the combination of 0.5 lbs. dichlorprop-p/A plus 0.25 lbs. bromoxynil/A applied postemergence in wheat or barley provided excellent activity on kochia, averaging 96% control at 30 days after application. Averaged across 10 locations in 2022 trials, this premix provided 92% control of kochia 30 days after application. In addition to kochia control, the premix of dichlorprop-p plus bromoxynil provided greater control of lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), Russian thistle (*Salsola tragus*), and Canada thistle (*Cirsium arvense*) than bromoxynil applied alone. Further studies in small grains have indicated that dichlorprop-p has excellent crop safety and compatibility with grass herbicides.

Smooth Scouringrush Control with Glyphosate is Affected by Surfactant Choice and Application Time. Marija Savic*, Mark E. Thorne, Drew J. Lyon; Washington State University, Pullman, WA (097)

Smooth scouringrush (*Equisetum laevigatum*) is a perennial herbaceous plant with a high silica content that may impede herbicide uptake. We hypothesized that stomatal flooding may improve herbicide uptake and efficacy. To test this hypothesis, 3.78 L ae ha^{-1} of glyphosate was tank mixed with either organosilicone surfactants, an organosilicone + nonionic surfactant blend, or an alcohol-based adjuvant and applied either during the day or at night. Treatments were applied in 2020 at Malden, WA, and in 2021 at Reardan, WA, and Rock Lake, WA using a backpack sprayer calibrated to deliver 140 L ha^{-1}. Initial stem counts were taken at each site before herbicide applications. Final stem counts were taken one year after application from two 1 m^2 subsamples in each plot. Count data were fitted to a negative binomial distribution and analyzed with SAS software using initial counts as a covariate. There was a significant treatment by site interaction (P-value<0.001). At Malden, a tank mix of glyphosate with an organosilicone or organosilicone + nonionic surfactant applied during the day provided the greatest efficacy. At Reardan, glyphosate with an organosilicone surfactant applied at night provided the greatest reduction in stem density, while at Rock Lake, a tank mix with an alcohol-based adjuvant or an organosilicone surfactant applied during the day provided the best control. Adding an organosilicone surfactant or organosilicone + nonionic surfactant blend to glyphosate to control smooth scouringrush may improve efficacy. However, further research is needed to determine if stomatal flooding is responsible for improved efficacy.

Fall Pyroxasulfone for Wild Oat Control. Kirk A. Howatt*[1], Joseph Mettler[1], Ken J. Deibert[2]; [1]North Dakota State University, Fargo, ND, [2]BASF Corporation, West Fargo, ND (098)

Select fields across North Dakota contain wild oat that expresses resistance to ACCase- and ALS-inhibiting herbicides. For hard red spring wheat production, the VLCFA-inhibitor pyroxasulfone presented an alternative, but observed wild oat control has ranged from 0 to 97% using the label suggestion of delayed pre-emergence application. Field experiments were established at two North Dakota locations in October 2021 to compare spring wild oat control with pyroxasulfone (0 to 291 g ha^{-1}) to control with 1120 g ai ha^{-1} triallate, another VLCFA-inhibitor. Locations experienced

excessive rain and delayed plant growth during the spring of 2022. At the minimum tillage site, pyroxasulfone at 118 or 146 g ha^{-1} provided 76% wild oat control while triallate gave 43% control. At the conventional tillage site, 118 g ha^{-1} pyroxasulfone gave 64 to 69% control of wild oat, but 146 g ha^{-1} provided 80 to 87% control. Greater control within herbicide rate resulted in plots that received mechanical incorporation. Triallate control of wild oat was as high as 98%. Minor wheat response to labeled herbicide rates was recorded early in the season at either field location and the response did not persist. A greenhouse experiment was conducted in October 2021 to evaluate the relative response of 19 widely-grown wheat and durum cultivars to 0, 146, and 291 g ha^{-1} pyroxasulfone, which was mechanically incorporated into mineral soil with depth of 2.5 cm and placed surrounding the seed to maximize response. Establishment and growth varied across cultivar and herbicide rate. Durum was very susceptible to pyroxasulfone. Half of the hard red spring wheat cultivars responded similarly to the cultivar used in the field. An additional third showed slightly more injury, but 20% of the cultivars were injured enough to warrant additional evaluation under field conditions to assess yield. Pyroxasulfone applied in the fall presented a viable use pattern to control wild oat the following spring, but additional research to validate this activity and the response of various wheat cultivars is underway in the field.

Fluxofenim Safens Wheat to Group 15 Herbicides. Joan Campbell*, Traci A. Rauch; University of Idaho, Moscow, ID (099)

Very-long-chain fatty acid inhibiting herbicides, *S*-metolachlor and dimethenamid-P, offer options for control of annual grasses, particularly Italian ryegrass, but they are not registered in wheat. Greenhouse studies determined fluxofenim safener, applied to wheat seed, protected wheat from metolachlor, dimethenamid, and pyroxasulfone herbicides. Three winter wheat and four spring wheat varieties were treated with fluxofenim safener at 0.64 oz/100 lb seed. Safener treated and non-safener treated seed was planted at two locations in 2020, 2021 and 2022. Metolachlor, dimethenamid, and pyroxasulfone were applied pre-emergence to winter wheat at 4.76, 2.95, and 0.293 lb ai/a, and to spring wheat at 2.86, 1.5, and 0.293 lb ai/a, respectively. A non-treated check was included in the split block, randomized complete block experiment with four replications. At the Genesee location, safener treated wheat yield increased 10, 24, and 52% over the non-treated safener in 2020, 2021, and 2022, respectively, after metolachlor application. Safener treated wheat yield increased 22% and 39% over the non-treated safener in 2021 and 2022, respectively, after dimethenamid application. Winter wheat yield did not differ among any treatments after pyroxasulfone applications at either location. At the Moscow location, winter wheat yield increased 32, 40, and 70% over the non-safener treated in 2020, 2021, and 2022, respectively, after metolachlor application. Safener treated wheat yield increased 19 and 59% over the non-safener check in 2020 and 2022, respectively, after dimethenamid application. Spring wheat yield was not affected by herbicide application in 2020 at either location or in 2021 at Moscow. Metolachlor application at Genesee in 2021 reduced non-safener treated 'Ryan' yield compared to the non-treated check. Wheat yield of safener treated 'Ryan' was increased compared to the non-treated check. In 2022, spring wheat yield was increased 39, 31, and 10% with safener treated seed after metolachlor, dimethenamid, and pyroxasulfone, respectively.

Weed Efficacy of a Novel Cereal Herbicide Mixture of Tolpyralate and Bromoxynil. Joe Yenish*[1], David Johnson[2], Ryan Humann[3], Kevin Falk[4], Cody J. Chytyk[5], Jeff Krumm[6], Rory Degenhardt[7]; [1]Corteva Agriscience, Billings, MT, [2]Corteva Agriscience, St. Paul, MN, [3]Corteva Agriscience, Fargo, ND, [4]Corteva Agriscience, Winnipeg, MB, Canada, [5]Corteva Agriscience, Saskatoon, SK, Canada, [6]Corteva Agriscience, Hastings, NE, [7]Corteva Agriscience, Edmonton, AB, Canada (100)

GF-5036 herbicide is a novel formulated combination of an HPPD inhibiting herbicide, tolpyralate (HRAC Group 27) and a Photosystem II inhibiting herbicide, bromoxynil-octanoate (HRAC Group 6) for use in wheat (including durum), barley and triticale. It was developed by Corteva Agriscience in partnership with ISK Biosciences Corporation. At its target use rate of 11 fl. oz. per acre, GF-5036 delivers 150 g bromoxynil ae/ha and 15 g tolpyralate ai/ha. Field research was conducted from 2019 to 2022 cropping seasons at multiple locations across the U.S. Northern Plains and the Prairie Provinces of Canada to evaluate GF-5036 herbicide's efficacy and crop safety when applied post-emergence in spring or winter cereals. GF-5036 herbicide was applied with and without external adjuvants, and tank mixed with MCPA ester and 2,4-D ester. GF-5036 herbicide provides excellent control of redroot pigweed (*Amaranthus retroflexus*), common lambsquarters (*Chenopodium album*) waterhemp (*Amaranthus tuberculatis*), smartweed (*Persicaria maculosa*), kochia (*Bassia scoparia*), and both green and yellow foxtail (*Setaria* spp.). There is little to no crop response on spring cereals with GF-5036 herbicide, indicating excellent crop safety. GF-5036 herbicide provides cereal growers with a new tool for controlling many difficult to control broadleaf weeds, including herbicide resistant biotypes of kochia, pigweeds, foxtails, and other species. ™® Trademarks of Corteva Agriscience and their affiliated companies or their respective owners.

Jointed Goatgrass Control with Imazamox and Quizalofop-p-ethyl. Cody F. Creech*[1], Amanda C. Easterly[2]; [1]University of Nebraska, Scottsbluff, NE, [2]University of Nebraska, Sidney, NE (122)

Control of jointed goatgrass continues to be an issue for wheat producers due to limited herbicide options for in-season control. Herbicide tolerant wheat technologies such as Clearfield® and CoAXium® are available for wheat producers to use post-emergence to apply imazamox (for Clearfield®) and quizalofop-p-ethyl (for CoAXium®) for grass weed control. The objectives of this research were (1) compare jointed goatgrass control using imazamox and quizalofop-p-ethyl, and (2) to evaluate application parameters that may improve jointed goatgrass control.

POST Applied Residual Herbicide Options for Wild Oat (*Avena fatua* L.) Control in Spring Wheat. Clint W. Beiermann*; Montana State University, Kalispell, MT (123)

Wild oat (*Avena fatua* L.) is a major weed competitor in spring planted cereal grains. In 2022 a study was initiated in northwestern Montana to investigate the effects of soil active residual herbicides and application timing, on wild oat control in spring wheat. Residual treatments consisted of pendimethalin 1065 g ai ha^{-1}, pyroxasulfone 91 g ai ha^{-1}, and pyroxasulfone 98 g ai ha^{-1} + carfentrazone 7 g ai ha^{-1}. Residual treatments containing pyroxasulfone were applied PRE and pendimethalin was applied to spiking wheat. Each of the residual treatments were applied alone, as a residual product only, applied with a POST application of pinoxaden 60 g ai ha^{-1} + fenoxaprop 30 g ai ha^{-1} following when wheat reached the joint stage, and applied POST as a tank mix with pinoxaden + fenoxaprop at the 4th tiller stage. Treatments also included a single POST application of pinoxaden + fenoxaprop at the joint stage, as well as a non-treated check. Wild oat density was similar in the non-treated, pendimethalin, pyroxasulfone, and pyroxasulfone + carfentrazone treatments, four weeks after final POST application. All residual treatments applied with the addition of pinoxaden + fenoxaprop, and the pinoxaden + fenoxaprop only treatment, resulted in the lowest levels of wild oat density four weeks after final POST application. Wild oat biomass was lowest in all treatments containing pinoxaden + fenoxaprop. The residual only treatments reduced wild oat biomass in comparison to the non-treated. Spring wheat yield was highest in all treatments containing pinoxaden + fenoxaprop. The treatments, pendimethalin, pyroxasulfone, and pyroxasulfone + carfentrazone, increased spring wheat yield compared to the

non-treated. The increase in yield from these treatments could be due to increased control of common lambsquarters and not improved wild oat control.

Introducing Florpyrauxifen-benzyl (Rinskor) Herbicide: Development of A New Postemergence Tool for Managing Weeds in Sugarbeet. Craig M. Alford*[1], Kelly A. Backscheider[2], Ryan Humann[3], David Johnson[4], Marisa Salas[5]; [1]Corteva Agriscience, Ankeny, IA, [2]Corteva Agriscience, Franklin, IN, [3]Corteva Agriscience, Fargo, ND, [4]Corteva Agriscience, St. Paul, MN, [5]Corteva Agriscience, Guyancourt, France (124)

Rinskor active (flopyrauxifen- benzyl) belongs to the arylpicolinate class of chemistry, a new structural class of the synthetic auxin (Group 4) herbicides. Rinskor is currently registered as Loyant® herbicide in the US for use in rice where it has broad spectrum activity on grasses, broadleaves, and sedges. Rinskor has a low use rate (<30 g ai/ha), a favorable environmental and toxicology profile, rapid degradation in the soil and plant tissue, and little persistence in the environment. Due to its favorable profile, Rinskor received a "reduced-risk" review from EPA and a residue tolerance exemption in October 2019. Corteva is exploring potential opportunities to expand Rinskor into other crops including sugar beet. In Europe, Rinskor has been evaluated on sugar beet as part of a POST program where 3-4 POST applications are made in sugar beet. Results indicate that sugar beet has acceptable tolerance to Rinskor when applied from cotyledon to 6 leaves and that Rinskor provides good control of weeds in the Chenopodiacea, Apiaceae or Umbellifera families. In the United States, sugar beet growers can use glyphosate, a valuable tool in managing weeds on glyphosate-tolerant sugar beet. However, glyphosate resistance has continued to spread and additional weed control options in sugar beet are limited. Previous work has indicated that Rinskor provides excellent control of difficult-to-control weeds such as common lambsquarters (*Chenopodium album*) and other broadleaf weed species. In 2021, two trials were conducted in ND/MN utilizing Rinskor in sugar beet to evaluate crop tolerance and control of glyphosate-resistant waterhemp (*Amaranthus tuberculatus*). Initial results from this work indicated that 0.5-1.0 g ai/ha of Rinskor applied prior to 10-leaf sugar beet as the potential target rate range and application timing. In 2022, several trials were conducted throughout the sugar beet growing regions of the US. Rinskor applied alone caused visible crop response to sugar beet and the addition of glyphosate, ethofumesate, and s-metolachlor increased crop response. Two applications of a program treatment including Rinskor provided good to excellent control of common lambsquarters, waterhemp, Palmer amaranth (*Amaranthus palmeri*), kochia (*Kochia scoparia*), and common ragweed (*Ambrosia artemiisifolia*). Future work in the United States will continue to define the use rate and program treatments required to manage weeds with Rinskor in sugar beet.

Winter Cereal Cover Crops and Herbicide Programs for Weed Control in Sugarbeet. Albert T. Adjesiwor*; University of Idaho, Kimberly, ID (125)

Field experiments were conducted in 2021 and 2022 to evaluate cereal cover crops and herbicide programs for weed control in sugar beet (*Beta vulgaris*). The experiment was set up as a split-split plot randomized complete block design with four replications. The main plot was two fall-planted cereal cover crops (cereal rye and winter wheat) and no cover crop, the split-plot factor was five cover crop termination timings (14 and 7 days before planting, day of planting, 14 and 7 days after planting), and the split-split plot factor was three herbicide programs (dimethenamid-p + glyphosate at 4 leaf sugar beet; dimethenamid-p + glyphosate at 4 leaf sugar beet followed by glyphosate at 10 leaf stage; and glyphosate at 4 leaf sugar beet followed by glyphosate at 10 leaf stage). Terminating cover crops after sugar beet was planted reduced weed density by up to 90% before the first herbicide application. Cereal rye produced more biomass and suppressed weeds

better than winter wheat. Weed density was about 77% less in the dimethenamid-p + glyphosate followed by glyphosate treatments compared to the one-time application of dimethenamid-p + glyphosate. Delaying cover crop termination until 7 or 14 days after planting reduced sugar beet stand density and reduced root yield by 8 to 28%. Integrating cereal cover crops with herbicides may help reduce the number of in-season glyphosate applications for proactive and reactive herbicide resistance management.

WSWS PROJECT 4: TEACHING AND TECHNOLOGY

Exploring New Research Methods at the Winfield United Innovation Center. Gregory K. Dahl*[1], Ryan J. Edwards[2], Joshua J. Skelton[3], Steven A. Fredericks[2], Kassi Kosnicki[4], Eric P. Spandl[2], Elizabeth R. Alonzi[2], Elizabeth Buescher[2], Cody Hoerning[2], Derick Jiwan[2]; [1]Winfield United, Eagan, MN, [2]WinField United, River Falls, WI, [3]WinField United, Saint Paul, MN, [4]Land O' Lakes - Winfield United, River Falls, WI (126)

The Winfield United Innovation Center in River Falls, Wisconsin opened in September 2017. It was designed and constructed to address agriculture research needs, size chemical and spray capabilities, and support the business needs of Winfield United and its owners. We regularly conducted tours and meetings for growers, researchers and others interested in herbicides, adjuvants, application methods, fertilizers, crops, and other areas. Many features and capabilities were incorporated into the Winfield United Innovation Center which include: 1.) Chemistry labs, equipment and chemists analyze, develop, optimize, and scale up product manufacturing; 2.) Greenhouses and growth chambers for year-round research and trials that are difficult to conduct in the field; 3). Wind tunnel spray analysis systems were created or reengineered to improve spray droplet analyses and imaging to understand droplet formation, characteristics, movement, and fate; and 4.) A high throughput phenotyping system that monitors and measures plant phenotypes over time in the presence of different products. Current research conducted at the Winfield United Innovation Center included a spray drift and deposition comparisons of dicamba and glyphosate-containing mixtures in a large, closed, wind-tunnel system using susceptible soybean plants and spray collectors. High speed imaging equipment was used to observe droplet formation with Pulse Width Modulation (PWM), elevated wind speed, simulated aerial application conditions, and other demonstrations. Another study used high throughput plant phenotyping methods to evaluate control of corn plants treated with clethodim or clethodim plus adjuvants.

The Resistant Wild Oat Action Committee. Eric N. Johnson[1], Breanne D. Tidemann*[2], Nathan Eshpeter[3]; [1]University of Saskatchewan, Saskatoon, SK, Canada, [2]Agriculture and Agri-Food Canada, Lacombe, AB, Canada, [3]Resistant Wild Oat Action Committee, Daysland, AB, Canada (127)

The Resistant Wild Oat Action Committee Eric Johnson[2], Breanne Tidemann[1*], Nathan Eshpeter[3] [1]Agriculture and Agri-Food Canada, Lacombe, AB. [2]University of Saskatchewan, Saskatoon, SK. [3]Resistant Wild Oat Action Committee, Lacombe, AB. Wild oat (*Avena fatua* L.) resistance is prevalent on the Canadian prairies, and remaining herbicide options are limited. A cross-industry Resistant Wild Oat Action Committee (RWOAC) was formed in 2020 with a mission to develop herbicide resistant wild oat management solutions through producer engagement, knowledge transfer, and research. Two project proposals were submitted to industry and commodity group funding opportunities within the Canadian Prairies. The RWOAC is not a legal entity; therefore, the proposals were submitted through the Canadian Weed Science Society (CWSS-SCM). Both proposals were accepted with funds administered by CWSS-SCM. A 2-year project with

contributions from the Alberta Wheat Commission, Saskatchewan Wheat Commission, Manitoba Crop Alliance, and the Saskatchewan Forage Seed Development Commission commenced in April 2021. Nathan Eshpeter from Daysland, AB was hired as Project Manager. Nathan has organized a community-based organization in central Alberta that organizes extension activities (meetings, field days) and applied on-farm research trials. A resistance testing and survey project was also initiated that targets growers who are suspicious of resistance but have not tested previously. The second project, funded by Results Driven Agriculture Solutions, entitled "Farmers Talk About Herbicide Resistance" is an extension project with matching funds provided by the Alberta Wheat Commission, Saskatchewan Wheat Commission, Saskatchewan Barley Commission, and the Manitoba Crop Alliance. This project has resulted in the production of a video entitled "Understanding Resistant Wild Oats", which has been widely distributed. Additionally, 13 infographics have been produced. The video and infographics are available on the CWSS-SCM website (https://weedscience.ca/wildoat-action-committee/). The RWOAC has been successful in increasing awareness and engaging producers in Central Alberta to proactively address wild oat resistance, and is planning additional activities to broaden their scope, range and impact in the future.

Engaging Our Extension Clientele on Weedy Topics. Jeanne Falk Jones*; Kansas State University - NW Area Office, Colby, KS (128)

Social media can be one way to get weed science information to farmers and agronomy professionals. Videos can be important way to deliver that information in an 'easy to use' format. Both live and recorded videos have been disseminated via the K-State Sunflower District Agronomy facebook page. In 2022, four live videos were broadcast from this facebook page. These videos were recorded in the field, using a cell phone and tripod. The topics were weed control in wheat and herbicide symptomology. The videos ranged from 4 to 7.5 minutes in length. In addition, the link to the live videos were sent to farmers and agronomy professionals via email. These efforts resulted in over 1500 views of the videos. In addition, follow-up questions were asked by 14 farmers regarding weed control in wheat. One farmer commented that their whole team had watched the video together and discussed what it meant for weed control in their operation.

WSWS PROJECT 5: BASIC BIOLOGY AND ECOLOGY

Uncovering Mechanisms Conferring Metribuzin Resistance in Winter Wheat (*Triticum aestivum*) Under Field Conditions in the Inland Pacific Northwest (PNW). Samuel R. Revolinski*, Tara L. Burke, Arron H. Carter, Ian Burke; Washington State University, Pullman, WA (101)

Understanding the genetic mechanisms underlying the response of winter wheat (*Triticum aestivum* L.) to metribuzin, in field settings, is imperative for developing weeds management strategies in dryland cropping systems, breeding metribuzin resistant wheat, and understanding the physiological basis for metribuzin resistance in grasses. Our study here, used a genome wide association study (GWAS) to investigate the genetic underpinnings of metribuzin resistance for winter wheat grown in field conditions. Using 475 lines from the quality association mapping (QAM) winter wheat panel and their associated genotypes derived from the wheat 90K genotyping assay, genomic regions associated with metribuzin resistance were identified. Phenotyping for height percent of control (PHPC) and percent injury (PI) was performed in field conditions for four consecutive years (2019-2022) at the Spillman farm in Pullman, WA, spraying metribuzin at

timings typical for agricultural production in the inland Pacific Northwest (PNW). Our GWAS analyses using the BLINK method from the genome association and prediction integrated tool (GAPIT) uncovered 14 marker-trait associations (MTAs). Based on the proximity of the MTAs to genes with annotation relating to processes involved in herbicide resistance, in the IWGSC RefSeq V2.0, six candidate genes were identified. Among the candidate genes identified, *FtsH 7* that has been implicated in the degradation of damaged D1 subunits of photosystem II, and a number of genes implicated in stress response through reactive oxygen species (ROS) scavenging, DNA repair, and membrane related processes were uncovered. The GWASs were unable to uncover consistent associations of large effect, indicating that polygenic non-target site resistance (NTSR) likely underlies metribuzin resistance in wheat.

IWGC Progress in Genomic Sequencing of Western Weeds Including Russian Thistle and Kochia. Philip Westra*[1], Todd A. Gaines[1], Eric L. Patterson[2], Jacob S. Montgomery[1], Nick A. Johnson[2], John Cmp Lemas[1]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (103)

Abstract not Available

Common Lambsquarters Seed Germination in Response to Far-red Light. Jonah Zubil Ziyaaba*[1], David A. Claypool[1], Albert T. Adjesiwor[2], Andrew R. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Idaho, Kimberly, ID (104)

Common lambsquarters is a troublesome weed in rainfed and irrigated crops. Common lambsquarters seed germination is reduced in plant-canopy light or far-red light compared to full sunlight. However, it is not clear whether the far-red sensitivity is a wide-spread phenomenon among all weedy populations, or if it is specific to certain genotypes. The objective of this study was to determine common lambsquarters seed germination from a variety of genetic backgrounds in response to far-red light. Eleven accessions of common lambsquarters seeds were sourced from the U.S. National Germplasm System and increased under greenhouse conditions to reduce maternal environment and age effect. Thirty seeds of each accession were put in petri dishes and put in two light environments (red light or far-red light) for a 16 hr photoperiod. Each light environment had three replicates of each accession in a completely randomized design. Daily germination data was analyzed using a three-parameter log-logistic regression model. Germination reached 52 to 98% under red light depending on the accession. Far-red light completely inhibited germination (0%) in two accessions, and nearly completely (<5%) in three other accessions. One accession reached 40% germination under far-red light. There seems to be variation among common lambsquarters genotypes in the seed germination response to far-red light.

Renovating Crested Wheatgrass Monocultures into Functional Rangeland by Integrating Herbicide and Seeding. Peter T. Bugoni*[1], Jane Mangold[2]; [1]Confederated Salish and Kootenai Tribes, Pablo, MT, [2]Montana State University, Bozeman, MT (105)

To compete with weed species, stabilize soil, and provide livestock forage, crested wheatgrasses (*Agropyron cristatum* [L.] Gaertn. and *A. desertorum* [Fisch. ex Link] Schult.) were seeded across thousands of hectares of western rangelands. Many historic plantings resulted in monocultures, causing a loss of native plant diversity and homogenized ecosystems. To restore more functional habitats, diversification efforts are necessary. We designed a 5-year study at two sites in Montana that integrated herbicide treatments to control crested wheatgrass and seeding to establish native species. Our herbicide treatments included glyphosate at a high (2.3 L/ha) or low (1.12 L/ha) rate and an untreated control (Untreated). Planting a mix of six native grasses and six native forbs, our seeding treatments had two levels, planting grasses and forbs combined in the same drill row

(Combined) or separately and perpendicular to each other (Separate). Before applying these treatments, cattle grazed the sites for two years. We sampled the cover and density of crested wheatgrass, seeded forbs, and seeded grasses for three growing seasons. Both high and low glyphosate treatments reduced crested wheatgrass cover by an average of 45% compared to the untreated controls. Seeded forbs established at an average density of 20 stems/m^2 greater in herbicide-treated plots compared to untreated plots. Seeded grasses followed a similar pattern, establishing at an average density of 24 tillers/m^2 greater in herbicide-treated plots compared to untreated plots. Both seeded species showed no difference in seeding treatments. These results suggest we can suppress crested wheatgrass with a standard rate of glyphosate (1.12 L/ha), and seeding grasses and forbs separately does not lead to greater establishment.

Genetic Mapping to Understand Quantitative Metabolic Resistance to Tembotrione in Palmer Amaranth. Carlos Alberto G. Rigon*[1], Jacob S. Montgomery[1], Roland S. Beffa[2], Anita Küpper[3], Franck E. Dayan[1], Todd A. Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Senior Scientist Consultant, Frankfurt, Germany, [3]Bayer AG, Frankfurt, Germany (106)

A tembotrione-resistant population of Palmer amaranth from Nebraska (NER) has a faster tembotrione-hydroxylation than a susceptible (NES). RNA-seq study identified four cytochrome P450 genes upregulated in resistant plants and only one (*CYP72A219*) was able to metabolize tembotrione using yeast as a heterologous expression system. The objective of this work was to identify quantitative trait locus (QTL) that are involved in tembotrione resistance. Two crosses of susceptible and resistant plants were performed to generate F1 and subsequent pseudo-F2 populations. Segregation in the pseudo-F2 population was measured in response to tembotrione at 77 g a.i. ha^{-1}. Genetic mapping was made using 382 plants, 181 most susceptible, 150 most resistant plants, and parental plants. Plant tissues were collected before herbicide application. Fresh biomass was measured 28 d after herbicide application. GBS libraries were made with ApeKI sequenced using NovaSeq S4 with 150 bp paired-end reads (Illumina). Reads were aligned to the male reference genome of *Amaranthus palmeri* (BASF - id55760) using BWA. Variant calling was performed using GATK 4.0. After filtering 4,405 variants were identified and used for genome scan. A high-effect QTL in scaffold 10 was identified. This QTL is localized on chromosome 4, only 3.2 Mb upstream of the *CYP72A219* gene. The QTL englobes 189 genes, among them four transcript factors and one transcript repressor. *Trans*- and *cis*-elements may regulate the expression of *CYP72A219*. Understanding the regulation of metabolic genes may help to design and select the best herbicide molecules in the early stages of the herbicide discovery pipeline.

Application of Thermal Requirements for California Weedy Rice (*Oryza sativa* f. *spontanea*) Seedling Emergence: a 2-year Field Study. Liberty B. Galvin*[1], Whitney Brim-DeForest[2], Kassim Al-Khatib[1]; [1]University of California, Davis, Davis, CA, [2]University of California Cooperative Extension, Yuba City, CA (107)

Identification of weedy rice (*Oryza sativa* f. *spontanea*) is difficult in California rice cropping systems due to the conspecificity with cultivated rice. Post-emergent control applications are being developed, but biological knowledge of the pest should be utilized to optimize application timing for improved efficacy. The objective of this research was to determine the thermal time requirements for weedy rice seedling emergence in a field setting. Rice fields west of University of California Davis campus were hand-seeded in rows with California weedy rice accessions 1, 2, 3, and 5 in both 2019 and 2020 to simulate an infested weed seed-bank. Once seedlings emerged from the soil, they were removed and burial depth was noted. Soil temperature was logged hourly and used to calculate thermal time to emergence for all accessions. Time to initial emergence, 50 and 90% emergence was calculated to illustrate major management benchmarks. 98% of all

seedlings counted emerged from 1 cm soil burial depths. Initial emergence of accessions 1, 2, and 3 occurred within 6 days after flooding in both 2019 and 2020. Time to 50 and 90% emergence was not consistent across years for each accession, respectively. Four-parameter, log-logistic models were utilized to predict timing benchmarks, but had significant amounts of error and were not well-fit to the variation of the collected data (RMSE=4.264, AIC=4251 in 2019; RMSE=2.018, AIC=3152 in 2020). Additional studies are needed to determine other environmental sources of influence, e.g., cloud-cover at time of flooding, over California weedy rice, and whether or not these can be incorporated into the model for improved predictive power.

SYMPOSIUM: Water in the West

Western U.S. Climate Change Trends and Spring Seasonal Outlook. Sophia Adams*; National Weather Service, Boise, ID (050)

Anthropogenic climate change will have a drastic impact on water resources, weather, and climate in the Western United States. This presentation will cover the current trends and basic information about climate change. Different climate models will be presented along with the corresponding predicted outcomes throughout the Western United States. From these climate model predictions, various potential weather and agricultural impacts for the Western United States will be explored. Additionally, the Climate Prediction Center's seasonal outlook for spring and summer 2023 and the current SWE (snow water equivalent) measurements from SNOTELs (Snow Telemetry Network) for the Western United States will be presented.

Evolving Water Resource Management in the Southwest. Charles E. Ester, III*; Salt River Project, Phoenix, AZ (051)

The Salt River Valley in south central Arizona was once an agricultural paradise. The building of Roosevelt Dam in the early 1900s as the cornerstone of the US Bureau of Reclamation's Salt River Project (SRP) secured an adequate and reliable supply of water to the area. The dependable water supply and yearlong growing season allowed agriculture to flourish. Vibrant agriculture gave way to increasingly rapid urbanization following World War II. Today, the Salt River Valley is home to the nation's 5th largest city, Phoenix. The change from an agricultural community to a vast metropolitan area has required SRP to be responsive to the changing needs of our constituents. Adaptations once driven by local issues are now being influenced by regional and even world scale concerns like the overallocation of Colorado River to climate change impacts. SRP has and will continue to adapt and evolve its water resource management practices to ensure the ability to provide the adequate, reliable, and sustainable water supply our shareholders have come to depend.

Follow the Water - Invasive Plants and Global Change in a Dry Grassland. Dana M. Blumenthal*; USDA-ARS Rangeland Resources & Systems Research Unit, Fort Collins, CO (052)

As global changes alter plant communities, a key question is how invasive plants will respond. Since 2003, we have been testing how global changes influence invasion in mixedgrass prairie, focusing on changes that influence water, the key limiting resource. We found that while increased snow, summer precipitation, and nitrogen deposition all facilitated invasion, increased snowfall had the strongest effects, allowing invasion by three species, diffuse knapweed (*Centaurea diffusa*), baby's-breath (*Gypsophila paniculata*), and Dalmatian toadflax (*Linaria dalmatica*), that were rarely observed under ambient conditions. In subsequent experiments where we manipulated atmospheric CO2 and warming, both Dalmatian toadflax and diffuse knapweed responded strongly

to elevated CO2, increasing above-ground biomass by more than an order of magnitude, while warming had little effect. While the dominant perennial grass, western wheatgrass (*Pascopyrum smithii*) decreased stomatal conductance under elevated CO2, Dalmatian toadflax maintained high stomatal conductance and increased photosynthesis, suggesting that its strong CO2 response may be facilitated by less conservative water use. Finally, cheatgrass (*Bromus tectorum*) responded positively to warming (but not elevated CO2), likely due to an expansion of its distinct phenological niche. Together, these results suggest that global change will pose additional challenges for revegetation in semi-arid regions, and that changes that alter water availability will have the strongest influence on invasion.

Traits That Confer Weediness Also Facilitate Adaptation to Climate Change. Ian Burke*; Washington State University, Pullman, WA (053)

Changing climate will affect weed biology, with consequences for management across the western United States. Weed response to climate change have focused on two main areas: competition between plants of different photosynthetic functional groups under conditions of increased temperature and CO_2 concentrations, or range shifts of weedy plant species on a regional scale. However, functional traits regulated by external environmental cues will facilitate response to climate variability and likely contribute to success for weed populations. Indeed, those traits are currently facilitating success by weeds across climate clines currently present across the western United States. Furthermore, the same traits in crop species are tightly controlled or eliminated in certain cases, likely creating niches for weeds to fill as weed populations adapt to climate, but crops lag in adaptation due to the inherent lag typical of plant breeding programs. Important traits regulating seed dormancy, germination, emergence, above ground growth, and floral initiation are under continuous selection by climate as well as management. Consideration of these traits will not only facilitate understanding how weeds will respond to climate, but also facilitate their management.

Predicting Plant Invasions Under Climate Change in Aquatic and Riparian Systems in the Pacific Northwest. David R. Clements*[1], Emma Nikkel[2], Jennifer Williams[2]; [1]Trinity Western University, Langley, BC, Canada, [2]University of British Columbia, Vancouver, BC, Canada (054)

Climate change predictions for the Pacific Northwest region of North America include both warmer and more unpredictable weather, such as extreme events like floods and droughts. There are numerous invasion pathways for aquatic or riparian non-native plants in the Pacific Northwest. Aquatic environments are expected to warm more gradually than terrestrial environments, but if freezing occurs less frequently bodies of water could be vulnerable to new plant invasions. Increased frequency of extreme climate events such as flooding favor many invasive plant species adapted to dispersing or reproducing under such conditions. We will discuss factors that predict such plant invasions, within a framework incorporating climate dynamics, ecosystem resistance, and invader fitness. Shifts under climate warming will be reviewed for one group of plants, and a second group will be examined in terms of extreme events. The first group will include water hyacinth (*Pontederia crassipes*), water lettuce (*Pistia stratiotes*), floating heart (*Nymphoides peltatum*), parrot feather (*Myriophyllum aquaticum*), and flowering rush (*Butomus umbellatus*). The second group will include Phragmites (*Phragmites australis*), giant reed (*Arundo donax*), Himalayan balsam (*Impatiens glandulifera*), Tamarix (*Tamarix ramosissima*), Buddleia (*Buddleia davidii*), and knotweeds (*Reynoutria* spp.). These case studies point to the need for more research on how changing conditions in aquatic systems predict the vulnerability of sensitive habitats to invasion by these and other species of concern. Better monitoring of aquatic sites is needed as aquatic and riparian species have frequently gone undetected for years or have rapidly increased

in response to changing conditions resulting in more flooding. As well as vigilance, ultimately the goal should be to increase ecosystem resistance in the Pacific Northwest to help prevent large scale invasions that have been recorded for many of these species, either in this region or in other regions of North America and throughout the world.

Runaway Lakeshores and Widespread Plant Invasions: Insights on Revegetating Wetlands in the Arid West. Jes Braun*, Karin Kettering; Utah State University, Logan, UT (055)

Revegetating lakeshores post-invader removal is a challenging task. Alongside the threat of reinvasion, there are unpredictable weather patterns, exceptional drought conditions, and increasing water demand. Nonetheless, to achieve ecosystem management goals, practical solutions for revegetation must be developed. Two key decision points are (1) where should vegetation be reintroduced as lakeshores rapidly recede over the growing season and (2) what seeding or planting strategies optimize native plant establishment in the face of reinvasion? We addressed these questions in a lakeshore revegetation experiment on Utah Lake, a highly valued aquatic ecosystem in the Intermountain West that is experiencing dramatic water loss from upstream diversions and invasions by the non-native grass Phragmites australis. Here we present the results from a multi-year revegetation experiment where we looked at the effects of seeding density, plug planting, and elevation on the establishment of native vegetation. We seeded a 19-species seed mix of functionally diverse native plants at low (the typical seeding rate) and high (five times the typical seeding rate) densities. The results suggest that higher seeding density decreases invasive cover, however some higher density seeded areas experienced reduced species richness. Elevation of plug planting was a strong indicator of establishment over the two years of monitoring. Seeded elevations closest to the lake had the least amount of invasive cover and can be a prime area to target for restoration, however too close to the lake can lead to seed loss. Species richness increased over time, with some seeded species taking two years to germinate. In addition to this experiment, we conducted an extensive review and synthesis of the lakeshore revegetation literature. In our Extension publication "Best practices for lakeshore revegetation in the eastern Great Basin", we share our findings and provide a step-by-step guide for successful revegetation. We discuss the importance of careful planning and species selection, as well as the need for monitoring projects for continuous learning. Our goal is to empower others to restore the vegetation of lakeshores in the eastern Great Basin and ensure that these vital resources remain healthy for future generations.

Water & Weeds: Supporting Idaho's Thriving Agricultural Economies. Paul Arrington*; Idaho Water Users Association, Boise, ID (056)

At its core, Idaho is an agricultural state. Agriculture counts for nearly one quarter of the total state GDP. Water is, perhaps, the most vital component of this industry. In fact, farming, ranching and food processing would not be possible without water. In Idaho, water is largely delivered to farms and ranches through a series of canals, laterals and ditches. It is common for water management organizations to be responsible for hundreds of miles of these facilities. Weed control is an essential component of the management of these facilities. Water organizations throughout Idaho implement rigorous weed management programs to ensure that water is safely and efficiently delivered through their systems. This presentation will discuss weed management from the perspective of a water manager.

DISCUSSION SESSIONS

Project 1 Discussion Session: Pasture, Range, Forestry, and Natural Areas

Moderator: Lisa Jones

Notes prepared by: Rachel Seedorf

Topic: *Opportunities for projects that would benefit from private-public partnership.*

- Lisa started discussion with explaining the "3P's" involved in the partnership: private entity that funds projects, projects and revenue from public groups, and a common problem between both groups – shared vision and desired outcome
  - Example: create networks to help detect new invaders
- Do we already have these partnerships in place to some degree? Are we reinventing the wheel when addressing private-public partnerships?
- Energy companies look for ecosystem restoration credits to help offset their footprint
  - Cryptocurrency tied to ecosystem degradation that allowed for payment of services to improve their footprint on the ecosystem
  - An increased ESG score looked favorable for private energy companies.
  - How do we repeat something like this? More research is needed to see how it works and how it can be accurately and consistently measured.
  - Needs to be done for private business looking to pay for credits and entity doing the research/ecosystem improvements.
- Could seeding projects be considered as an additionality to improving ecosystems and be considered for carbon credit market?
  - Need a certification process and evaluated on current and future practices.
  - Carbon credits sold to large, private companies at no cost to those doing the additional practices.
- Are carbon credits the next step in these kinds of partnerships? Find ways to measure carbon increases/changes in rangeland/pasture ecosystems. Find methods to measure differences in an intact, undisturbed system vs. an invaded system.
  - Would high Carbon footprint companies be interested in investing in research of the impact in these systems to help them find more opportunities for purchasing offset credits?
    - Need instrumentation to measure Carbon changes within an ecosystem
  - What is the carbon capture in an invaded vs. undisturbed system?
    - There is still a lot of research that needs to be done
- Defending the Core is an important concept to keep remembering. Continuing this could help protect the Carbon that is already present vs. taking an additionality perspective
- Success story from University of Wyoming: IMAGINE – created an urgency among landowners and some private groups
  - Made awareness for the need to control invasive winter annual grasses.
  - Always the same people at the table; open communication among everyone
- Challenge in funding projects: matching federal funds for additional funding.
- There is a social component in these projects: building trust, starting with smaller projects to solidify further research needs and feasibility of projects
- Ownership on public lands can cause some challenges: who has authority of these lands?
- There are multiple uses on these lands: grazing, recreational.
- Are we getting away from the bigger picture if we focus too much on Carbon sequestration? Does logical land management get lost?

    - i.e. broadleaf weeds can sequester more carbon than annual grasses – would land managers lean towards keeping broadleaf weeds to sequester more carbon if they get too caught up in that goal?
- Operational projects are still an opportunity to learn even if proper research can't be done with available funds.
- Question posed to the group: What is the perspective from industry companies present? What value do they see from private-public partnerships?
    - Extension – what are they seeing?
    - Publishing is important and helpful for land managers.
    - Educating the next generation of potential industry reps.
    - Provide funding for student projects that further research.
    - Patents coming from universities that benefit industry.
    - University research is valuable to industry – quality is so important to industry; noticing that some of this is being lost.
- Academia is challenged with hiring qualified, relevant researchers that answer necessary questions versus chasing after researchers that bring in money for the university.

Also in this session: Jaycie Arndt was chosen as the 2024 section chair-elect.
Jake Courkamp agreed to be considered as the 2025 section chair-elect.

Chair 2023:
Lisa Jones, University of Idaho, Moscow, ID
lisajones@uidaho.edu

Chair-Elect 2023:
Rachel Seedorf, Aero Applicators, Inc.
rachel@aeroapplicators.com

Chair-Elect 2024:
Jaycie Ardnt, University of Wyoming Extension, Sheridan, WY
jarndt1@uwyo.edu

List of Attendees not available.

Project 2 Discussion Session: Weeds of Horticultural Crops

Moderator: Elizabeth Mosqueda

Topic: *The Future of On-Line Extension Resources, continued from 2022.*

The Weeds of Horticultural Crops Section had ten paper presentations in 2022, and all presentations were well attended, ranging from 20 to 45 participants. The discussion session was held on Wednesday, March 9, from 3:30 to 4:45 pm PT. The topic was *The Future of Online Extension Resources in Horticultural Crops*.

Discussion points from last year:

Challenges

- Dwindling resources – financial and time, it takes a lot of time to update these resources. Many resources are moving online only therefore most won't be sold to generate funds.
- Human capital loss- less people to do more work.
- Organic and non-chemical information – usually more expensive, so how do we make a more integrative approach to changing this.
- New formats of presenting information (videos, etc).
- Crop diversity within and across state – we all deal with many different crops.

Where should we go from here?

- Consolidate efforts
- New funding model

What has been done this past year to try and alleviate these issues?

-Pesticide information network has funds but have little to no information for users – You would need to talk with Ed to figure this out. If its pesticide information, its challenging to find resources to share for stakeholders (its more for homeowners vs agricultural use).

-As an agent the questions can be answered with phone call or email, but its extensive answering the same questions over and over. There's no repository where some of these questions can be kept and shared with others. There are few consolidated sites to try and refer people to. CA has good groups of people to share out information, but some of the landscape or homeowner info. is still difficult to pass on. Its challenging to have to pull from so many areas to answer one question. Also, it's a challenge to figure out which resources are reputable.

-In Idaho, resources are being consolidated, and they can somewhat serve different groups of stakeholders, but it can still be challenging to use. Rural interface can be challenging. Videos work well for this to direct clients to.

-At USU a Crops Team was created that has a website that has all info for everyone. Organized based on crop, fert., etc. Managed by 1 Extension Specialist. If this specialist leaves, another will take over.

-Almost need a campaign manager of some sort to manage all of this.

-UCIPM is a resource that many use because of how extensive the topics are. They do have a staff and website developer that manages this. It is extensive updating all of this information and it very challenging doing this, especially with certain UC positions remaining unfilled for

extended amounts of time. As time progresses, funding to maintain this has become more restrictive.

-PNW Weed Handbook – online, no longer selling hard copies

-How do we maintain the resources we have in a feasible way?

-At UID the role of the university website is for student recruitment opposed to hosting resources. If resources online want to be implemented or maintained, you need to use your own funds.

-At ID videographer is being utilized to create YouTube content

-Farm Talk videos on tiktok used, can Extension utilize this? Some states report being unable to use this platform.

-CSU also has a similar resource

-UCD has participated in podcasts

-Reliance Wheat Beat podcast

-How are these resources advertised? Some have used other social media platforms to share this content with others (twitter, FB, etc.)

-Even WSWS needs more exposure- we need to remember that we can recruit others, especially from the state where the annual meeting is being held! We need to do a better job at drawing the local weed specialists!

-Perhaps the next time we host the annual meeting in CA we can create a symposium for PCA's and ensure they can get CE hours. Or a special symposium with its own separate registration? Just ensure it's a regionally specific/important topic.

-At Potato Association they have a Grower Day where important information that's relevant to growers is presented for one day

-How to reach out to other weed specialists – We need to ensure they get the information very early on to ensure they can budget for travel/time. Start ASAP and ask them about topics they would like to hear about! Use Social media platforms – leads/supervisors distribute this information to others.

-Weed Supervisors - Public Relations committee could help with this. Create a list to ensure we maintain these contacts for different weed control associations.

-WSSA has a public awareness committee

-Create an option during registration to help weed supervisors defer costs (carpool, room share, etc.).

-other talks of interest at WSWS for Weed Supervisors: Biocontrol

-Support weed supervisors to ensure they extract the main takeaway points in all of our talks. Ensure that what's being discussed is valuable to all.

Elect New Chair-Elect
-Nominations:
Clint Mattox – USDA Corvallis - clint.mattox@usda.gov

Motion to have Clint M. as Chair-Elect – Marcelo Moretti
Second – Pamela Hutchinson

No discussion, motion passed – Clint Mattox is the new Chair-Elect for the Weeds of Horticultural Crops session

Chair 2023:
Elizabeth Mosqueda, Madera Community College
elizabeth.mosqueda@scccd.edu

Chair-Elect 2024:
Jose Luiz Carvalho de Souza Dias, University of Arizona Cooperative Extension
joseluizdias@arizona.edu

Chair-Elect 2025:
Clint Mattox

Attendees:

Elizabeth Mosqueda	Renan Guidini
Cody Zesiger	Curtis Rainbolt
Jill Schroeder	Brad Hanson
AJ Mondor	Harlene Hatterman-Valenti
Pam Hutchinson	Jane Mangold
Kai Umeda	Dan Kunkel
Jesse Richardson	Cathy Ford
Tom Getts	Tim Prather
Marcelo Moretti	Phil Banks
Joel Felix	Alan Helm

Project 3 Discussion Session: Weeds of Agronomic Crops

Moderator: Stephen A. Valenti

Topic: *Using Precision Technology in Research*

Notes: By Kyle Roerig for Alix Whitener

Discussion Summary:

Questions were posed to kick off the discussion: Which precision/digital tools are working well? Which ones are not? Do precision tools save time/money? Do precision/digital tools take some of the physicality out of daily plot work? Do these new tools improve data accuracy?

General comment made: The idea of having a discussion session on precision/digital tools was sparked from a magazine article that discussed 32 new apps now available for use in agriculture. Many precision tools are already being used and include GPS tripping, drones for stand counts, pictures, applications, auto steer Trimble, Greenstar, mapping of trials, remote sensors especially for weather, aerial imagery, data loggers, robots, pulse width modulation sprayers, etc. The comment was made at the start and in the end that perhaps this is an area that could be useful to many of us with invited speakers on this very topic at future meetings.

At the end of the session, we probably had more questions being asked than being answered. The following are some comments during the 1-hour discussion session.

NDSU pulse modulating plot sprayer – doesn't use it that much, due to issues with the pump. Ian Burke uses the same sprayer but uses CO_2 as the propellant. This resolves the issues caused by the pump.

GIS spray mapping, multi boom sprayer allows the researcher to spray at normal grower speeds. Six to eight miles per hour were reported. Very important to gain more similarity between what the farmer/ applicator is doing and research to more accurately predict weed control results. There will come a time when applications will be triggered by correct GPS coordinates at the plot level similar to what commercial applicators utilize for their large rigs on commercial fields.

Winfield answer plots – GIS planting maps are in use to take advantage of more data with the same amount of plot work as usual.

Ian Burke uses laser systems for evaluations, no LiDAR. Corteva uses LiDAR mapping for orchard trials. Differences in plant size can be determined where that would otherwise be impossible visually.

Researcher has to drive to WiFi to upload software updates for their planter. Sometimes that takes more time, but it is great when it works.

Stand counts on v3 on corn is very accurate by drones, this eliminates the use of labor to do stand counts at this juncture of the growing season…however it is not so accurate later in the season. So this can be a small cost and time savings. Drone pilots fly plots daily, multi spectral, stand count. Evaluation of plots with multiple species by drone is very limited and is not accurate in the short term. Will need better optics and high speed ai to evaluate complex weed stands. Visual evaluations remain the best method for taking weed control ratings especially in complex weed populations. Additionally, the human eye is useful to tease out parameters like nutrient issues between reps.

Some efficiencies gained with water measuring devices for herbicide plots. Especially, helpful to reduce time spent measuring water and it also improves accuracy.

Greenhouse Technology – conveyors bring barcoded pots through at a rapid pace to evaluate for plant structure, stress, etc. In many instances digital devices see things the humans can't begin to measure. This is crucial because this may mean the difference between a product going to the next step in development process…..or perhaps not through the development process… and getting shelved.

Satellite imagery to identify patches of weeds in fields…..some doubts were expressed regarding the feasibility of identifying weed species. Some advantages in using satellite imagery to place plots properly so you are avoiding low wet spots that you may not otherwise be aware of especially at a new field location that appears level but maybe is not so level.

Canopeo app from Oklahoma State University was mentioned as a tool for objective evaluations.

USDA Sample Point – you pick species, select pixels, and then the software makes objective measurements. It is especially useful on range studies. High quality photos are needed, and the researcher needs to ID plants (ground truth) on site before leaving. This technology pairs well with visual evaluations.

California extension demo – four rows of self-driving laser weeder. It runs day/night and kills little weeds. A farmer was heard saying to his son "This is what weed control will look like in 20 years. Chemical control will be less relevant." In Yuma a farmer didn't like it – too much thinning. Is it affordable in wheat? No, not really to much thinning.

AI in animal agriculture is advancing faster than crops. Farmers seem to be reluctant to move forward on some technologies…might be a lack of trust in the technology. To many monitors in the cab to watch and thus not paying as much attention to what is going on outside the cab. Algorithms come from data, not AI.

Reductions in pesticide use needs to be a talking point to the public and to the EPA as these new application devices are rolled out. Especially spot spraying with drones, does that ease the pressure on application rates per acre, or the use of certain products into areas that may have otherwise been prohibited.

Some Comments and questions asked. **We can't spray our way out of herbicide resistance, we need to add technology.** Are these things adding to our lives/profession? Will technology bring more people or less people into agriculture? Will that result in less connection between the public and agriculture? Could we recruit video gamers to control robotic weeders? They are sitting around at computers anyway. What did we want 20 years ago? Now we have new technology and more. What will the next 20 years look like? If we don't keep up with technology, will we still be qualified as things stand today, seems like we need to adapt? What will we do with outdated technology?

All of this technology advances so fast that hardware and software is outdated very quickly and sometimes not serviceable. Disposal and retrofitting of outdated hardware will be problematic given the short service life anticipated due to the rapid advances in technology year to year. Seems like there is always a better widget.

By the end of the discussion session, we barely scratched the surface of this topic and the suggestion was made to possibly identify people who are involved in Precision/Digital Technology

and start inviting them to the Western Society Of Weed Science to present on their information, findings, and experiences whether they are from the private or public sector.

Section Election For Chair Elect:

Kirk Howatt motioned to elect Joe Mettler as section chair elect.

Brian Jenks seconded the motion.

Voting on the motion was unanimous and in the affirmative. Congratulations Joseph Mettler!

Alix Whitener will be the Moderator and Chair of this Project Section in 2024.

Joe Mettler is Chair -Elect and will be Moderator and Chair in 2025.

Steve Valenti is the Past-Chair

Special Thanks To Kyle Roerig for stepping in and taking notes.

Chair 2023:
Steve Valenti, Bayer Crop Science
stephen.valenti@bayer.com

Chair-elect 2024:
Alix Whitener, FMC
alix.whitener@fmc.com

Chair-elect 2025:
Joe Mettler

List of Attendees not available.

Project 4 Discussion Session: Teaching and Technology

Moderator: Breanne Tidemann, past Chair

Topic: *Delivering information to where our clientele already interact*

The final presentation in the Teaching and Technology Project was on use of videos to get information to clientele and led nicely into the discussion section. There was discussion that video segments are great for extension activity, but could also be good for classes. Mention was made of some WSWS members who use videos for both industry/producer engagement, as well as student engagement in classes. One of the issues is remembering to take the videos in the summer to have them for winter classes.

Questions were raised on where to get help with video making and assistance posting them for those members not interested or not familiar with the process. Private company members mentioned hiring of marketing groups or individuals based on size, or they have colleagues who already do it or are interested in technology. Some public institutions have internal support, although some of them charge for video time and publication support. One idea that was raised was including video/electronic presence support in grants for research as part of the knowledge transfer component or writing specific grants for electronic support. Maybe we can tap into marketing/design programs for undergraduate student help. There might even be collaboration opportunities with some of these programs who may need subject material to use in design or marketing class projects. Capstone final year agriculture classes (or other subject classes) may also be an opportunity to reach students with more interest or experience with some of the technology extension.

Many members do not feel comfortable on camera and wondered how and why some of those doing the videos got started. Many members got into the area because they were asked to do so by their clientele or they were told to by supervisors, and they did have to accept a learning curve as they got started. Some members with more experience in this type of technology use in extension activities provided examples from their practice: create timely responses to important events, but keep all of your videos in a library so you can reuse them for future similar events, generate a script outline to stay on track, be mindful of the environment and extraneous distractions (wind, traffic), if the camera is set on a tripod make sure you stay in frame, and be aware if you are using a corded microphone to remember you are tethered to the camera.

Other comments suggested that doing videos alone is more intimidating while interview or discussion videos may be easier and more comfortable to film and it was agreed that was definitely a strategy that can be used. Challenges of this strategy include trying to coordinate with another person and their schedule which might delay the production of the video making it less timely or more difficult to find examples of the proposed topic in the field. There are dual microphone systems available, including wireless ones. There are splitters for corded microphones, but again beware of the tether. And always make sure you have demonstration plants or items easily to hand.

A comment was made that the NCWSS has a video contest which could help some of our members develop these skills. A comment was made that the WSWS will be initiating a video contest that will likely have a theme each year and be open to all.

The discussion moved into other areas such as twitter communities. These group posting forums can generate really good discussion but the discussion can go off track or misinformation can be spread. A big concern is around the time to monitor that activity, and depending on the interface whether or not it's possible. Prevention is a big key here and actively monitoring who is allowed into the group forum can save a lot of time and headache down the road.

There was also discussion on coffee shops or discussion tables and their ability to generate more participation. These are where there are no presentations but simply an expert available for discussion, similar to a 'reversed classroom' scenario. This increases University/Extension visibility and often serves as a two-way flow of information giving researchers new research ideas as well. Field days can also be set up in a similar format with demo/answer plots that provide more interaction and dialogue than formal presentation or dictation.

Finally, we touched on another high-tech option with virtual reality walking tours now possible. These use 360° camera technology and are used for facility tours. We discussed their potential for plot tours if we are able to access and become familiar with the technology.

Final thoughts that were shared was to take advantage of commodity groups and industry funders and use some of their resources such as podcasts to reach out to clientele. Include expenses or human resources for some of these activities and supports that we might not be comfortable with in grants. Finally, not everyone needs to use the same strategies but working with others who have strengths in other strategies can be useful and beneficial to everyone.

In the Teaching and Technology Transfer meeting, there were 14 members present. The discussion started out with slides summarizing 'Learning from the Past to Improve the Future of the Teaching and Technology Transfer'. We looked at the words that described the past/current state and the future hopes for Extension.

The discussion then moved to what should be covered in the 'Teaching and Technology Transfer' section. Many folks discussed that this section should be focused on how to extend scientific concepts to our audiences (i.e., How do we teach hard/difficult to understand topics? How to we use social media to share research findings?) The challenge is that those type of talks are not as 'valued' as scientific talks where we share research findings. These topics are important though, because we (as Extension educators) learn from each other on communicating and demonstrating difficult weed control concepts.

The question surfaced on how we recruit members/talks into our section? Also, where do folks fit in the society that are focused on technology/robotics/automated weed control? Do they fit in 'Teaching and Technology Transfer'? Basic biology? Agronomic Crops? There were no definitive answers on these questions, but general thoughts expressed. These topics are going to be further discussed at the board meeting.

Kirk Howatt volunteered to be the incoming vice-Chair (Chair in 2024).

By Jeanne Falk Jones, K-State Multi-County Agronomist (vice-Chair for 2022).

Chair 2023:
Jeanne Falk-Jones, Kansas State University
jfalkjones@ksu.edu

Chair-elect 2024:
Kirk Howatt, North Dakota State University
kirk.howatt@ndsu.edu

Chair-elect 2025:
Harlene Hatterman-Valenti, North Dakota State University
h.hatterman.valenti@ndsu.edu

Attendees:

Breanne Tidemann	Brian Jenks
Jeanne Falk-Jones	Greg Endres
Kirk Howatt	Dan Kunkel
Jill Schroeder	Earl Creech
Shaun Sharpe	Brian Olson
Greg Dahl	Pete Berry
Kyle Roerig	John Spring
Jane Mangold	Chris Mayo

Project 5 Discussion Session: Basic Biology and Ecology

Moderator: Rui Liu

Topic: *Impact of Changing Climate on Weed Adaptation in Western US*

Notes: About 11- 13 people joined the discussion. Below are specific discussion points:

- Weed species ranges are moving north:
    - Kochia is moving north in Alberta, Canada. Reported cases of kochia found along roadways, not yet reported in agricultural fields. It is suspected that the introduction came from new oil leases.
    - Green foxtail and other C4 weed species are also shifting north in Canada
- Drought and fire happen more frequently, which increased the chances of early colonizers, especially new species, to take over. Because of little competition and predation.
- Waterhemp and Palmer amaranth started to make their way to North Dakota, and PPO-resistant Kochia is spreading in ND.
- Weeds shifting ranges before crops- maybe it is an early indicator of if a new crop can be suitable the new crop. E.g. testing soybean in Canada, etc.
- Palmer amaranth is not in Washington but found in
- Extreme weather like flooding and wild fire, etc, impact weed populations, and the dormancy of weed seeds. The tolerance of flooding in weed species is also changing. In addition, resistance in weed populations is changing, for example, annual bluegrass resistance, ryegrass resistance, hairy fleabane resistance to glyphosate in orchards will make management more challenging.
- In California, weed shift/ flushes overtime- field bindweed, hairy fleabane emerges in December.
- Wild oat hardly seen in orchard may relate to highly disturbed environment. Seed coat could have changed and adapted to wild fire, etc. How long does it take for the adaptation to be sufficient?
- Water availability decreased. In vineyard, water is relatively easier to adjust. How does water availability impact weeds?
- Canadian government has strong interest in climate change. How do weed scientists studying weeds & climate change? Limited resources to address carbon capture, etc.
- Winter change in Canada, more above freezing, then back to below zero. Crops losing insolation in snow cover. Last few years have been hard on the crops because of no insolation.
- Average temperature is higher compared to before in North Dakota, but temperature extremes still happen often. Temperature fluctuation makes permaculture harder.
- Central Valley CA is historically hot and dry in summer, mild and wet in winter. Now more and more late spring rain. It makes rice planting harder and late summer rain storms, which is challenge for harvest. Humidity change is easy to notice. Disease will be a problem.

- Weed adaptation, functional ecology, population genetics. Understand adaptation traits and variation. Important to focus on one or two species to take apart the traits. Genome information- common garden work- phenotype and genotype. GWAS study to determine the genes to identify the genes, then model.
- Bottleneck the weed populations. Trap them in cropping sequences. Cheatgrass grass as an example, avoids harvest input through its life cycle. Management can be done through manipulating it.
- Sanitation is important. E.g., Palmer amaranth was introduced to Manitoba, Canada, through combine purchasing; Sterile brome (hardly make any seeds) in WA spread a lot because combine purchases. Custom combines move around in Canada, potential risk for weed spreading. Maybe a big bath machine, or radiation machine, or microwave could happen in future to clean equipment.
- Studying adaptation for climate change or herbicide resistance: geneticists usually look at adaption to explain how it happened. People need to be better at the reverse genetics process, looking at genome across space and time, and see what is popping out. There is a lot of ecological models to forecast distribution but limited done for real time genomic monitoring, signal adaptation, etc. Quick and easy diagnose methods are needed to study adaptation.
- Investing in genomic resources can transform the ability to detect things. It's a slow process.
- Learn from Covid genome examples: predict mutation, predict/ detect change rapidly. It's easy to detect genes currently sweeping, but hard to find sweeps already happened.
- Breeding programs are limited by generations. Time frame and scale with weeds are different but can be draw from breeders.
- Climate change makes it harder because year by year environments are different. Breeders deal with climate change by referring it as "reaction norms" and quantify them by using simple and multiple environmental scales.
- Wild oat control relies on PRE, but activation moisture causes lack of control. If control failed and population builds up, herbicide resistance is more likely to happen.
- Climate change impacts gardens for trees/ shrubs planning, and future planting, because trees will be there for a long time. Hand weeding, mulching, etc. are used for gardens.
- Invasive species like cogon grass, and kudzu moving to this region -train goats; weed and feed program etc.?

Chair 2023:
Rui Liu, Kansas State University
tabitha723@ksu.edu

Chair-elect 2024:
Alex Ceseski, University of California
arceseski@ucdavis.edu

Chair-elect 2025:
Breanne Tidemann, Canada Agriculture and Agri-food Canada
breanne.tidemann@canada.ca

List of Attendees not available.

Discussion Session: Education and Regulatory

Moderator: Jane Mangold

Topic: *Communicating the Complexities of Weed Science and Management in an Age of Information Snippets.*

These discussion notes are not verbatim but are intended to provide a summary of the discussion that took place.

The discussion session began with Dr. Mangold presenting a brief overview of the current complicated environment of communicating Weed Science to stakeholders. Namely that Weed Science and management is complex, site specific, interdisciplinary, and information often is nuanced and needs to be contextualized. However, stakeholders often want straightforward answers, easy-to-implement solutions or specific products, and quick results.

This overview led to the first question for discussion: ***Is this a fair assessment of the situation?***

Participants in the section agreed that often there is a conflict of information, which depends on the goals of each party. Addressing stakeholder needs might mean going through intermediaries —land managers, agronomists, salespersons, ect…—, who may have different set of goals then either the stakeholder or weed scientists. Further, conflicts can also arise between neighboring stakeholders who might share different management goals and values.

And while participants in the discussion generally agreed with Dr. Mangold's assessment of communicating Weed Science, there was also agreement that some stakeholders do seek out as much detail as possible to address their situation. Other times a stakeholder thinks their question is simple when it is in fact quite complex. A number of participants in the discussion session pointed out that public community forums are a great opportunity for discussing complex management issues and exposing differences in goals and values among stakeholders.

The second question Dr. Mangold asked was: ***Who are our stakeholders and customers?***

In terms of agronomic Weed Science, agronomists or farm advisors are becoming more common as stakeholders; as these intermediaries may be elevating difficult problems and challenges to weed scientists rather than directing farmers to the subject matter experts. Farmers may not appreciate the contribution of university extension professionals in addressing their concerns as they may be unaware that extension professionals were ever contacted. Some in the room considered this lack of direct contact with "on the ground" stakeholders as a challenge, while other thought of intermediaries as an opportunity to multiply their impact. Further, when discussing university extension, which is historically constrained to within state lines, a lot of current extension is occurring outside the states where a professional is employed.

The third set of questions asked was: ***How do you navigate these discrepancies?***

- ***Share approaches that have worked/not worked?***
- ***How do you know if something worked/didn't work?***

Many of the participants in this section of the discussion who spoke worked in public land management, from county governments, state governments, and the National Park Service. One participant noted that in his area a lot of the public is not receptive to chemical weed control and confrontations are common in the public space. Another participant also had similar negative interactions in the past with public stakeholders. Both agreed that the most important strategies.

for addressing conflicts is to not argue or become confrontational, and to focus on staying in a "service" mentality when interacting with the public.

Among university extension professionals, it was agreed by many that when trying to address challenging and complex topics, communicating small amounts of information at a time, and using a lot of repetition of that information can be an effective strategy regardless of the media used.

The final question asked was: ***How do we "package" weed science and management information to be more effective?***

This last question led to several good examples of teaching survey techniques, herbicide resistance management, and other Weed Science knowledge to clientele in the form of a hands-on workshops. This discussion exposed that there is often a lack of good examples of how information can be communicated in extension. From this point, the idea was discussed of developing a future symposium on communicating Weed Science to stakeholders. Such a symposium could be focused on presentations on sharing previous science communication successes or could invite experts to walk symposium audience members through various mock workshops. Submitting titles and abstracts within the Teaching & Technology and Education & Regulatory sections of WSWS was also encouraged.

Chair 2023:
Jane Mangold, Montana State University
jane.mangold@montana.edu

Chair-elect 2024:
Nevin Lawrence, University of Nebraska-Lincoln
Nlawerence2@unl.edu

Attendees at the Education and Regulatory Discussion Section

Name	**Email**
Jane Mangold (Chair)	jane.mangold@montana.edu
Nevin Lawrence (Chair-Elect	nlawerence2@unl.edu
Phil Banks	marathonag@zianet.com
Jill Schroeder	jischroe1@gmail.com
Tim Prather	tprather@uidaho.edu
AJ Mondor	ajmondor@canyoncounty.id.gov
Cody Beckley	cody.beckley@usu.edu
Dirk Baker	dbaker@campbellsci.com
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Corey Ransom	corey.ransom@usu.edu
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Brad Hansen	bhanson@ucdavis.edu
Kai Umeda	kumeda@cals.arizona.edu
Kelsey Brock	kbrock5@uwyo.edu

WSWS ANNUAL BUSINESS MEETING MINUTES (2022)

Newport Beach, CA
March 10, 2022

Attendees: 130 members attending.

Call to Order: President McDonald called the meeting to order at 7:06am

Welcome and Introductions

Officer Reports:

Secretary – John Madsen (approval of minutes).

WSWS Annual Business Meeting Minutes on
Virtual, March 4, 2021 (6:30 to 9:15am PST)

- Motion: Kirk Howat
- Second: Rick Zollinger
- Vote: Approval was unanimous

Business Manager and Treasurer Report – Eric Gustafson

- Eric is working hard at the registration desk.

Treasurer Report – Phil Banks

- Our assets are $477,964.00
- Assets to cover at least 2 years of expenses, we are currently at 3 years of expenses.
- Our assets went up 10.4% last year. We are down 1.4% since June.

President – Sandra McDonald

- This has been a strange time, so we have had 3 board meetings instead of the usual 2 meetings.
- Voting has been largely by electronic voting, and many meetings on zoom.
- We voted to update the website; the platform is outdated and needs to be brought up to date with a better look.
- The Western Aquatic Plant Management Society will join us for a joint annual meeting in Boise next year in person.

Past President – Corey Ransom

- It's been a pleasure to serve on the board the past eight years.
- Recognized the retirements of four active retirees at the reception.

President Elect/Program Chair – Joel Felix

- Joel thanks those who gave presentations, whether poster or oral.
- Thanks to the members of the program committee for their assistance, the meetings were all virtual.
- Thanks to those who participated in the General Session.

Research Section Chair – Judit Barroso

- Thanked Joel for his work with the committee members and assisting the research section chair.

Education and Regulatory – Carl Coburn

- One symposium led by Steve Fennimore, seven talks that were well attended.
- Workshop with Matt Baur on wildfire in the west
- Group of talks celebrating the 75th anniversary of the society
- Incoming chair is Jane Mangold

Member-at-Large Public – Steve Fennimore

- The session held demonstrated a practical method to treat weeds without herbicides, and do not require pesticide registration.

Member-at-Large Private – John Coyle

- Outreach to contractors, managers, and consultants.
- Appreciates the opportunity to serve.

WSSA Representative – Alan Helm

- Meeting went virtual in 30 days.
- A twelve-part symposium put on by WSSA this spring.

CAST Representative – Greg Dahl

- He thanks the society for the opportunity to be the CAST representative.
- The mission of CAST is to use its network of experts, assembles, interprets, and communicates credible, balanced, science-based information to policymakers, the media, the private sector, and the public.
- Lots of interesting things going on in agriculture
- WSWS works with the other weed science representatives from the national and regional chapters.
- Thanks to Jill Schroeder (the WSSA rep) for her work with the other weed science representatives.
- Working on a publication on invasive species. Proposal approved by WSSA, NAISMA and CAST Board.

Student Liaison – Jodie Crose

- Student night out was a fun experience. 30 professionals took 43 students.
- Silent auction still going on, will continue until about 9:30am.
- 25-30 items were donated.
- All money goes to the Elaine Sanchez scholarship. We are at about $800 for the scholarship. We are working to a $3,000 goal.
- We need pictures of the attendees. Please share your pictures.
- Next student liaison is Grace Ogden
- Incoming Student Liaison is Aaron Becerra-Alvarez

Director of Science Policy – Lee van Wychen

- No report
- Sandra serves on Science Policy Committee with WSSA and regional societies.
- This provides an opportunity to educate legislators on weed science issues.

Committee Reports:

Publications Committee (Joel Felix)

Proceedings – Carl Libbey

- Send information to Carl Libbey
- Changes to operating manual to add retiree list

WSWS Newsletter – Carl Libbey

- Comes out four times per year.

Research Progress Reports – Traci Rauch

- We had 26 reports last year, the number of submissions is declining
- We need more reports
- Reports are due in January.

Website – Eric Gustafson

- 238 Conference Registered attendees
- Website includes a new registration system
- We are in process of updating website hardware and will update software and the website look and capabilities.
- Reports are up from the meeting.

Local Arrangements – Sonia Rios

- Sandra thanks everyone for coming to the meeting. Sonia was unable to attend the business meeting.
- 2023 – Boise
- 2024 - Denver

Nominations – Vipan Kumar

- New Board Members elected:
- Curtis Rainbolt, President Elect
- Marcelo Moretti, Research Section Chair
- Misha Manuchehri, Education/Regulatory Section Chair
- Joe Vassios, Secretary

Public Relations – Albert Adjesiwor

Fellows and Honorary Members – Ed Peachey

- Richard Zollinger, Fellow
- Andrew Kniss, Fellow
- Hugh Beckett, Honorary Member

Site Selection – Byron Sleugh

- Boise, 2023, Joint Meeting with Western Aquatic Plant Management Society
- Denver, 2024

Awards – Rich Zollinger

- Thanks to the committee
- We recognized the award winners from 2021 and 2022:
  - *WSWS Outstanding Weed Scientist – Early Career:*
    - Dr. Charles Geddes, Agriculture and Agri-Food Canada, Lethbridge, Alberta
  - *WSWS Weed Manager:*
    - Julie Kraft, Sublette County Weed and Pest District, Pinedale, WY
  - *WSWS Elena Sanchez Student Scholarship Program:*
    - Jodie Crose, a 3rd year Ph.D. candidate at the University of Wyoming, advised by Dr.
    - Ednaldo Alexandre Borgato: a 4th year Ph.D. candidate at Kansas State University advised by Dr. Mithila Jugulam and Dr. Anita Dille
    - Sachin Dhanda, a 1st year Ph.D. candidate at Kansas State University, advised by Dr. Vipan Kumar
  - *Rita Beard Endowment Foundation Scholarship:*
    - Jodie Crose, a 3rd year Ph.D. candidate at the University of Wyoming, advised by Dr. Brian Mealor
  - *WSWS Presidential Award of Merit:*
    - 2021 Program Committee:
      - Mithila Jugulam (Research Section Chair),
      - Todd Neel (Education & Regulatory Section Chair),
      - Dennis Scott (Student Paper Judging Committee Chair),
      - Mirella Ortiz (Student Liaison)
  - *WSWS Honorary Member:*
    - Dr. Hugh Beckie, Director of the Australian Herbicide Resistance Initiative and a Professor in the School of Agriculture and Environment at the University of Western Australia.
  - *WSWS Fellow*:
    - Dr. Richard Zollinger, Northwest Region Product Development Manager for AMVAC Chemical Corporation
    - Dr. Andrew Kniss, Professor of Weed Science and Head of the Department of Plant Sciences at the University of Wyoming
- Congratulations to all of our recipients and thank you for your outstanding contributions to the field of weed science, and the Western Society of Weed Science.
- Please nominate individuals for awards
- Tim Prather will be next chair

Poster – Caleb Dalley

- Thanks those that submitted posters, 57 posters were displayed.

Necrology – Ryan Rapp

- Poster was up of the past members that have passed.
- Another member, Doug Ryerson, pass just before the meeting.
- Necrology report:

    - Richard Comes was a month away from 90th birthday when he passed. Dick worked with USDA ARS in Laramie WY, later in Prosser WA. WSWS Fellow in 1993. WSSA Fellow in 1996.
    - Doug Ryerson earned an MS and PHD from Univ. Wisconsin-Madison, and worked at Univ. Idaho and later worked with Monsanto. Active in WSWS
- We had a moment of silence for past members.

Sustaining Membership – Rachel Zuger

- Stephen Valenti was unable to attend.
- She thanks the sustaining members for their support. Sustaining members support a number of the activities of the society and the annual meeting.

Legislative – Rachel Zuger

- John Vickery was unable to attend
- Updating contact information for state weed coordinators

Herbicide Resistant Plants – Lavreet Schegril

- Misha Manuchehri was unable to attend
- The committee wants to move away from resistant plant survey since we get few responses
- Respond instead to the central information source at WSSA
- Results of past surveys will be on the website, and submit to the central website.

Ad Hoc Website – Sandra McDonald on behalf of Lynn Ingegneri

- Working to highlight needed changes to website.

Ad Hoc Invasive Species – Lisa Jones

- Co-chairs are not present, the committee will continue

Ad Hoc Diversity and Inclusion Committee – Elizabeth Mosqueda

Thank you to review the documents, and all who participated in the survey.
Reviewing operating procedures to make it more inclusive.

Ad Hoc History Committee – Vanelle Peterson

- Phil Banks, Don Morishita, Rod Lym were committee members.
- The document is complete, over 374 pages
- Book includes the original Arnold Applebee history
- The book is digital and has hyperlinks
- The book is searchable.

Presidential Comments - Sandra McDonald

- Winner of the History Contest was Harlene Hatterman-Velenti
- President McDonald not so gently (and I own that! Thanks for noting) reminded us to nominate people for the various awards.

Student Paper/Poster Judging – Josh Adkins

- Thank all the judges of the contest.
- Student score sheets are available for all students, please pick up near the registration desk.
- Awards:
  - *Agronomic Crops Oral Presentations M.Sc.:*
    - 1st – Tyler Hicks, University of Wyoming
    - 2nd – Ryan Johnson, University of Wyoming
  - *Agronomic Crops Oral Presentations Ph.D.:*
    - 1st – Grace Ogden, Oklahoma State University
    - 2nd – Liberty Galvin, University of California, Davis
  - *Basic Biology and Ecology Oral Presentations*
    - 1st – Joe Ballenger, University of Wyoming
    - 2nd – Albert Kwarteng, University of Idaho
  - *Horticultural Crops Oral Presentations*
    - 1st – Deniz Inci, University of California, Davis
  - *Range, Forestry and Natural Areas Oral Presentations*
    - 1st – Chloe Mattilio, University of Wyoming
    - 2nd – Jodie Crose, University of Wyoming
  - *Agronomic Crops Poster Presentations*
    - 1st – Sachin Dhanda, Kansas State University
    - 2nd – Milos Zaric, University of Nebraska-Lincoln
  - *Basic Biology and Ecology Poster Presentations*
    - 1st – Crystal Sparks, Colorado State University
  - *Horticultural Crops Poster Presentations*
    - 1st – Andrew Contreras, University of California, Davis
  - *Range, Forestry and Natural Areas Poster Presentations*
    - 1st – Jodie Crose, University of Wyoming
    - 2nd – Mariana Amaral, Washington State University
  - *Undergraduate Poster Presentations*
    - 1st – Felipe Bagnara, Colorado State University

New Business:

- Remind people to join a committee. Find the chair or talk with Joel Felix, or another officer.
- Board of Directors Members in Maui – please come to get your picture.
- Board of Directors Members in 2021 please come for your picture
- Board of Directors in 2022 please get your picture
- Incoming board members please join to get a picture.

Passing of the Gavel:

- President McDonald to new president Joel Felix
- She thanks Joel for his great job on the program.
- President Felix thanks everyone for the opportunity to serve.
- He thanks the many people who helped with the program and program committee
- President Felix presents the presidential plaque to new Past President Sandra McDonald. He thanks Sandra McDonald for service to WSWS.

Adjourn at 8:53am by President Felix

Name of Person Preparing this Report: John D Madsen

WSWS BOARD OF DIRECTOR'S MEETING MINUTES

WSWS Board Meeting Agenda
Boise, Idaho February 27, 2023

Welcome and Introductions

Call to order and Approval of Agenda– *Joel Felix*

Called to order at: 12:30 PM.

- Motion to approve agenda: Sandra McDonald
- Second: Alan Helm
- No discussion
- Approval: Unanimous Approval

Welcome and Introductions

Attendees: *Lee Van Wychen, Tim Prather, Curtis Rainbolt, Sandra McDonald, Alan Helm, Phil Banks, Joe Vassios, Nevin Lawrence, Grace Flusche Ogden, George Newberry, Ryan Rapp, Marcelo Moretti, Gregory Dahl, Clarke Alder, Joel Felix, Eric Gustafson, Jane Mangold, Richard Zollinger*

Officer Reports

Secretary – *Joe Vassios*

Approval October 2022 Board Meeting Minutes with proposed changes:

- *Motion to approve minutes: Greg Dahl*
- *Second: Sandra McDonald*
- *No discussion*
- *Approval: Unanimous approval*

Business Manager Report – *Eric Gustafson*

New website up and running. Front end is great and the backend reporting is much better.

- *Ryan Rapp has asked for Finance Committee Report and Treasurer Report linked on the website.*

245 registrants, 176 WSWS Regulars, 29 students, 8 retired, 32 APMS attendees

Treasurer Report – *Phil Banks*

- *Treasurer is chair of Finance Committee. Update the Operating Guide to clarify this.*
- *Quarterly call. 10-14 days after end of the quarter.*
- *Committee Members & Investment Advisor – Stan is retired as advisor. Had a long-term advisor role for WSWS. Replacement is Frank Vargas. Slightly different philosophy vs. Stan. Suggests diversifying more than we have in the past. Committee will meet during Annual Meeting to discuss if a change is needed in investment advisor.*
- *Posted on website under Finance Committee Report from Summer Meeting or Annual Meeting.*
- *In good financial condition. Over $420,000 in assets among several categories. Checking, Money Market, CD's and investments. See report for updated financials.*
- *Do have conservative investment policy.*
- *Need two new committee members for the Finance Committee. Replacements for Nevin and Ryan.*

President – *Joel Felix*

- *Joel's report has been posted online.*
- *We have had several e-votes. Most are unanimous. Contained in President's Report.*
- *Joel also completed appointments to committees.*
  - *Need to reinforce with committee members what their responsibilities are.*
  - *Chair needs to share this with the committee members on deadlines, etc.*
- *Has been participating in the Science Policy, Finance Committee, Nominations Committee, Awards Committee.*
  - *Need to continue to remind members about award nominations.*

Past President– *Sandra McDonald*

- *Vanelle has added the student history from working with Dirk Baker*
- *Sandra will honor retirees. Please let her know if any are missing. Those are listed in her report:*
  - *Greg Dahl*
  - *Stott Howard*
  - *Marie Jasienuk*
  - *Paul O. Johnson*
  - *Kelly Luff*
  - *Kai Umeda*
  - *Harvey Yoshida*

President Elect/Program Chair – *Curtis Rainbolt*

- *Thank you to all for their help with the meeting, including Joel, Sandra, Jane and Harlene*
- *~150 papers. Several have had to drop out*
- *73 from WSWS, 20 from WAPMS, 48 posters, most of the posters from WSWS.*
- *26 students, 3 are WAPMS*
- *Trend is lower than past years, not sure why numbers are lower?*
- *SW Idaho Government attendees may be impacted by Society for Rangeland Management being in Boise several weeks back*
- *Largest section is Agronomy, but Range and Pasture is large too.*
- *Would suggest that a MOU is signed regarding a joint meeting with WAPMS, and there is difficulty in differences in deadlines.*
- *WAPMS is down to 20 papers, Sandra asked if it is time to approach WAPMS about incorporating back into the WSWS.*
- *Recommendations to the Board*
  - *Continue to monitor poster and paper submission trends*
  - *For future meetings with other societies, consider standard agreement*
  - *Consider having IMI Group handle most of the program and meeting planning responsibilities in the next contract*
- *Jane suggests possibly incorporating program development responsibilities to others such and Ed and Regulatory Chairs.*

Education and Regulatory – *Jane Mangold*

- *Activities for the year follow the Operating Guide duties*
- *Sent symposium solicitation in summer. Did not have submissions, so extended deadline. No proposals were received.*
- *Jane ended up coordinating with assistance from other WSWS and WAPMS members.*
- *Possible symposiums for 2024:*
  - *Ryan Rapp has ideas for symposium*
  - *Sandra mentioned CO interest in Weed and Seeds*

Member-at-Large Public – *Sonia Rios*

- *No report currently.*

Member-at-Large Private – *Clarke Alder*

- *While operating guide has some details, Clarke didn't always know what his responsibilities were. Would be good to clarify or continue to work with Program Chair.*
- *Feedback from some local people, cost can be an issue for attendees that might be limited by travel concerns.*
- *Amalgamated Sugar did provide a sponsorship based on Clarkes recommendation.*

Research Section Chair – *Harlene Hatterman-Valenti*

- *Have had some difficulties in getting the talks from the moderators.*
- *At NCWSS late submissions would be penalty for student presentations.*
- *Deadlines in Operating Guide should be updated to reflect shifting meeting timeline.*

WSSA Representative – *Alan Helm*

- *Attended joint NEWSS/and WSSA meeting.*
- *555 attendees*
  - *150 graduate students*
  - *54 EPA attendees.*
- *5 total symposia*
- *Graduate students had breakfast on mental wellbeing and balancing school and life.*
- *Annual Weed Contest will be in Union City, TN July 25-27*
- *Addressed declining revenue and publications in the society. Many are choosing to publish elsewhere due to cost. Only 19% of WSWS members are members of WSSA.*
- *Herbicide Handbook will be delayed approximately another year. Likely will be online w/ a subscription.*

WSSA Finance Committee Representative – *Richard Zollinger*

- *No report currently.*

CAST Representative – *Greg Dahl*

- *WSWS Participates in Plant Working Group on issues papers for lawmakers*
- *Jill Schroeder pulled together all Weed Science members for PWG on occasion to discuss issues.*
- *Developing 2 Invasive Species papers currently.*
- *Attended CAST National Meeting & 50th Anniversary - CAST annual report & upcoming projects attached to Board report on website.*
- *Planning to attend annual meeting this fall.*

Student Liaison – *Grace Flusche Ogden*

- *Assisted in soliciting students to assist with committees. Students seem willing.*
- *Assisting with silent auction*
- *Have been sharing opportunities and information for students on social media and email.*
- *Assisted Vanelle of history for student organizations*
- *Assisted with coordinating Student Night Out*
- *New Student Representative from UC Davis will be Aaron Becerra-Alvarez*
- *Eric noted that Western students don't apply for WSSA opportunities as often as other regions.*

Director of Science Policy – *Lee van Wyche*n

- *Did conduct in-person congressional visits*
- *Congress did support IR-4 for $15 million for FY 2023*
- *Congress did provide $21 million for CPPM in Omnibus appropriations bill. First increase since FY 2017*
- *New funding of $6 million to address hydrilla control, research and demonstration in CT.*
- *FIFRA and ESA Requirements – will be ongoing issues. Could have changes on herbicide labels to address ESA issues. County level registration removals or mitigations will have to be implemented.*
- *NISAW was last week.*
- *Additional ongoing issues outlined in Lee's report on the website.*
- *Weed Science Society Presidents will be doing a DC Fly In April 17-20.*

Representative for Constitution and Operating Procedures – *Chad Cummings*

- *Next BOD meeting will need to review and approve edits in the Constitution and Operating Procedure Guides.*
- *Review prior to next meeting and discuss/approve.*
- *Will need replacement for Chad's position since he has completed his term. Needs to be appointed by BOD.*
- *Nomination of Sandra McDonald as next Chair.*
    - *Motion: Phil Banks*
    - *Second: Greg Dahl*
    - *No Discussion*
    - *Approval: Unanimous Approval*

Committee Reports:

Publications Committee (Curtis Rainbolt – board contact)

Proceedings – *Carl Libbey*

- *Suggest to update Operating Guide for Proceedings Editor to include the "Timeline for Specific Duties", March 1. 2nd Section,*

WSWS Newsletter – *Carl Libbey*

- *See report for updates.*

Research Progress Reports – *Traci Rauch*

- *Only 16 submitted in 2023. Came from ID, KS, WA*

Website – *Eric Gustafson*

– Lynn Ingeneri

- *See Business Manager report for updates.*

Local Arrangements – *George Newberry* – chairperson (Curtis Rainbolt – board contact)

- *All good to go so far.*
- *Poster room is set up.*

Finance – *Phil Banks* – chairperson - Treasurer

- *Already presented during treasurer report.*

Nominations – *Brian Schutte* – chairperson (Sandra McDonald – board contact)

- *Slate was presented and votes have been cast.*
    - *Incoming Board Members:*
        - *President Elect – Tim Prather*
        - *Research Section Chair – Dirk Baker*
        - *Education/Regulatory Section Chair – Nevin Lawrence*
        - *Treasurer – Ryan Rapp*

Public Relations – *Albert Adjesiwor* – chairperson (Jane Mangold – board contact)

- *Video contest rules have been emailed for review.*
- *Committee requesting approval of video contest rules.*
- *Motion to approve Official WSWS Video Contest Rules*
  - *Motion: Sandra McDonald*
  - *Second: Alan Helm*
  - *Discussion incorporated changes to the rules. Final Rules added as Appedix A to these minutes.*
  - *Approval: Unanimous Approval*
- *Need to determine if we would like to extend contract for Social Media Management. Curtis to share with PR Committee.*
- *Contract discussion needs to occur within the Committee and will be voted on following Committee recommendation.*

Fellows and Honorary Members – *Ed Peachey (Richard Zollinger)* – chairperson (Joel Felix – board contact)

- *No nominations were initially received for Fellows or Honorary members. Committee solicited nominees*
  - *Fellow Nominations:*
    - *Cory Ransom*
    - *Brad Hanson*
  - *Honorary Member:*
    - *Dan Kunkle*
- *Suggest including Operating Guide that winners are notified 2 months prior to the meeting.*
- *Richard has noticed that Fellow Guidelines are not very strong vs. other societies. Suggests the committee updates these and proposes changes.*

Site Selection – *Ryan Bryant-Schlobohm* – chairperson (Joel Felix – board contact)

- *2025 Shortlist:*
  - *Seattle*
  - *Albuquerque*
  - *Oklahoma City*
- *Committee recommends that we start contract negotiations with Westin Seattle. Based on initial quotes with Eric, they were providing best rates and concessions.*
- *Eric working on negotiating contract. Tentatively holding our space.*
- *Motion to approve negotiation for Seattle Westin as 2025 site based on the site selection committee recommendation:*
  - *Motion: Sandra McDonald*
  - *Second: Curtis Rainbolt*
  - *Discussion – Are we looking for later dates? Yes. Were local scheduling conflicts this year.*
  - *Approval: Unanimous approval*
- *Have committee consider locations for 2026 as soon as possible.*
- *Also consider 2027 joint meeting with WSSA. Possibly in Hawaii? For discussion at the Summer Board Meeting.*

Awards – *Tim Prather* – chairperson (Joel Felix – board contact)

- *Documents for Elena Sanchez award has been updated. Timelines for announcements and deadlines are updated*
  - *3 applicants for this year. All 3 were awarded*
- *Outstanding Achievement*
  - *3 nominations for this year.*

- *Considering committee members who can assist with nomination solicitation. Would not preclude others from nomination but would ensure some nominees are put forward for each award.*
- *Encourage those who have won the awards to nominate other members for the awards.*
- *Discussion between Rita Beard and Elena Sanchez awards to ensure fairness between the two awards.*
    - *Committee to make recommendation to BOD to consider and discuss further at summer board meeting.*

Poster – *Rui Liu* – chairperson (Curtis Rainbolt – board contact)
- *Boards were stored at Utah State. Were brought down and will take back to deliver to Denver next year*
- *No Recommendations from Poster committee.*

Student Paper/Poster Judging – *Clint Beiermann* – chairperson (Curtis Rainbolt – board contact)
- *Met and no recommendations for scoring sheet*
- *Recommendations for Board Action:*
    - *On Undergrad Contest: Op. Guide says poster, Contest rules say poster or paper. Moving forward will be in both poster and paper.*
    - *Poster size recommendation needs to be consistent. Need to coordinate with program chair yearly to ensure posters are correct size based on boards.*

Necrology – *Rachel Seedorf* – chairperson (Joe Vassios – board contact)
- *Report received. Necrology poster has been made and will be at the meeting.*

Sustaining Membership – *Rachel Zuger* - Chairperson (Sandra McDonald – board contact)
- *No report.*
- *Committee did a good job of getting support for the meeting this year. Some have not paid in time to get in the program.*

Legislative – *Slade Franklin*– chairperson (Alan Helm – board contact)
- *Survey sent in August. Got 16 responses by states and provinces around weed issues.*
- *Individual states have issues with commercial sale of prohibited plants.*
- *Supply chain issues and herbicide availability last season.*

Herbicide Resistant Plants – *Lovreet Shergill* - chairpersons (Clarke Alder – board contact)
- *Several virtual committee meetings this year. Follow up conversations on the future of the committee.*
- *Planning symposium for next year.*

Diversity and Inclusion Ad-Hoc Committee– *Elizabeth Mosqueda* (Joel Felix – board contact)
- *Committee has been hoping to give suggestions to the board, will plan to make recommendations for the summer board meeting.*
- *Committee suggests including a Diversity and Inclusion tab on the website.*
    - *Under Society tab have a D&I tab to host what the committee has developed.*
        - *D&I Mission Statement*
        - *D&I Survey Results*
        - *List of previous actions to date*
        - *Listing of those who make up Ad-hoc committee.*
        - *All content has been previously approved by the board*
    - *Motion to incorporate D&I content to the website:*
        - *Motion: Sandra McDonald*

    - *Second: Jane Mangold*
    - *Discussion on the posting of past information and format for that. Condensed version for website.*
    - *Approval: Unanimous approval*
- *Sandra McDonald asked if Ad-hoc committee needs to become standing committee. Elizabeth agrees.*
- *Suggest committee prepare a recommendation to the Board and set the process in motion to vote on at the summer BOD meeting.*

Invasive Species Ad-Hoc Committee – *Brian Mealor/Chad Cummings* (Joel Felix – board contact)

- *Attended SRM meeting and developed full day workshop on invasive species.*
- *Suggest committee prepare a recommendation to the Board and set the process in motion to vote on at the summer BOD meeting.*
- *New committee members have been adding.*
- *Suggest replacing current co-chairs as both current chairs will rotate off of the committee. To be appointed by the President.*

Needs of our Agency members (Ad Hoc) – *Julie Kraft* (Joel Felix – board contact)

- *Did not get much feedback this year.*
- *Have been challenged with how to proceed with little feedback received.*
- *Will try another year to see if can formalize some ideas.*

Revisions to WSWS sections – *Andrew Kniss* (Sandra McDonald – board contact)

- *No report at this time.*
- *At end of summer BOD meeting, Board was going to read Andrew's input on rearranging.*
- *Some provided email comments.*
- *Sandra to follow-up with Andrew.*

New Business:

Motion to Adjourn at 4:52 PM

Motion: Alan Helm
Second: Phil Banks
Vote: Unanimously approved.

APPENDIX A

OFFICIAL WSWS VIDEO CONTEST RULES

1) ENTRY GUIDELINES

1. General
   - Contest is held annually.
   - Participation is open only to current WSWS members
   - Only one video is permissible per student/team.
   - Participants may enter as a team/individual.
   - Prize money will be awarded only to the person(s) named in the "Video Contest Submission Form"
   - Submit the "Video Contest Submission Form" and your completed video to <Contact Person> by 5 p.m. on MM/DD/YYYY.
2. Video Production
   - Videos must be at least 1 minute in length and may not exceed 3 minutes in length.
   - Videos must be in a format acceptable for YouTube/Twitter/Facebook, etc.
   - The video must be appropriate for all ages.
   - Participants must provide credits at the end of the video to acknowledge the sources of any images or music used.
   - Videos must be developed by students/teams for a broad audience. No professional (paid) assistance may be used in the production of the video. Any entry doing so may be disqualified.
3. Content
   - Must address the current Annual Meeting and/or Symposium themes
   - Must include names of all participants.
   - Must be in good taste and appropriate for all audiences.
   - Must be original content authored, composed, and performed by student/team identified in the entry form as participants, except for third party content for which the rightful owner has granted permission, in writing, (a) to incorporate the third-party content (including, for example, background music and artwork) into your video entry, (b) to reproduce and distribute such incorporated third party content through YouTube and other online media, (c) to grant to WSWS the license rights described in Section "Licenses, Waivers, and Releases", below.

2) JUDGING CRITERIA

1. Content
   - Did the video address the current theme?
   - Was the information clear and well expressed?
2. Creativity
   - Was there an unexpected or innovative use of video that enhanced the power of the video's message? (Creativity of execution)
   - Did the message provide a new perspective? (Creativity of idea)
   - Did the total video presentation display a combined innovative use of design, materials, and ideas? (Creativity of total product)
3. Overall effectiveness of delivery
   - Was there one key message that was clearly stated?
   - How engaging was the message?
   - Is the viewer compelled to keep watching?
4. Technical quality for videos
   - Lighting, Sound, Editing
     poor sound quality can adversely affect all other judging criteria
5. Time
   - Is the video 1 to 3 minutes in length? (All points or nothing)

3) SUBMITTING YOUR ENTRY

1. For your video entry to be considered in the Contest, you must submit the "Video Contest Submission Form" and your video to <Contact Person> by 11:59 pm MDT on the due date (MM/DD/YYYY).
2. Your video entry must contain "WSWS Video Contest" in the title of the video. The format for the title should be: "WSWS Video Contest" | *Your Unique Video Title*".

3. Your video might be uploaded to WSWS YouTube and social media pages and made accessible to the public. Please ensure that your video does not violate Google Terms of Service, Google Privacy Policy, YouTube Terms, Twitter, Facebook, Instagram policies
4. Further information concerning participants could be requested.

4) REPRESENTATIONS AND WARRANTIES

By entering the Contest, you represent and warrant that the video entry complies with the Contest Rules and Entry Guidelines, and that:

1. You own or have the necessary licenses, rights, consents, and permissions to reproduce, distribute and publicly perform works of authorship or other content, including music, and images or likeness of any person, contained in your video entry, and you have the right under all patent, trademark, trade secret, copyright or other proprietary rights to grant to WSWS the licenses described in Section 6, below.
2. Your video entry complies with the Google, YouTube; Twitter, Instagram terms of service.
3. At the time of entry or any time thereafter, your video entry does not contravene any contractual, legal or other obligation.
4. At the time of entry or any time thereafter, your video entry does not infringe the intellectual property rights of any third party.
5. Your video entry does not contain any profane, pornographic, obscene, or defamatory materials.
6. Use of the video by WSWS, as contemplated by the Contest Rules, will not infringe any copyrights, rights of publicity, or any other rights of any person, living or dead. The video and materials used are not subject to any prior agreements that would limit the scope of the permission granted to WSWS under the Rules; and
7. You have complied with all relevant laws, rules, and regulations in the production of your video entry.

5) PRIZES*

At WSWS annual meeting the winners will be announced during the ceremony and awarded the following prizes:

- First Place Prize of $500.00
- Second Place Prize of $250.00
- Third Place Prize of $100.00

*The total sum of each prize will be awarded to the entire team, not each member of the team.

6) LICENSES, WAIVERS, AND RELEASES

1. In consideration for your participation in the Contest, you, on behalf of yourself and the participants listed in the entry form, hereby grant WSWS a worldwide, non-exclusive, royalty-free, perpetual, sub-licensable, and transferable license to exercise the rights in your video entry as stated below:
    - to reproduce the video.
    - to create and reproduce derivative works of the video.
    - to distribute copies of, display publicly, and perform publicly by means of a digital audio and video transmission of the video and any derivative works of the video.
2. For the avoidance of doubt, where the video entry incorporates a musical composition, you and each participant named in your entry form waive any exclusive right to collect royalties for the public performance or public digital performance (e.g., webcast) of the video or any

derivative works of the video.

3. For the avoidance of doubt, where the video entry is deemed a sound recording, you and the participants named in your entry form waive any exclusive right to collect, whether individually or via a performance rights society, royalties for the public digital performance (e.g., webcast) of the video.
4. The above rights may be exercised in all media and formats whether now known or hereafter devised. The above rights include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. All rights not expressly granted by you are hereby reserved.
5. You understand that use of the video by WSWS may include, but will not be limited to, the following:
    - Initially, the video will be posted on YouTube, Twitter, and other social media pages, which is made publicly available and subject to the applicable rules and licenses; and
    - The video entry may be displayed, reproduced, distributed, and modified for use by WSWS in academic settings and higher education institutions.
6. If the video entry is selected by WSWS as a contest winner, you understand that the prize will be made payable only to the person or persons submitting the video entry form.
7. WSWS reserves the right to request that the video entry be removed from a platform.

WESTERN SOCIETY OF WEED SCIENCE NET WORTH REPORT

April 1, 2022 through March 31, 2023

ASSETS	
Cash and Bank Accounts	
American Heritage Checking	$67,440.68
American Heritage Money Market	$50,439.22
CD#4	$26,398.41
CD#5	$25,408.78
CD#6	$26,518.09
CD#7	$27,135.56
TOTAL Cash and Bank Accounts	$223,340.74
Investments	
RBC Dain Rauscher Account	$203,683.52
TOTAL Investments	$203,683.52
TOTAL ASSETS	$427,024.26

WESTERN SOCIETY OF WEED SCIENCE CASH FLOW REPORT

April 1, 2022 through March 31, 2023

INFLOWS ($)	
Annual Meeting Income	157,762.28
California Weeds Book	130.00
Interest Income	1,208.42
Dividend Income	10,118.72
Membership Dues	900.00
Rita Beard Endowment	50.00
Royalty for Proceedings - RPR	692.66
Security Value Change	-24,841.47
Student Travel Account	1380.00
Sustaining Member Dues	12,500.00
TOTAL INFLOWS	**159,960.61**
OUTFLOWS ($)	
Annual Filing Fee	385.00
Annual Meeting Expense	77,540.12
Mobile Meeting App	2,217.85
Total Annual Meeting Expense	**79,757.97**
Bank Charge	3,337.92
CAST Annual Dues	1,500.00
Copies	137.60
Director of Science Policy	9,558.78
Fee Charged	5,066.85
Insurance	500.00
Management Fees	23,368.80
Miscellaneous	162.79
Supplies	470.10
Proceedings/Publications	750.00
Postage	35.19
Summer Meeting	2,568.28
Student Awards	4,812.16
Taxes	10.00
Travel to Summer Meeting	932.66
Travel to WSWS Meeting	665.08
Website Design	1,875.00
Social Media	3200.00
Web Site Hosting	4,000.00
TOTAL OUTFLOWS	143,094.18
OVERALL TOTAL	$16,866.43

WSWS 2023 FELLOW AWARDS

Fellows of the Society are members who have given meritorious service in weed science, and who are elected by two-thirds majority of the Board of Directors.

Brad Hanson, University of California - Davis

Dr. Brad Hanson is a Professor of Cooperative Extension at the University of California-Davis. In 2016, he was recognized as the Outstanding New Academic by the University of California Division of Agriculture and Natural Resources, and in 2020 he was recognized with the Graduate Advising and Mentoring Award by UC Davis Graduate Studies. Brad has an active research program that supports his Extension activities. He has garnered more than $1 million in gift funding and more than $3 million in grant funding as PI or co-PI. Brad has published 92 peer-reviewed publications across a wide range of scientific journals. He has delivered more than 500 Extension presentations, published 11 Extension publications, and 5 book chapters. Brad has been active in the WSWS since 1997. He has coauthored 59 papers presented at the WSWS annual meetings. Brad has served on the WSWS Board twice as the Research Section Chair and once as the Education and Regulatory Section Chair. He has served on the necrology committee and the public relations committee, and he has co-chaired the Basic Biology and Ecology Discussion Section and the Weeds of Horticultural Crops Discussion Section. Brad has also been very active in the WSSA and the California Society of Weed Science. He served as an Associate Editor for Weed Technology from 2013-2020. In his letter of support, Dr. Andrew Kniss stated “Dr. Hanson is human, and so, presumably, he has faults. But I’m currently unaware of any. I promise this committee that I will keep searching and let you know if I find any.”

Brad Hanson (left) receives the WSWS Fellowship Award from President Joel Felix (right).

Corey Ransom, Utah State University

Dr. Corey Ransom is an Associate Professor and Extension Weed Scientist at Utah State University. In 2011, he was recognized as the Graduate Research Mentor of the Year by the College of Agriculture, and in 2013 he was recognized by the Department of Plants, Soils, and Climate as the Teacher of the Year. Corey has an active research and Extension program that has brought in more $5 million in grant funding. He has published 45 journal articles, 31 WSWS Progress reports, 125 Special Reports, 138 professional society abstracts, including 84 WSWS abstracts, 16 Extension publications, 5 popular press articles, and 130 extension presentations. Corey has been an active WSWS member since 1991. In addition to serving as WSWS President in 2020-2021 – a particularly challenging time as the result of the COVID-19 pandemic – Corey has chaired the site selection committee, served as a student paper judge three times, was Research Section Chair, chair of the necrology committee, and served as the board as the Constitution and Operating Procedures representative for five years. Additionally, Corey has been an active member of the WSSA and local weed science organizations in Utah and Oregon. Dr. Ralph Whitesides, in his support letter, stated that "If I was going to select someone to represent the Western Society of Weed Science to the world, it would be Corey Ransom. He is the kind of individual we would like our society to showcase as a really nice person with a passion for weeds."

Corey Ransom (left) receives the WSWS Fellowship Award from President Joel Felix (right).

WSWS 2023 HONORARY MEMBER

Daniel Kunkel, AMVAC Chemical Corporation

Dr. Daniel Kunkel is the Northeast Field Product Development Director for AMVAC Chemical Corporation. Prior to joining AMVAC in 2020, Dan spent nearly 30 years at Rutgers University serving in several different roles within the IR-4 Project, including Associate Director, Food and International Programs, Senior Associate Director, and Acting National Director. Throughout his career with the IR-4 Project, Dr. Kunkel's expertise as a weed scientist was beneficial to specialty crop production in the US. Dan was also a US delegate on several international committees and working groups related to pesticide tolerance standardization, which is of critical importance to the specialty crops that have large export markets. Much of what Dr. Kunkel and the broader IR-4 Project do is the "behind the scenes" work of funding and coordinating research to develop required datasets, shepherding pesticide petitions through the regulatory process, and coordinating the complexities of state, national, and international differences in pesticide residue rules. In his nomination letter, Dr. Brad Hansen stated "As a weed scientist who works in specialty crops and as the supervisor of one of the IR-4 Field Research sites in the western US, I know first-hand how important the work of the IR-4 Project is to registering herbicides, other conventional pesticides, and biopesticides in this diverse crop sector in the WSWS states. I respect and admire the significant contributions that Dr. Daniel Kunkel has made to weed control in the western US and I appreciate that he does it with humility, good humor, and wonderful collegiality."

Dan Kunkel (left) receives the WSWS Honorary Member Award from President Joel Felix (right).

WSWS 2023 OUTSTANDING WEED SCIENTIST AWARDS

Outstanding Weed Scientist, Early Career, Public Sector: Breanne Tidemann

Dr. Breanne Tidemann is a research scientist with Agriculture and Agri-Food Canada in Lacombe. She completed all of her degrees at the University of Alberta, and holds a B.Sc in Biological Sciences, and an M.Sc. and a Ph.D. in Plant Sciences with projects focused on weed science and weed management. Breanne started with Agriculture and Agri-food Canada in 2016 as a Weed Scientist/ Field Agronomist. Her research program in Lacombe focuses on management of herbicide resistant weeds, integrated weed management strategies, weed biology, and alternative methods of weed control. She lives in Blackfalds, AB with her husband and their two sons.

The Outstanding Weed Scientist, Private Sector: Byron Sleugh

Byron Sleugh leads Corteva's Weed Management Biology and Field Sciences team which is comprised of Discovery Herbicide Biology, and Regional and Global Biology Leaders. This team is instrumental in the design, discovery, development, launch and technical support of all herbicides globally. Prior to joining Dow AgroSciences in 2006 as a Field Scientist in Pasture and Land Management, Byron was an Associate Professor at Western Kentucky University. Byron has held several roles over the years, including Field Scientist and Field Research Station Leader at the Western Research Center in Fresno, CA and served as Global Biology Leader for Pasture and Land Management. He has been actively involved in WSWS since 2006 and has collaborated with many WSWS members on projects related to noxious and invasive weeds management, restoration, weeds in trees and vine, and more.

The Outstanding Weed Scientist, Public Sector

The Outstanding Weed Scientist, Early Career, Private Sector

These awards were not conferred in 2023

WSWS 2023 PROFESSIONAL STAFF AWARD

The Outstanding Professional Staff: Beth Fowers

Dr. Beth Fowers serves as an Assistant Research Scientist at the University of Wyoming's Sheridan Research and Extension Center, where she contributes valuable support to multiple investigators and conducts independent research in weed science and rangeland restoration. Dr. Fowers earned her A.S. from the College of Southern Idaho, her B.S. and M.S. from Utah State University, and her Ph.D. from the University of Wyoming. Dr. Fowers has authored or co-authored 18 scientific meeting presentations, delivered dozens of invited extension presentations, co-authored 30+ extension publications, and has served leadership roles in the Wyoming Society for Range Management. In addition to her research outputs, Dr. Fowers provides valuable training to both graduate and undergraduate students, she shares her passion for weed science and agricultural research with young people, and manages the Sheridan Research and Extension Center research greenhouse facilities.

The Outstanding Weed Manager

This award was not conferred in 2023

WSWS 2023 PRESIDENTIAL AWARD OF MERIT

Charlie Hicks

Charlie Hicks, with Bayer CropScience in Fort Collins, Colorado received the 2022/2023 WSWS Presidential Award of Merit from Joel Felix for outstanding contribution to the society through organizing and executing the 'What's New in Industry' session at the WSWS annual meetings for many years.

Charlie Hicks (right) accepts the Presidential Award of Merit from the WSWS President Joel Felix (left).

WSWS 2023 ELENA SANCHEZ MEMORIAL STUDENT SCHOLARSHIP RECIPIENTS

Timothy Prater, Awards Committee Chair announced the recipients of the "WSWS Elena Sanchez Outstanding Student Scholarship Program" were:

Carlos Alberto Gonsiorkiewicz Rigon, 3rd year Ph.D. candidate, Colorado State University, Todd Gaines advisor

Georgia Harrison, 3rd year Ph.D. candidate, University of Idaho, Tim Prather and Eva Strand advisors

Zachariah Fighter, 2nd year M.S. candidate, Montana State University, Jane Mangold and Scott Powell advisors

A big thanks to their advisors for bringing along such great promising talent for the future of weed science.

Carlos Rigon

Georgia Harrison

Zachariah Fighter

WSWS 2023 RITA BEARD ENDOWMENT STUDENT SCHOLARSHIP

The Rita Beard Endowment Foundation Board of Trustees has selected three recipients of travel scholarships for 2023. They are Melissa Meyers, a M.S. student at New Mexico State University; Lilly Sencenbaugh, a Ph.D. student from Montana State University; and Valerie Repp, Coordinating Invasive Species Biology for Pheasants and Quail Forever. The Rita Beard Endowment Foundation is a 501 (c) (3) non-profit that was created from a generous donation by Rita Beard's family and friends. Funds are awarded to support educational opportunities of students and early career invasive species managers by providing registration and travel to professional meetings including Society for Range Management, Western Society of Weed Science, Western Aquatic Plant Management Society, and the North American Invasive Species Management Association. Melissa Meyers will be attending the Society for Range Management annual meeting in February, Lilly Sencenbaugh will be attending the Western Society of Weed Science/Western Aquatic Plant Management Society joint annual meeting in February-March, and Valerie Repp will be attending the North American Invasive Species Management Association annual conference in October.

Melissa Meyers

As an indigenous person coming from Taos Pueblo and the Navajo Nation, I was taught the traditional importance of farming and ranching. Growing up around a small family ranch in Taos Pueblo, NM, I was able to witness the hard work that goes into sustaining the land so that it can be utilized for many generations. Early on, I took interest in the plants and the environments they grew in which ultimately led me to pursue a bachelor's degree in environmental science with a minor in
range science. During my undergrad career, I obtained a pathways internship position with the Natural Resources Conservation Service where I was able to help identify resource concerns on various ranch operations in southern New Mexico. One resource concern that was common was non-native plants invading rangelands and decreasing their quality. Observing how common plant invasion is interested me because it is a concern that affects many operations and can have negative impacts on the livelihoods of producers when the quality of their land is decreasing. When the opportunity arose to study E. lehmanniana invasion, I was intrigued because it was an opportunity to learn more about the drivers of invasion which can be a steppingstone to learning how to implement management practices to prevent invasion and restore invaded areas. . . Ultimately this research will help elucidate E. lehmanniana interactions with native plants and provide information crucial for rangeland restoration in E. lehmanniana invaded areas. As I move into my career, hopefully with an agency such as the BLM or USFS, I want to facilitate effective management practices on rangelands to restore invaded sites.

Lilly Sencenbaugh

I became interested in invasive species management through the extended time I spent in the outdoors in Iowa tall-grass prairies. During my undergraduate studies I worked as a naturalist intern at Dorothy Pecaut Nature Center where I learned the importance of grassland ecosystems and how they are impacted by woody encroachment. I conducted undergraduate research. . . at the University of South Dakota in Spirit Mound Historic Prairie, where I mapped the locations of invasive species, especially invasive grasses, and wrote management plans. This work made me very passionate about the field of invasive species management, particularly in grassland and rangeland environments, and led to my graduate studies. My current research has extended my previous interests into traditional and novel management strategies to control invasive annual grasses in rangelands, and how native species respond to management. . . Within my research I work with extension agents, county weed agents, local landowners, and students. My goal is to provide useful management information for all my collaborators. I am excited to continue collaborating with landowners and provide them with practical solutions for their complex weed problems, while also monitoring native species for, hopefully, increases in density. I hope to continue studying invasive species over the course of my career and expand our knowledge on their impacts on rangelands.

Valerie Repp

Working in the Missouri Ozarks for the past four years, I have developed knowledge of the invasive species issues that threaten this beautiful region and a passionate commitment to protecting the unique and diverse ecosystem here. My current position with Quail Forever is unique; in this role, I serve as the coordinator for the Scenic Rivers Invasive Species Partnership (SRISP). This partnership is the first established CISMA in Missouri, making it a pioneering collaboration for the state. The CISMA has over twenty partners ranging from federal, state, and NGO agencies to private landowners. As coordinator, I facilitate partner communication, write and apply for grants, oversee all outreach and education, and work as a field technician to provide technical assistance and boots-on-the-ground work. . .I also provide outreach and education to Missouri citizens and technical assistance to private landowners. The SRISP covers nine counties in southern Missouri, comprising of cattle farms, natural areas, the Ozark National Scenic Riverways, and more populated areas such as Poplar Bluff and West Plains. These communities are diverse, meaning the outreach I provide must be tailored to many different audiences. . .I want to continue growing this very young CISMA and see it transform into an example framework for forming more partnerships within the state of Missouri.

WSWS 2023 STUDENT PAPER AND POSTER AWARDS

2023 Paper judging committee: Josh Adkins, Clint Beiermann, Alix Whitener, and Georgia Harrison

There was a total of 34 oral and poster entries made in the student contest. As always, WSWS students brought outstanding presentations and posters to this year's meeting. Oral presentation sections for weeds of horticultural crops and basic biology & ecology were combined due to a low number of entries.

A big thank you to all 36 members who volunteered to judge the student contest:

Mirella Ortiz	Tina Bond	Caleb Dalley
Dan Tekiela	Dennis Scott	Elizabeth Oys
Jodie Crose	Harlene Hatterman-Valenti	Alix Whitener
Lisa Rew	Rui Liu	Joe Yenish
Marty Schraer	Jake Courkamp	Garrison Gundy
Chloe Mattilio	Ben Westrich	Vicki Maloney
Gregory Endres	Clint Beiermann	Sonia Rios
Chris Mayo	Tyler Hicks	Eric Westra
Cody Creech	Pete Berry	Vicki Maloney
Josh Adkins	Ben Fischer	Quincy Law
David Belles	Rachel Seedorf	Breanne Tidemann
Jaycie Arndt	Clarke Alder	Sandra McDonald

Sections with 9+ entries were awarded first, second, and third place. Sections with 5-8 entries were awarded first and second. Sections with 1-4 entries were awarded first only. The winners of each section were announced at the business breakfast and presented with a check. Customized plaques will be mailed to the award winners at a later date. Contest winners are listed below for each section.

Posters:

Weeds of Range, Forestry, & Natural Areas

1st place: Weston Maughan, Utah State University
Testing barrier-created safe sites for revegetation purposes in indaziflam-treated areas

Weeds of Agronomic Crops

1st place: McKenzie Barth, University of Wyoming
Late-Season Weed Control in Dry Bean With Split Application of Residual Herbicides

2nd place: Chandra Montgomery, University of Idaho
Weed Seedbank Control in Rotational Crops for Proactive Herbicide Resistance Management

Weeds of Horticultural Crops

1st place: Joshua Miranda, Oregon State University
Indaziflam Resistance in Annual Bluegrass (Poa annua L.) from Hazelnut Orchards

Basic Biology & Ecology

1st place: Andre Lucas Simoes Araujo, Colorado State University
Weed survey in Colorado sugar beet farms reveals resistance to Dicamba and Glyphosate

Oral presentations:

Weeds of Range, Forestry, & Natural Areas

1st place: Erin Hettinger, Utah State University
Community Repsonse to Dyer's Woad Control Efforts

2nd place: Erin Teichroew, Montana State University
Impact of native vegetation on cheatgrass fitness: A neighborhood study

3rd place: Walker Billings, University of Wyoming
Effects of Grazing Deferment Following Invasive Annual Grass Control with Indaziflam in Northeast Wyoming

Weeds of Agronomic Crops

1st place: Marija Savic, Washington State University
Smooth Scouringrush Control with Glyphosate is Affected by Surfactant Choice and Application Time

2nd place: Victor Ribeiro, Oregon State University
Herbicide Resistance in Downy Brome from Winter Wheat Fields in Eastern Oregon

Weeds of Horticultural Crops + Basic Biology & Ecology

1st place: Joshua Miranda, Oregon State University
European Hazelnut (Corylus avellana L.) and Canada thistle (Cirsium arvense L.) Response to Florpyrauxifen-benzyl

WSWS 2023 ANNUAL MEETING NECROLOGY REPORT

At the Thursday business meeting, the WSWS members who passed away this year were honored with a moment of silence. Those members were:

Scott K. Parrish

Scott passed away on June 29, 2022, at his home in Logan, Utah near his children and grandchildren. Scott was born in Logan, Utah to Wallace and Treva (Killian) Parrish. He grew up in Logan spending his summers swinging on a rope swing with his childhood friends and fishing with his dad. At an early age Scott took to sports and as a natural athlete excelled at basketball and football. That passion took him to Utah State on scholarship for basketball, eventually transitioning to football and becoming an all American on the Utah State football team. After college he was drafted by the New Orleans Saints, later finishing his football career as a Denver Bronco.

After receiving his bachelor's in agriculture from Utah State in 1976, Scott completed his graduate degree at Washington State University where he earned his master's in crop physiology and doctorate degree in Agronomy with minors in plant breeding and soil sciences. In September of 1977, Scott married his beautiful high school sweetheart Lynn Margaret Broadbent who he met while attending Logan High. Later their marriage was solemnized in the Logan Temple sealing them to their six children.

Following his desire to feed the world, Scott pursued a career in agricultural research where he had numerous professional achievements which include the discovery and development of multiple herbicides and other agricultural inputs which greatly shaped modern agriculture. Scott considered himself a "professional Killer" (of weeds).

After graduating from Washington State, Scott accepted a research and development position with Monsanto in St. Louis, Missouri. While there, his ability to create products to assist in controlling weed growth was met with great success, sending him throughout the world. He cherished his opportunities as he witnessed the effectiveness of the products he had created to improve farming and food production in many underdeveloped countries. After his time at Monsanto, Scott continued his desire to help feed the world by creating his own agricultural research and development company, Agrasyst, Inc.

At a young age, Scott caught wanderlust. It all started in Logan Canyon and moved to Star Valley, WY. He went on to river rafting as a guide in southern Utah among other places. His love for nature and plants started while fishing with his dad at his favorite place, Greys River, WY. He became an avid fisherman, catching trout fever and out fishing his brother, Alan. His professional life allowed him to travel around the world where he could, in his own words, "drag Lynn around with him" on their many adventures. She certainly loved it.

Aside from his professional and adventurous life, Scott was deeply spiritual and was a devoted lifelong member of the Church of Jesus Christ of Latter-day Saints. His strong and abiding testimony of his Savior Jesus Christ influenced his daily life.

Although a very accomplished scientist and athlete, Scott considered his greatest accomplishment to be the creation of his family. As a father of six, his greatest joy was watching his children grow and sharing in their accomplishments.

Scott is survived by his loving children, Alexandria Lynn Parrish, McCall Parrish Florez, Maddison Parrish, Chance Parrish, and Cade Parrish. Grandchildren Ryland and Adelynn Florez. Siblings Jan Parrish Campbell (Ted), Alan K. Parrish (Marcia), Jean Parrish Longhurst (Reed), and Joan Parrish Boman (Tel). Scott is proceeded in death by his beloved wife, Lynn Broadbent Parrish, son Dalton Scott Broadbent Parrish, and brother Steven Wallace Parrish. Parents Wallace Alonso Parrish and Treva Killian Parrish.

Scott's huge character and big heart leaves a massive void in our lives and he will be greatly missed by all that knew him.

Albert Fischer

Provided by Trina Kleist, UC Davis Department of Plant Sciences

Albert Fischer passed away on November 22, 2022, in Davis, California at the age of 72, shortly after being awarded the Outstanding International Achievement Award by the International Weed Science Society (IWSS).

Albert was born in Montevideo, Uruguay. He earned his bachelor's degree in crop science and animal husbandry from the University of the Republic of Uruguay and his Master of Science and Ph.D. from Oregon State University in crop science.

He started his career in weed research and extension at the Plant Protection Center, Uruguay, in 1975. He was a professor at the Autonomous University of Chapingo, Mexico, from 1979 to 1981. He was a rice and weed physiologist at the International Center for Tropical Agriculture (CIAT) in Cali, Colombia, from 1989 to 1996. During that time, he was also a visiting weed biologist at North Dakota State University, Fargo.

Fischer joined the faculty at UC Davis in 1997 and spent his time there specializing in weed ecology, competition of weeds in rice and integrated weed management until his retirement in 2016. During that period, he mentored more than 15 graduate students and six postdoctoral researchers, and he hosted short and long-term visiting scholars from many countries. Fischer and his colleagues published more than 80 papers in peer-reviewed journals and more than 300 non-refereed scientific documents, reports, and presentations at scientific meetings. His writings were mostly in the areas of weed physiology and management.

He had a lifelong passion for ending hunger in developing countries and collaborated extensively with colleagues around the world. His research and scientific service were highly regarded, both in California and internationally. He held the Melvin D. Androus Professorship for weed research

in rice for most of his career. In 2017, the Cooperative Rice Research Foundation awarded him the Marlin Brandon California Rice Industry Award for his impact on weed management. His peers elected him vice-president of the IWSS, which he served as president in 2014. His students and colleagues remember him as a good scientist and collaborator, an outstanding mentor, and a man of sharp wit and humor.

Fischer spoke English, Spanish, German, French, Portuguese and Italian. He was known for his love of sailing, reading, music and other hobbies. More recently, he enjoyed editing and sharing his lifetime of photography from numerous trips to Africa, Central and South America, Europe, and Asia.

Albert is survived by his wife, Madeleine, and sons Patrick and Eric. A celebration of life was held on Saturday, February 11, 2023, at the Walter A. Buehler Alumni Center on the UC Davis campus.

Bobby J. Goeman

Bobby Joe Goeman was born on December 18, 1957 in Bridgeport, NE to Donald and Jean Goeman. He attended school and graduated from Bridgeport High School in 1976. He met his wife, Tracy, in Fort Collins, CO and were married in 1980.

Bobby worked at the Larimer County Weed District from 2001-2015 as a Weed Specialist. He was a loyal participant in the WSWS annual meetings, giving posters or helping out whenever he was asked. His passion for land management was evident in the way he was always willing to help anyone who wanted to do research in the Larimer County area. He worked closely with folks at the university and industry level, not only to secure research sites, but help with all aspects of the research. He was always enthusiastic about establishing, spraying, and evaluating plots, as well as always working toward new solutions based on research. He volunteered for the Western Invasive Weed Short Course for a few years helping when he was asked and doing calibration demonstrations. As a selfless servant helping everyone improve their herbicide expertise, Bobby was there to lend a hand, offer a tank mix suggestion, or simply listen and learn from those around him. His ability to strike up a conversation with anyone will be missed.

Bobby enjoyed hunting and fishing, playing pool and hunting for arrowheads. He was especially fond of spending time on the family ranch in Wyoming and recently created a beautiful pond named Chelsi's Pond, stocked with fish for his grandchildren to enjoy. Along with traveling and planning his next adventure, Bobby's life was his wonderful family, spending time with his beloved grandsons.

Bobby is survived by his father, Don Goeman, mother Jean McKnight, former wife Tracy Mill, daughter and son-in-law Chelsi and Isaiah Childers and grandsons Chase and Carter.

Mike Newton

Mike Newton, known worldwide as a legend in Forestry, one of the oldest and most beloved teachers at Oregon State University and loved community member has gone to be with his

Heavenly Father and wife, Jane on August 30th, 2022, surrounded by family after a prolonged battle with Alzheimer's Disease. He never lost his sweetness.
Mike was born October 24th, 1932 in Hartford, Connecticut to Margaret Young Newton and David Newton. Margaret was a Vassar graduate and David a graduate of Princeton. Mike was the youngest of four siblings. The family purchased a 200-year-old farm in West Townsend, VT, where they proceeded to create a "Working Boys Prep School". Mike grew up on the farm, speaking French and Latin, milking cows and logging with horses. They cut ice chunks from Burbee's Pond for their icehouse where they stored their food for the year. He learned to work hard caring for animals and studying to meet the high expectations of his rigorous parents.

The "boys" would cross country ski for miles to go to a square dance in the winter. When Mike was 14, he went to Loomis Chaffe Prep School for Boys. He then went to University of Vermont at age 16, where he majored in Dairy Science with a minor in Forestry and played on the UVM Football Team. He was "dirt poor," and did odd jobs including gun smithing to make ends meet for college. Mike's sister, Mary, had a roommate at nursing school named, Jane. A romance developed and they were soon married there on the farm. Mike was in ROTC, then joined the US Army, where he served at Fort Riley, Kansas, where his son Dan was born, then stationed in Germany on the Russian border. In the Army he was an explosive expert and also taught marksmanship on the range. He served two years, and then arrived in Corvallis in 1957 to begin his master's degree in Botany and Forest Ecology, graduating with a Ph.D. He worked two jobs to support his growing family, bought a house for $3500 and remodeled it while studying. His research was primarily in weed science and silviculture. Mike became a professor at OSU Dept. of Forestry where he taught and did research from 1959 until 1999 when he retired. He published over 400 papers on Forest Science, taught 67+ Graduate students from 11 countries and will be remembered for his unconventional teaching techniques. Mike was an active participant at WSWS presenting forestry research and he was also a Fellow of WSWS. He was known as a "dirt forester" who would spend more time in the field with hands on teaching, critical thinking and humor. He was known for his strength, a wonderful mentor, loved to dance, was hospitable, kind and a good father and husband. He loved working on his "stump ranch" in Eddyville rehabbing it into a beautiful forest. If you would listen… he would teach and make you think. Mike could fix anything with ingenuity. He will be greatly missed and remembered by all who knew him, with much love. Mike is preceded in death by his wife of 63 years, Jane Webster Newton, his parents, Margaret and David Newton, siblings, John Newton, Marg Mechanic and Mary Western, daughter, Melanie Newton and Grandson, Andy Pederson. He is survived by his Newton children, Dan and (Kathy), children and great grandchildren, Linda & (Mike), and children, Tom and (April) and children.

Charles Randall Hart

Dr. Charles Randall Hart lost his battle with Leukemia on Sunday, November 27, 2022, in Abilene, TX. Charles was born in Lubbock, TX on February 25, 1964 to Bill and Linda Hart. He married Melanie Rose on April 19, 1986, in Carlsbad, New Mexico, and they were blessed with 36 years of marriage together. Charles graduated from Baird, TX High School in 1982. He received his B.S. in Agriculture Business from Abilene Christian University (ACU) in 1987, also his master's in Wildlife Biology in 1989 from ACU and a Ph.D in Range Science from New Mexico State

University in 1992. Charles began his career as an extension agent at Colorado State University and he was a Range and Pasture Development Specialist with Corteva Agriscience. He spent 17 years of his career as an Extension Range Specialist with Texas AgriLife Extension in Fort Stockton and Stephenville, before taking his current role in the fall of 2012. With almost 30 years' experience in the field, Dr. Hart worked with Corteva Research and Development to evaluate experimental herbicides, launch new products, and develop uses for current products. His primary role supported this commercial business by assisting Sales Reps, distributor partners and applicators with technical support and training. His primary emphasis was in brush and weed control in the Southwestern US and worked globally for Corteva assisting with the Pasture and Land Management business in South Africa, China, Brazil, and Argentina. Charles received many awards including ACU Aggie of the Year 1998, Texas A&M Vice Chancellor's Award in Excellence 1999, Society for Range Management Texas Section President 2004, Society for Range Management International President 2020, and many more. Charles appeared on tv shows like Cattleman to Cattleman several times. He published many books and research articles. Charles had many hobbies that he enjoyed such as hunting, coin collecting, and he loved jeep crawling. His favorite place was on his family's ranch. Charles worked hard and sacrificed daily for his family that he loved dearly, and he loved and served God with all his heart.

Charles is proceeded in death by his father, Bill Hart. Charles is survived by his loving wife Melanie Rose Hart; daughters Morgan and husband Reed Parker, Lauren and husband Jace McLeroy with a grandson due in May; his mother Linda Hart; sister Cindy and husband Jerry Hickerson; sister Marilu and husband Bill Hall; brother Keith and wife Chris Hart; numerous nieces and nephews.

WSWS 2023 ANNUAL MEETING RETIREES REPORT

Since the last meeting, a total of seven members of the society were brought forward as new or soon to be retired from the Western Society of Weed Science. The members were formally recognized at the Business Meeting. Their attendance, years of service, and professional leadership will be greatly missed.

Greg Dahl, Land O'Lakes/Winfield United

Stott Howard, Syngenta

Marie Jasieniuk, University of California - Davis

Paul O. Johnson, South Dakota State University

Kelly Luff, Bayer

Kai Umeda, University of Arizona

Harvey Yoshida, Corteva

Submitted by Sandra K. McDonald, Immediate Past President

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