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Gustavo Marcelo Sbatella  
1964 - 2017

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**OF**  
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**PREFACE**

The Proceedings contain the written abstracts of the papers and posters presented at the 2018 Western Society of Weed Science Annual Meeting plus summaries of the research discussion sections for each Project. The number located in parenthesis at the end of each abstract title corresponds to the paper/poster number in the WSWs Meeting Program. Authors and keywords are indexed separately. Index entries are published as received from the authors with minor format editing.

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Proceedings Editor: Carl Libbey

<b>POSTER SESSION . . . . .</b>	<b>1</b>
<b>Undergraduate Posters . . . . .</b>	<b>1</b>
Confirmation of ALS-Inhibitor Resistance in Wild Buckwheat ( <i>Polygonum convolvulus</i> L. Polco) from Kansas. . . . .	1
Relative Competitive Abilities of Bulbous Bluegrass and Downy Brome with Perennial Grasses.. . . .	1
<b>Project 1. Weeds of Range, Forest, and Natural Areas . . . . .</b>	<b>2</b>
Modeling Waterhyacinth ( <i>Eichhornia crassipes</i> ) Drift and Dispersal in the San Joaquin Delta Using GPS Drogues.. . . .	2
The Return of the Monarch Butterfly; Protection and Restoration of Milkweed Habitat.. . . .	2
Large Scale Control of Invasive Weeds and Response of Native Species to Esplanade 200 SC Tank Mixes. . . . .	3
Integrating Herbicide or Mowing with Biological Control for Improved Tamarisk Control. . . . .	4
Treatment Life and Economic Comparisons of Brush Management Applications. . . . .	5
Reduced-Rate Chemicals Provide Improved Control of Waterhyacinth in the Sacramento-San Joaquin Delta. . . . .	6
Management of <i>Ventenata dubia</i> in the Pacific Northwest. . . . .	6
Control of Medusahead in the Intermountain Region of California.. . . .	7
Invasive Annual Grass Control and Perennial Grass Response with Residual Herbicides in Utah. . . . .	8
Evaluating the Efficacy of Four Graminicides on <i>Bromus tectorum</i> and <i>Bromus japonicus</i> .. . . .	9
<b>Project 2. Weeds of Horticultural Crops . . . . .</b>	<b>10</b>
Current Weed Management Practices and Future Weed Control Needs: A Survey of Washington Wine Grape Growers.. . . .	10
Stale Seedbeds for Summer Annual Weeds in Chile Pepper. . . . .	11
Organic Herbicide Efficacy in Apples.. . . .	12
Comparison of Solarization and Biosolarization for Weed Control in a Tree Seedling Nursery in Western Oregon. . . . .	12
Field Bindweed Response to Preemergence Herbicides in Highbush Blueberries. . . . .	13
Control of Green Suckers with Herbicides in Hazelnut. . . . .	13
Effects of Saline Water on Saflufenacil and Rimsulfuron Partitioning in California Orchard Soils. . . . .	14
Strawponic for <i>Phelipanche aegyptiaca</i> Management in No-Till Potato. . . . .	14
Sharppoint Fluvellin Management in Horticulture Perennial Crops of Western Oregon. . . . .	15
Injury Symptoms and Detection of Bispyribac-sodium in Walnut Leaves Following Simulated Drift. . . . .	15
Cover Crop Tolerance to Herbicides: Implication for Interseeding.. . . .	16

<b>Project 3. Weeds of Agronomic Crops . . . . .</b>	<b>16</b>
Effect of Intensified Wheat-Based Cropping Systems on Weed Infestation. . . . .	16
Rattail Fescue and Downy Brome Control in Winter Wheat with Mesosulfuron/Thiencarbazon. . . . .	17
Cross Resistance Patterns in Multiple ALS-Resistant Downy Brome ( <i>Bromus tectorum</i> L.) Accessions from Washington. . . . .	17
Herbicide Systems with Pyroxasulfone for Management of Downy Brome in Winter Wheat.	18
Fall and Spring Timings for Preseed Applications of Halauxifen Plus Florasulam for Spring Cereals. . . . .	18
Winter Wheat and Palmer Amaranth Competition: Seed Germination in Response to Competitor and Light. . . . .	19
Broad-Spectrum Postemergence Weed Control with Pyroxulam in California Cereals. .	20
Barley Tolerance to Soil-Applied Herbicides. . . . .	20
New Flucarbazone Formulation Evaluation in Spring Wheat. . . . .	21
Bicyclopyrone Plus Bromoxynil Controls Mayweed Chamomile in Wheat. . . . .	21
Rescuegrass Management in Oklahoma Winter Wheat. . . . .	22
Harvest Weed Seed Control and Herbicide Resistance Survey of Winter Annual Grasses in Colorado. . . . .	22
Horseweed Management in Oklahoma Winter Wheat. . . . .	23
The Development and Management of ACCase Resistant Italian Ryegrass in Oklahoma. .	23
Effects of Synthetic Auxin Herbicides on Seed Production and Seed Viability of Herbicide Resistant Populations of Italian Ryegrass ( <i>Lolium perenne</i> ssp. <i>multiflorum</i> ) in Western Oregon. . . . .	24
Grass Weed Control in Kentucky Bluegrass and Perennial Ryegrass. . . . .	24
Using a Leaf Tissue Test for Glyphosate and Dicamba Drift Injury to Field Peas and Dry Beans.	25
Rescue Treatment Options for Glyphosate-Resistant Palmer Amaranth in Sugarbeet. . .	25
Variable Tolerance of Common Lambsquarters to Glyphosate in Corn-Sugarbeet Fields. .	26
Herbicide Options for Weed Management in Dormant-Seeded Safflower. . . . .	26
Evaluation of Herbicide Options for Kochia Control in Western North Dakota. . . . .	27
Variable Response of Kochia Populations to Dicamba and Fluroxypyr. . . . .	27
Management of Glyphosate- and Dicamba-Resistant Kochia ( <i>Kochia scoparia</i> ) in Roundup Ready® Xtend Soybean. . . . .	28
Desert Cotton Sensitivity to 2,4-D and Dicamba. . . . .	29
Effect of Crop Rotation, Tillage and Herbicide Diversity on R:S Ratio of Kochia Seed Bank Over Four Years. . . . .	29

Effects of Selected Adjuvants on Weed Control with Glufosinate-ammonium in Colorado and South Dakota. . . . .	30
Influence of Shade and Drought on the Control of Junglerice ( <i>Echinochloa colona</i> ) with Postemergence Herbicides.. . . .	30
<b>Project 4. Teaching and Technology Transfer . . . . .</b>	<b>30</b>
Kansas Mesonet Real-Time Temperature Inversion Decision Tool. . . . .	30
2017 EPA Tour of Western Kansas. . . . .	31
Initiation of the North American Kochia Working Group. . . . .	32
Using a Structured Decision Making Tool to Update the Utah Noxious Weed List and Guide. . . . .	32
<b>Project 5. Basic Biology and Ecology . . . . .</b>	<b>33</b>
Bindweed Root and Shoot Development and the Potential to Disrupt Dormancy and Improve Control. . . . .	33
Winter Wheat: Kin Recognition Under Controlled Conditions. . . . .	33
Performance of New High Loaded 2,4-D and Dicamba Acid Herbicide Formulations with Built-In Drift Reduction Technology. . . . .	34
Herbicide Resistance in Spring Wheat. . . . .	34
Ecological Management of Kochia in Irrigated Western Cropping Systems: Approaches and Path Forward.. . . .	34
Effect of Integrated Kochia ( <i>Kochia scoparia</i> ) Management in a Four Year Rotation Study. . . . .	35
<b>GENERAL SESSION . . . . .</b>	<b>36</b>
Introduction – Meeting Announcements. . . . .	36
Presidential Address.. . . .	36
Washington Update. . . . .	36
Land Acknowledgement & Contemporary Indigenous Issues in Science. . . . .	40
Growing Disneyland.. . . .	40
<b>PROJECT 1: WEEDS OF RANGE, FOREST, AND NATURAL AREAS . . . . .</b>	<b>40</b>
The Science of Miconia Management in the East Maui Watershed: A Brief History and Bioeconomic Projection of the Future.. . . .	40
Water Temperature as an Environmental Driver of Waterhyacinth ( <i>Eichhornia crassipes</i> ) Growth.. . . .	41
Developing a Detection Method for New Invaders at the Landscape Scale. . . . .	41
Scotch Broom Germination and Growth Responses to Red and Far-Red Light: Implications to Logging Debris Effects After Forest Harvesting. . . . .	42
A Plant Pathologist Looks At Rangeland Ecology Pre and Post Wildfire. . . . .	43

Herbicide Application Using a Pulse Sprayer for Invasive Weed Control in Pasture and Rangeland. . . . .	43
Treatment Life of Mesquite Herbicides; Beyond Two Years After Application. . . . .	44
Herbicide Residues in Unexpected Places: Does Aminopyralid Leak from Treated Plants After Basal Bark Application? . . . . .	45
A Comprehensive Summary of Long-Term Invasive Winter Annual Grass Control with Esplanade 200 SC. . . . .	45
Does a Dry Herbicide Delivery System Provide Increased Downy Brome Control Beneath a Shrub Canopy? . . . . .	46
Use of the Bioherbicide D7 to Manage Cheatgrass Invasions. . . . .	47
Herbicide Susceptibility of Garden Loosestrife ( <i>Lysimachia vulgaris</i> ). . . . .	47
Indaziflam Effects on Seed Production and Viability for Various Rangeland Grasses. . . . .	48
Using a New Natural Areas Herbicide to Control Winter Annual Grasses and Establish Native Species. . . . .	48
Medusahead and Ventenata in the Northern Great Plains Ecoregion: Invasion History and Management Efforts. . . . .	49
Needles in a Haystack: Identifying Thresholds in Annual Grass-Dominated Rangelands. . . . .	49
Aminopyralid in Combination with Picloram and Fluroxypyr for Pricklypear Control in Texas. . . . .	50
Timing Aminopyralid Applications to Prevent Medusahead ( <i>Taeniatherum caput-medusae</i> (L.) Nevski) Seed Production Controls the Invader and Increases Forage Grasses. . . . .	50
<b>PROJECT 2: WEEDS OF HORTICULTURAL CROPS . . . . .</b>	<b>50</b>
Developing Pest Management Applications with Unmanned Aerial Systems. . . . .	51
Soil Solarization in Oregon: The Impact of Solarization Duration and Soil Moisture on Weed Control in a Tree Seedling Nursery. . . . .	51
Effect of Glyphosate and Dicamba Residues in Russet Burbank Seed. . . . .	51
Ethalfuralin Potato Tolerance: Processor and Specialty Varieties. . . . .	52
Weed Control in Pacific Northwest Potatoes. . . . .	52
Efficacy of Dormant Season PRE Herbicides for Spring/Summer Weed Control in Apples. . . . .	53
Weed Management in Western Pecans with Penoxsulam+Oxyfluorfen. . . . .	54
Evaluation of Preemergence and Postemergence Herbicides for the Control of Panic Liverseedgrass ( <i>Urochloa panicoides</i> ) in Desert Turf. . . . .	55
Effect of Herbicides on Newly Transplanted Red Raspberry Plugs. . . . .	55
Saflufenacil and Pyridate Efficacy and Tolerance in Western Mint Production. . . . .	56
Flumioxazin for Postemergence-Directed Applications in Chile Pepper. . . . .	56
<b>PROJECT 3: WEEDS OF AGRONOMIC CROPS. . . . .</b>	<b>57</b>



New Broad-Spectrum Pyroxsulam + Fluroxypyr Herbicide for Grass and Broadleaf Weed Control in Wheat. . . . .	57
Utility of Arylex™ Active Herbicides for Control of Emerging Weed Threats in Western Canadian Cereal Crops. . . . .	57
AccuDrop™ - A New Drift Control and Deposition Adjuvant. . . . .	58
HSMOC Adjuvants - Commercial Brands or Make Your Own? . . . . .	58
Use of Extender Adjuvants with Soil Applied Herbicides. . . . .	59
Prolonging the Activation Window for Preemergence Herbicides with an At-Cracking Treatment of Paraquat in Chickpeas.. . . .	59
Potential Fit for New Products for Broadleaf Weed Management in Grasses Grown for Seed. . . . .	60
Pre and Early Postemergent Control of Dock spp. with Flumetsulam and 2,4-DB in Clover spp. Grown for Seed.. . . .	61
Commercial Launch of the CoAXium Wheat Production System. . . . .	61
Application Methods to Improve Herbicide Spray Deposition in Wheat Residue. . . . .	62
Controlling Glyphosate Resistant Kochia in Wheat Stubble.. . . .	62
Are Auxinic Premixes That Include Fluroxypyr Safer to Wheat? . . . . .	63
Characterizing Putative Fluroxypyr Resistance in <i>Kochia Scoparia</i> . . . . .	64
Fluroxypyr Control of Kochia ( <i>Kochia Scoparia</i> ) in the North America Northern Plains From 1990 to 2014 - A Historical Perspective. . . . .	64
Crop Tolerance and Weed Control in Direct Seeded Onion with Bicyclopyrone.. . . .	64
Impact of Winter Rye Cover Crop on Weed Control and Pinto Bean Production. . . . .	65
Frequency and Distribution of Herbicide Resistant Biotypes of Italian Ryegrass ( <i>Lolium perenne</i> ssp. <i>multiflorum</i> ) in the Willamette Valley of Western Oregon. . . . .	65
The Effect of Climate Conditions on Weed Competition and Wheat Yields in the Northern Great Plains. . . . .	66
Using an Unmanned Aerial Vehicle to Detect Herbicide Damage with a Multispectral Camera.. . . .	67
Soybean Variety Sensitivity to Dicamba. . . . .	67
Effect of Seeding Rate and Herbicides on Weed Control of Dry Bean in Narrow Rows.. . . .	67
Characterization of Palmer amaranth Populations from Kansas with Resistance to Multiple Herbicides. . . . .	68
Integrating Crop Rotation and Herbicide Programs to Improve Control of Problematic Weed Species in Sugarbeet.. . . .	69
Seed Retention of Major Weed Species at Harvest in the PNW. . . . .	69
Brassicaceae Seed Persistence Under Different Tillage Regimes in The Willamette Valley.. . . .	70

<b>PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER . . . . .</b>	<b>70</b>
Effect of Fallow Management on Weed Infestation.. . . . .	70
Multi-Species Herbicide Efficacy Screens: A Tool for Teaching Herbicide Mode of Action Principles to Agronomists. . . . .	71
Wyoming Restoration Challenge: Winners, Losers, and Lessons Learned in Invasive Grass Restoration.. . . . .	71
Updates to the WSU Tree Fruit Weed Science Webpage - Weed Science Extension Outreach in the Columbia Basin.. . . . .	71
Turning a New Leaf: Engaging Industries in Policy Decision-Making for Prevention of Invasive Plant Introductions.. . . . .	72
<b>PROJECT 5: BASIC BIOLOGY AND ECOLOGY . . . . .</b>	<b>72</b>
Phylogenetic Analysis of Native and Invasive <i>Phragmites australis</i> Haplotypes in Colorado. . . . .	72
Shade Avoidance in Sugarbeet: Tragedy of the Commons?. . . . .	73
Effect of Water Potential on Germination of Kochia ( <i>Kochia scoparia</i> ) Accessions from the US Great Plains. . . . .	73
Effect of Crop Canopy and Herbicide Treatment on Kochia ( <i>Kochia scoparia</i> ) Density and Seed Production. . . . .	74
Why is Inhibition of Glutamine Synthetase Toxic to Plants? .....	74
Mechanism of Resistance to Glyphosate in Annual Bluegrass from California Perennial Crops. . . . .	75
First Case of Imazamox-Resistance Jointed Goatgrass ( <i>Aegilops cylindrical</i> Host.) in the Pacific Northwest. . . . .	75
Surfactant Effects on Absorption and Translocation of Metsulfuron in Smooth Scouringrush ( <i>Equisetum laevigatum</i> ). . . . .	76
Herbicide Resistant Weed Research Portfolio at Colorado State University. . . . .	76
<b>DISCUSSION SESSIONS. . . . .</b>	<b>77</b>
<b>Project 1 Discussion Session: Weeds of Range, Forest, and Natural Areas . . . . .</b>	<b>77</b>
<b>Project 2 Discussion Section: Weeds of Horticultural Crops . . . . .</b>	<b>80</b>
<b>Project 3 Discussion Section: Weeds of Agronomic Crops . . . . .</b>	<b>82</b>
<b>Project 4 Discussion Section: Teaching and Technology Transfer. . . . .</b>	<b>83</b>
<b>Project 5 Discussion Session: Basic Biology and Ecology. . . . .</b>	<b>86</b>
<b>WESTERN SOCIETY OF WEED SCIENCE NET WORTH REPORT . . . . .</b>	<b>88</b>
<b>WSWS CASH FLOW REPORT . . . . .</b>	<b>89</b>
<b>WSWS 2018 FELLOW AWARDS . . . . .</b>	<b>90</b>
<b>Phillip Munger. . . . .</b>	<b>90</b>
<b>Kai Umeda . . . . .</b>	<b>91</b>

<b>WSWS 2018 HONORARY MEMBER. . . . .</b>	<b>92</b>
<b>WSWS 2018 OUTSTANDING WEED SCIENTIST AWARDS . . . . .</b>	<b>93</b>
<b>Brian Schutte . . . . .</b>	<b>93</b>
<b>Rick Boydston . . . . .</b>	<b>93</b>
<b>WSWS 2018 WEED MANAGER AWARD . . . . .</b>	<b>94</b>
<b>WSWS 2018 PROFESSIONAL STAFF AWARD. . . . .</b>	<b>95</b>
<b>WSWS 2018 PRESIDENTIAL AWARD OF MERIT . . . . .</b>	<b>96</b>
<b>Roger Gast . . . . .</b>	<b>96</b>
<b>WSWS 2018 ELENA SANCHEZ MEMORIAL STUDENT SCHOLARSHIP RECIPIENTS. .</b>	<b>97</b>
<b>WSWS 2018 RITA BEARD ENDOWMENT STUDENT SCHOLARSHIP RECIPIENTS .</b>	<b>98</b>
<b>Shannon Clark. . . . .</b>	<b>98</b>
<b>Clay Wood . . . . .</b>	<b>98</b>
<b>WSWS 2018 STUDENT PAPER AND POSTER AWARDS . . . . .</b>	<b>99</b>
<b>WSWS 2018 ANNUAL MEETING NECROLOGY REPORT. . . . .</b>	<b>101</b>
<b>WSWS 2018 ANNUAL MEETING RETIREES REPORT. . . . .</b>	<b>102</b>
<b>WSWS 2018 ANNUAL MEETING ATTENDEES – Garden Grove, California . . . .</b>	<b>103</b>
<b>WSWS 2018 ANNUAL MEETING – AUTHOR INDEX. . . . .</b>	<b>110</b>
<b>WSWS 2018 ANNUAL MEETING – KEYWORD INDEX . . . . .</b>	<b>119</b>
<b>WSWS 2018 ANNUAL MEETING – ABSTRACT NUMBER, PAGE NUMBER INDEX. .</b>	<b>127</b>
<b>2017-2018 WSWS STANDING AND AD HOC COMMITTEES . . . . .</b>	<b>129</b>

## POSTER SESSION

### Undergraduate Posters

**Confirmation of ALS-Inhibitor Resistance in Wild Buckwheat (*Polygonum convolvulus* L. Polco) from Kansas.** Abigail Friesen\*, Dallas Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (058)

Wild buckwheat (*Polygonum convolvulus* L. Polco) is a summer annual weed prevalent in cereal crops. Recently, a population of wild buckwheat survived ALS-inhibitor applications in a wheat field in KS. The objectives of this research were to determine a) if the wild buckwheat had developed resistance to an ALS-inhibitor, chlorsulfuron (Glean®), and b) the mechanism of resistance to chlorsulfuron. The suspected resistant (R1) and a known ALS-inhibitor susceptible (S1) population of wild buckwheat were grown in the greenhouse. S1 and R1 wild buckwheat plants were treated with a series of chlorsulfuron doses ranging from 0 to 16x (x=18 g ai/ha) when plants were in the 3 to 4 leaf stage. Visual injury and plant dry biomass were recorded at 3 weeks after treatment (WAT). R1 plants produced significantly higher biomass than S1 plants at all chlorsulfuron doses. A portion of the ALS gene was sequenced from both S1 and R1 wild buckwheat. The Trp<sub>574</sub>Leu substitution that conferred ALS-inhibitor resistance in a Canadian wild buckwheat population was not found in R1. Experiments are in progress to determine if any other mutations or non-target site mechanisms bestow resistance in the R1 wild buckwheat. This is the first case of resistance to any herbicide in wild buckwheat in the U.S. Growers need to be proactive and manage this population before it becomes a challenge in KS wheat fields.

**Relative Competitive Abilities of Bulbous Bluegrass and Downy Brome with Perennial Grasses.** Jordan L. Skovgard\*<sup>1</sup>, Beth Fowers<sup>2</sup>, Brian A. Mealor<sup>2</sup>; <sup>1</sup>University of Wyoming, Laramie, WY, <sup>2</sup>University of Wyoming, Sheridan, WY (059)

Invasive grasses negatively impact desirable vegetation. While the effects of some species have been extensively studied, relatively little is known about others. This research compares the relative competitive abilities of bulbous bluegrass, a largely unstudied invader, and downy brome - arguably one of the most impactful weeds in the western U.S. We compared the growth of these grasses in a greenhouse replacement series experiment replicated five times. We used a clay-loam field soil and did not limit light or water. Focal species (downy brome and bulbous bluegrass) were grown alone, with one another, and with five desirable perennial grass species at focal plant:competitor ratios of 8:0, 6:2, 4:4, 2:6 and 0:8. Twelve weeks after planting, we collected aboveground biomass, dried it at 60°C for 72 hours, and weighed it to the nearest mg. As a group, perennial grasses were suppressed more by downy brome than by bulbous bluegrass, but individual species performance varied. Idaho fescue growth was suppressed by both invasive grasses whereas western wheatgrass was suppressed by downy brome, but not by bulbous bluegrass. Alternatively, downy brome was smaller when grown with Idaho fescue than with western wheatgrass. Bottlebrush squirreltail's competitive response was superior to all other native grasses and was similar to the non-native crested wheatgrass. Downy brome suppressed

bulbous bluegrass in direct competition and appeared to be a stronger competitor overall in this study. More research is needed to understand the potential impacts of bulbous bluegrass in Wyoming's rangelands.

## **Project 1. Weeds of Range, Forest, and Natural Areas**

### **Modeling Waterhyacinth (*Eichhornia crassipes*) Drift and Dispersal in the San Joaquin Delta Using GPS Drogues.** John Miskella\*, John D. Madsen; USDA-ARS, Davis, CA (001)

Abstract not available

### **The Return of the Monarch Butterfly; Protection and Restoration of Milkweed Habitat.** Jim Sebastian\*<sup>1</sup>, Steve Sauer<sup>2</sup>, Derek J. Sebastian<sup>3</sup>, Jim Daniel<sup>4</sup>, Harold Quicke<sup>5</sup>; <sup>1</sup>Boulder County Open Space, Longmont, CO, <sup>2</sup>, Longmont, CO, <sup>3</sup>Bayer, Fort Collins, CO, <sup>4</sup>Daniel Ag Consulting, Keenesburg, CO, <sup>5</sup>Bayer, Windsor, CO (002)

Monarch butterflies (*Danaus plexippus*) are one of the most iconic butterflies found in the US. Certain populations of these butterflies will migrate thousands of miles to their overwintering grounds in California or Mexico. Milkweed habitat loss, which is the primary forage for monarch caterpillars, has resulted in significant population reductions. Milkweed is also habitat to honey bees, native bees, hummingbirds, and other butterflies. Butterflies including the monarch, are key pollinator species, provide natural pest control, are indicators of healthy environments and ecosystems, and have many intrinsic/aesthetic values. In 2014, US Fish and Wildlife Service was petitioned to protect the monarch butterfly under the Endangered Species Act.

We initially screened recommended herbicides labeled for use along creeks, ditches, marshes, and wetland areas at two locations for products that selectively controlled invasive weeds with the least injury to milkweed. Telar XP was the most selective herbicide option for milkweed. Telar XP treatments were applied on 64 acres on 12 Boulder County Open Space Properties in fall 2016 and spring 2017, in response to favorable initial trial results where milkweed densities dramatically increased.

The target rangeland weeds on these properties were perennial pepperweed (*Lepidium latifolium*), Canada thistle (*Cirsium arvense*), and common teasel (*Dipsacus fullonum*). Telar XP provided 97 to 100% control of these invasive weeds from visual evaluations averaged over the 12 different properties in June 2017. Perennial grass, rush, and sedge canopy cover increased 3x on Telar XP treated properties. The dramatic increase in these native species will help prevent the re-establishment of invasive weeds on these properties. Invasive biennial and perennial weeds were highly competitive with showy and marsh milkweed on these treated properties. Once weeds were controlled milkweed densities increased dramatically. There was approximately 30% milkweed canopy cover on Telar XP treated properties and only 2% milkweed canopy cover on adjacent non-treated areas on these same properties. Although actual pollinator species and numbers were not monitored; monarch butterfly, bees, and other

pollinators were observed on flowering milkweed plants on these properties in response to the increase in showy and marsh milkweed.

The increase in milkweed and pollinators where Telar XP was sprayed prompted BCOS to fund collaborative work with CSU in 2017 to monitor pollinator habit enhancement work on additional properties. The focus of this research is to monitor the release of native pollinator flowering plants with indaziflam (Esplanade 200 SC, Bayer CropScience). Invasive winter annual grasses are highly competitive exotics that displace native vegetation by depleting the limited soil moisture and nutrients. As these invasive grasses thrive, this leads to extensive loss in native plant diversity. Pollinators, specifically bees are facing severe challenges associated with habitat degradation and associated depletion of nutritive pollen and nectar. Colorado is home to over 900 native bee genera and these bees have a long-standing mutualism with the native flowering plants of the region. Controlling and eliminating invasive annual grasses such as downy brome (*Bromus tectorum* L.) can facilitate restoration and protection of native flora. In this study, we compare Indaziflam treated plots with non-treated controls with the objective to determine whether indaziflam can be used to control invasive winter annual grasses and reinstate diminishing floral resources and their bee and other pollinators. We documented flowering plant diversity and abundance, available floral resources in control and treated plots, and observed pollinator visitations on flowering plants along transects in the experimental plots. This research authenticates the efficacy of indaziflam in facilitating pollinator conservation through the re-establishment of flowering plants in the rangeland ecosystems of northern Colorado.

**Large Scale Control of Invasive Weeds and Response of Native Species to Esplanade 200 SC Tank Mixes.** Jim Sebastian\*<sup>1</sup>, Steve Sauer<sup>2</sup>, Derek J. Sebastian<sup>3</sup>, Shannon L. Clark<sup>4</sup>, Harold Quicke<sup>5</sup>; <sup>1</sup>Boulder County Open Space, Longmont, CO, <sup>2</sup>, Longmont, CO, <sup>3</sup>Bayer, Fort Collins, CO, <sup>4</sup>Colorado State University, Fort Collins, CO, <sup>5</sup>Bayer, Windsor, CO (003)

Invasive species management on non-crop and rangeland remains a constant challenge throughout many regions of the US. While there are over 300 rangeland weeds, downy brome (*Bromus tectorum* L.), Dalmatian toadflax (*Linaria dalmatica*), musk thistle (*Carduus nutans*), Scotch thistle (*Onopordum acanthium*), diffuse knapweed (*Centaurea diffusa*), and moth mullein (*Verbascum blattaria*) have emerged as the most invasive and problematic on Boulder County Open Space properties. Downy brome, infesting over 22 million hectares in the US, is a competitive winter annual grass that is considered one of the most problematic invasive species on western rangelands. Downy brome germinates in the fall and early spring, exploiting moisture and nutrients before native plant communities begin active growth in the spring. Downy brome seeds can remain viable for up to 5 years. While glyphosate, imazapic, and rimsulfuron are currently recommended for annual grass control, they provide inconsistent control or injury to desirable perennial species. In addition, Dalmatian toadflax, musk thistle, moth mullein, and diffuse knapweed infest over 2.8 million ha alone, and are all Colorado Noxious Weed List B species. The increasing spread of biennial species is a result of their adaptability, life cycle, and prolific seed production. Many commonly used herbicides lack residual seedling control resulting in rapid re-establishment. Indaziflam (Esplanade® 200 SC, Bayer CropScience) has been adopted by many land managers throughout Colorado with a new open space and natural areas label. Field studies at Colorado State University (CSU) demonstrated that indaziflam provides superior long-term downy brome control (3+ years) with no documented injury to native perennial species. Indaziflam is a root inhibiting herbicide. This

allows for increased safety on desirable perennial plants that have roots below the layer where the herbicide is active. Indaziflam has excellent preemergence activity on many grass and broadleaf weeds and has several attributes that make it an ideal candidate to control weeds that reproduce primarily by seed production, 1) long soil-residual activity and 2) no documented injury to established perennial grasses, forbs, and shrubs. Two large-scale experiments were initiated in the spring of 2016 in collaboration with CSU, to evaluate the efficacy of currently recommended herbicides alone and in combination with indaziflam for restoring open space properties infested with invasive annual grass and broadleaf weeds. Aminocyclopyrachlor and picloram were applied alone and in combination with indaziflam to determine if indaziflam tank-mixes extend the duration of annual, biennial, and perennial invasive weed control by eliminating re-establishment from the soil seed bank. All herbicide treatments were successful at controlling 90 to 99% of weeds. Straight indaziflam and all indaziflam tank mixes resulted in 100% downy brome control the first growing season after treatment. All tank-mix combinations with indaziflam provided an increase in weed control as compared to treatments without indaziflam. Straight indaziflam did not injure any native grasses or forbs, resulting in a significant increase in species richness compared to the non-treated control. Indaziflam tank mixes did not reduce species richness. All treatments significantly increased perennial grass biomass compared to the non-treated control.

In addition to the large-scale CSU research plots, an additional 318 acres were sprayed with indaziflam and 87 acres sprayed with indaziflam tank mixes (picloram or aminocyclopyrachlor) on 23 Boulder County Open Space Property locations between spring 2016 and spring 2017 that were monitored for canopy cover and weed control in June 2017. Winter annual weeds on these properties included downy brome, Japanese brome, yellow alyssum, redstem filaree, jointed goatgrass, and volunteer rye. Target species with indaziflam tank mixes included the addition of common mullein, moth mullein, diffuse knapweed, field bindweed, and Dalmatian toadflax. Visual evaluations of perennial native grass, forb, and shrub canopy cover and invasive weed control were averaged over the 23 different property locations in June 2017 and were compared to adjacent non-sprayed areas. Several of the sprayed properties had extremely diverse natives present and there was no decrease or injury of any of the perennial native grass, forb, or shrub species in indaziflam treated areas. There were dramatic increases in natives in response to the release of invasive weed competition. These large-scale application results mirror the large scale field plot studies that demonstrated that indaziflam provides superior long-term downy brome control (3+ years) with no documented injury to native perennial species. Visual control and cover estimates and biomass harvests will continue in 2018 and provide further evidence for the utility of indaziflam on Boulder County Open Space properties for reducing annual and biennial weed re-establishment occurring from seed. This research provides new long-term control options for controlling annual and biennial weeds on Boulder County properties and other counties throughout the western US.

**Integrating Herbicide or Mowing with Biological Control for Improved Tamarisk Control.**  
Erik A. Lehnhoff\*, Leeland Murray, Brian J. Schutte; New Mexico State University, Las Cruces, NM (004)

*Tamarix* spp., invasive riparian shrubs, are ecological and economic threats in the southwest as they displace native vegetation and necessitate costly management. *Tamarix* control typically consists of chemical and mechanical removal, but these methods can cause negative ecological

and economic impacts. Tamarisk beetles (*Diorhabda* spp.) released for biocontrol, are becoming increasingly established within Western river systems and are another form of control. While there is abundant research on each of these treatment methods, no research has been conducted on integrating these methods to improve management. Our question was, could *Diorhabda* herbivory be combined with mechanical and chemical treatment to achieve greater control with fewer non-target impacts. A field experiment was conducted to test the impacts of integrating beetle herbivory with mowing or the herbicide imazapyr at standard and low rates (2.78 lb ae ha<sup>-1</sup> and 0.93 lb ae ha<sup>-1</sup>, respectively). Treatments were replicated five times, at two field locations — a seasonally flooded and a dry site in southern New Mexico. Green foliage percent and gas exchange (via LI-COR 6400) were measured, and water use efficiency (WUE) was calculated to assess plant stress. Results showed herbicide treatments reduced transpiration rates and green foliage at both sites and were influenced by adults and larva beetle numbers. At the end of two growing seasons, control plots showed a high green foliage percent recovery, while mowing and herbicide treatments all displayed severely reduced percentages of green foliage. Data show combining conventional management methods with biocontrol could result in additional stress through a combination of reduced green foliage recovery and a continued reduction in aboveground biomass. Incorporating this new knowledge into land management objectives for *Tamarix* control can result in more effective overall management plans.

**Treatment Life and Economic Comparisons of Brush Management Applications.** Case R. Medlin\*<sup>1</sup>, Wayne Hanselka<sup>2</sup>, Allan McGinty<sup>3</sup>, Robert Lyons<sup>4</sup>, Megan Clayton<sup>5</sup>, William Thompson<sup>6</sup>; <sup>1</sup>Bayer, Paradise, TX, <sup>2</sup>Texas A&M AgriLife Extension (Emeritus), Corpus Christi, TX, <sup>3</sup>Texas A&M AgriLife Extension (Emeritus), San Angelo, TX, <sup>4</sup>Texas A&M AgriLife Extension, Uvalde, TX, <sup>5</sup>Texas A&M AgriLife Extension, Corpus Christi, TX, <sup>6</sup>Texas A&M AgriLife Extension, San Angelo, TX (005)

Chemical treatment methods have been a primary means of managing undesirable brush across southwestern United States' grazing lands for decades. Longevity of these herbicide treatments directly impacts the economic return of these grazing lands on which land managers continue to combat invasive brush. Treatment longevity (i.e. treatment life) is defined here as the time between treatment application and the point when brush canopy cover reaches a level that significantly limits desirable forage production for livestock. Ansley et al. (2004) determined the critical honey mesquite (*Prosopis glandulosa*) canopy cover that significantly impacts desirable forage production to be 25% or greater. Similarly, Scifres et al. (1982) indicated this inflection point with huisache (*Acacia smallii* a.k.a. *Acacia farnesiana* and *Vachellia farnesiana*) canopy cover to be near 30%. For these reasons treatment longevity here is defined as the time from application to when 25% mesquite canopy cover or 30% huisache canopy cover is reached. Longevity of current industry standard herbicides was compared to aminocyclopyrachlor plus triclopyr amine (ACP+T) from assessments collected in 2017 from ten broadcast honey mesquite and five broadcast huisache trials established from 2007 to 2013 across Texas. Industry standard huisache treatments consisted of aminopyralid plus clopyralid, picloram plus 2,4-D, or aminopyralid plus 2,4-D plus picloram. Industry standard honey mesquite treatments consisted of aminopyralid plus clopyralid, and clopyralid plus triclopyr ester. On average, the longevity of industry standard huisache treatments (i.e. the length of time to reach 30% huisache canopy cover) was 3.1 years. In comparison, huisache canopy cover was on average 2.5% in ACP+T treated plots at 3.1 years after treatment. The longevity of industry standard honey mesquite treatments (i.e. the length of time to reach 25% mesquite canopy cover) was 8.6 years which



corresponds to 2% mesquite canopy cover in ACP+T treated plots. To assess the impact of treatment life of these programs on the economic potential of the land, the net present value (discounted cash flow generated by additional grazing resulting from each brush management program) for ACP+T and the industry standard were calculated [up to 12 years after application for huisache and up to 24 years after treatment for honey mesquite (to simulate three treatment cycles for the industry standard program for each species)] from additional animal unit months generated by each brush management treatment, herbicide and application cost, and the estimated leasehold value of the animal unit month. The net present values for ACP+T and the industry standard treatment were very similar until the treatment life of the initial standard treatment application was reached. At that point net present values of the programs diverged. Diverging net present values of the ACP+T and industry standard treatment was largely a result of sequential herbicide treatment input costs for the industry standard treatments required to produce sufficient forage production to maintain the optimum stocking rate on the land, while the ACP+T treatments did not warrant a sequential application through 12 or 24 years at the huisache or honey mesquite locations, respectively. These results indicate ACP+T provides effective, long-term control of honey mesquite and huisache, two of the most problematic and wide-spread invasive brush species in Texas.

**Reduced-Rate Chemicals Provide Improved Control of Waterhyacinth in the Sacramento-San Joaquin Delta.** Guy B. Kyser\*<sup>1</sup>, John D. Madsen<sup>2</sup>, John Miskella<sup>2</sup>; <sup>1</sup>University of California, Davis, Davis, CA, <sup>2</sup>USDA-ARS, Davis, CA (006)

Waterhyacinth is a worldwide aquatic weed that has become a significant nuisance in the Sacramento/San Joaquin River Delta (hereafter the Delta). Glyphosate and 2,4-D have been the predominant herbicides used for management. While these chemicals have been effective for control, additional herbicides need to be evaluated to address concerns over herbicide resistance management, environmental restrictions, and reduction in total active ingredient applied. We performed three trials in floating quadrats in the Delta. Treatments were applied in four replications using a 3-nozzle boom, with a standard spray volume of 935 L ha<sup>-1</sup> and *Agridex* surfactant at 3.5 L ha<sup>-1</sup>. In the first (2016), we applied two rates each of 2,4-D (1065 and 2130 g ae ha<sup>-1</sup>), glyphosate (1681 and 3363 g ae ha<sup>-1</sup>), imazamox (560 and 1121 g ae ha<sup>-1</sup>), and penoxsulam (53 and 88 g ai ha<sup>-1</sup>). The highest rates of all four herbicides provided satisfactory control (2,4-D, 82%; glyphosate, 87%; imazamox, 93%; and penoxsulam, 94%). In the second trial (2016), we compared the lower rate of glyphosate (1681 g ae ha<sup>-1</sup>) to four rates each of imazamox (187 to 1494 g ae ha<sup>-1</sup>) and penoxsulam (12 to 98 g ai ha<sup>-1</sup>). The highest rates of imazamox and penoxsulam provided excellent control (96% and 95%, respectively). In the third trial (2017), we applied other low-rate chemicals, carfentrazone and flumioxazin, alone and in tank mixes with imazamox or glyphosate. We also applied glyphosate (1681 g ae ha<sup>-1</sup>) in three spray volumes (234 L ha<sup>-1</sup>, 468 L ha<sup>-1</sup>, and the standard volume of 935 L ha<sup>-1</sup>). The tank mix of flumioxazin + imazamox (316 + 280 g ai/ae ha<sup>-1</sup>) and the 468 L ha<sup>-1</sup> application of glyphosate each produced better than 95% control. Imazamox and penoxsulam appear to be effective alternatives to 2,4-D and glyphosate for controlling waterhyacinth with reduced rates of active ingredient. Their availability also will facilitate management for herbicide resistance.

**Management of *Ventenata dubia* in the Pacific Northwest.** Lindsay E. Koby\*<sup>1</sup>, Tim Prather<sup>2</sup>, Ian C. Burke<sup>1</sup>; <sup>1</sup>Washington State University, Pullman, WA, <sup>2</sup>University of Idaho, Moscow, ID (007)

*Ventenata dubia* (Leers) Coss, an invasive annual grass in Eastern Washington and Northern Idaho, is a direct threat to non-cropland of the Palouse. Two sites near Moscow, ID and Pullman, WA were selected to evaluate indaziflam as a potential method for management of ventenata. Treatments were applied prior to dormancy break of native grasses and consisted of increasing rates of indaziflam alone and in combination with rimsulfuron. Treatments were evaluated over time for level of ventenata control, re-establishment of weedy species, and impacts to desirable vegetation. Biomass samples were collected, to evaluate treatment longevity, plant recovery and interaction between weedy and desirable species present. Based on cover data, control of ventenata was >98% when indaziflam was applied at two rates (73 or 102 g ai ha<sup>-1</sup>) with glyphosate (474 g ai ha<sup>-1</sup>) and >99% when indaziflam was applied with rimsulfuron at 102 and 70 g ai ha<sup>-1</sup>, respectively. Total species richness declined with herbicide treatment, largely due to increased ventenata control. However, mean biomass of perennial bunchgrasses did not decline with treatments that effectively reduce the mean biomass of ventenata. Perennial bunchgrass thrives in the absence of ventenata, demonstrating recovery with the absence of competition. Within the nontreated check the greatest amount of ventenata biomass exists (5.0 g/m) and severely competes with perennial bunchgrasses (18.4 g/m). Indaziflam (102 g ai ha<sup>-1</sup>), when applied with glyphosate (474 g ai ha<sup>-1</sup>), had the least amount of ventenata biomass (0.7 g m), greatest amount of perennial bunchgrass biomass (27.1 g/m) and had a modest impact on species richness when compared to other treatments.

**Control of Medusahead in the Intermountain Region of California.** Tom Getts\*<sup>1</sup>, Harold Quicke<sup>2</sup>, Robert Wilson<sup>3</sup>; <sup>1</sup>University of California Cooperative Extension, Susanville, CA, <sup>2</sup>Bayer, Windsor, CO, <sup>3</sup>University of California, Tulelake, CA (008)

Medusahead (*Taeniatherum caput-medusae* L.) native to the Mediterranean region, is an invasive winter annual grass which has invaded many western states. It is listed as noxious in six states due to its ability to create monocultures, which displaces native/desirable vegetation and offers poor forage for livestock. Medusahead creates a thick litter layer relatively resistant to decay, which favors its growth and makes it notoriously hard to control. Imazapic, which has been extensively tested in Oregon for medusahead control, is not a registered pesticide in California, and ranchers/land managers are left with limited effective options. Recently, work by Sebastian et. al. 2016 has shown indaziflam (Esplanade® 200 SC, Bayer CropScience LP) to be very active on another invasive annual grass, cheatgrass (*Bromus tectorum*), and further greenhouse trials indicate activity on medusahead. Additionally, work at other locations in the state by Kyser et. al. 2012 have shown high rates of aminopyralid (Milestone, Dow AgroSciences LLC) to be effective for pre-emergence medusahead control, and Rinella et. al. 2014 showed post-emergence applications have reduced medusahead seed formation. The objective of this work was to assess the effectiveness of indaziflam and aminopyralid as pre-emergence and post-emergence applications for controlling medusahead. Three separate trials were initiated during 2016. Two locations tested Post-emergence spring applications, two locations tested fall Pre-emergence applications and, one location tested fall post-emergence applications. Visual control assessments and percent cover by species functional classes were recorded throughout 2016 and 2017.

- Spring post-emergence treatments all contained 560g ae/ha of glyphosate to control emerged plants. Twenty months after treatment Indaziflam at 72 and 102g ai/ha gave 98-100 percent medusahead control at both sites.

- Fall pre-emergent applications of indaziflam at 72 and 102g ai/ha provided 79 and 90 percent control 14 MAT. Preemergent applications of aminopyralid at 245g ae/ha provided medusahead suppression 9 MAT, but only gave 9 percent control 14 MAT.
- Fall post-emergence treatments of indaziflam at 72 and 102g ai/ha initially provided medusahead suppression 7 MAT but gave 96 and 98 percent control 12 MAT. Fall post emergent aminopyralid applications offered some medusahead suppression 7 MAT, but less than 20 percent control was observed 12 MAT.

Sites selected for post-emergent trials prior to application were medusahead monocultures, and medusahead was largely replaced by bare ground, with small increases in other remnant species. Pre-emergent applications were made at sites with remnant perennial grasses, where medusahead cover was largely replaced with bare ground, and small numerical increases in perennial grasses. Study sites will continue to be monitored in 2018. Results from these trials indicate indaziflam has potential to offer excellent medusahead control at various application timepoints. Aminopyralid offered initial medusahead suppression but did not offer the level of control observed by Kyser in the lower elevations of California. Trials were implemented before the wettest winter in history within the region and further research under different environmental conditions is needed.

Sebastian, D. J., Sebastian, J. R., Nissen, S. J., & Beck, K. G. (2016). A Potential New Herbicide for Invasive Annual Grass Control on Rangeland. *Rangeland Ecology and Management*, 69(3), 195-198.

Sebastian, D. J., Nissen, S. J., & Rodrigues, J. D. S. (2016). Pre-emergence Control of Six Invasive Winter Annual Grasses with Imazapic and Indaziflam. *Invasive Plant Science and Management*, 9(4), 308-316.

Kyser, G. B., Peterson, V. F., Davy, J. S., & DiTomaso, J. M. (2012). Preemergent Control of Medusahead on California Annual Rangelands with Aminopyralid. *Rangeland Ecology and Management*, 65(4), 418-425.

Rinella, M. J., Bellows, S. E., & Roth, A. D. (2014). Aminopyralid Constrains Seed Production of the Invasive Annual Grasses Medusahead and Ventenata. *Rangeland Ecology and Management*, 67(4), 406-411.

**Invasive Annual Grass Control and Perennial Grass Response with Residual Herbicides in Utah.** Corey V. Ransom\*, Heather E. Olsen; Utah State University, Logan, UT (009)

Control of invasive annual grasses in the Western US continues to be challenging. Indaziflam, a new herbicide to the non-crop market, is showing promise for annual grass management. Studies were established in 2015 to evaluate indaziflam alone and in combination with various herbicides for control of medusahead (*Taeniatherum caput-medusae*), downy brome (*Bromus tectorum*), and Japanese brome (*Bromus japonicus*). The site with a mixture of downy and Japanese brome was located near Collinston, Utah and the medusahead site near Peterson, Utah. Selected treatments were applied both in the fall and in the spring. Treatments included glyphosate, propoxycarbazone, and rimsulfuron, alone and in combination with indaziflam. All treatments were compared to imazapic applied alone. Treatments were applied with a CO<sub>2</sub>-

pressurized backpack sprayer calibrated to deliver 234 l/ha at 276 kPa pressure. Fall applications were made in November of 2015 and spring applications in April of 2016. Injury and annual grass control were evaluated visually, and cover data was collected utilizing point-line transects in July 2017. In August 2017, biomass samples were taken from two 0.3m<sup>2</sup> quadrats in each plot and were combined. Biomass was sorted by species, dried, and weighed. No visible injury to desirable grasses was observed with any treatments, including those showing high levels of injury in 2016. At both the brome and the medusahead research sites, few treatments not containing indaziflam reduced invasive annual grass cover compared to the untreated plots. At the brome site a few treatments reduced brome cover to between 22 and 24% compared to the untreated (48% cover). At the medusahead site rimsulfuron and glyphosate in the fall and rimsulfuron or imazapic in the spring had medusahead cover of 29 to 42% compared to the untreated control at 69% cover. For indaziflam treatments, there was no downy or Japanese brome cover and 2% or less medusahead cover at the brome and medusahead trial sites, respectively. With a single exception, only treatments containing indaziflam increased desirable grass cover at either site. Crested wheatgrass cover in the indaziflam treatments was 35 to 50% compared to 21% cover in the untreated control, at the brome site. At the medusahead site, western wheatgrass cover in indaziflam treatments was 41 to 51% compared to the untreated at 14%. Biomass data correlated well with cover data with minimal invasive annual grass biomass collected in indaziflam plots and corresponding increases in desirable grass biomass at both sites. Indaziflam treatments increased crested wheatgrass biomass at the brome site from 49 g/m<sup>2</sup> in the untreated plots to 167 to 331 g/m<sup>2</sup> in the indaziflam plots. Similarly, western wheatgrass biomass increased from 42 g/m<sup>2</sup> in the untreated plots to between 141 and 204 g/m<sup>2</sup> in indaziflam treatments. At the brome research site, some treatments including those with indaziflam produced significant broadleaf biomass compared to the untreated. This was mostly due to western salsify in the indaziflam treatments and in a few instances, prickly lettuce in imazapic and rimsulfuron treatments. While several treatments were able to suppress both downy and Japanese brome or medusahead one year after treatment, only indaziflam treatments are providing significant control in the second year after treatment. Options for extended control of these invasive annual grasses hold promise for successful long-term management.

**Evaluating the Efficacy of Four Graminicides on *Bromus tectorum* and *Bromus japonicus*.**  
Emily Pierson-Metier<sup>1</sup>, Erik A. Lehnhoff<sup>2</sup>, Jane Mangold<sup>1</sup>, Matthew J. Rinella<sup>3</sup>, Lisa J. Rew\*<sup>1</sup>;  
<sup>1</sup>Montana State University, Bozeman, MT, <sup>2</sup>New Mexico State University, Las Cruces, NM,  
<sup>3</sup>USDA-ARS, Miles City, MT (010)

Annual non-native grasses are a major concern to production systems and can be particularly hard to control in rangeland settings. Cheatgrass (*Bromus tectorum* L.) and Japanese brome (*B. japonicus* Thunb.) are two non-native winter annuals that have invaded the western United States, with cheatgrass present in the cold deserts, western Great Plains, and western forests; and Japanese brome found mainly in the western Great Plains. Herbicide control of these species can be problematic when they grow intermixed with desired species such as sagebrush. The goal of our greenhouse study was to evaluate the efficacy of four graminicides (sethoxydim, clethodim, fluazifop, and quizalofop) and glyphosate on cheatgrass and Japanese brome biomass, at high and low label recommended application rates of each herbicide, using species accessions from disturbed and undisturbed habitats. Plants were sprayed at a height of 11 cm and harvested 45 days after treatment. All herbicides reduced biomass by more than 50%, and the negative impact on biomass was greater for Japanese brome compared to cheatgrass. The four graminicides

applied at high and low rates and glyphosate applied at high rate resulted in lower biomass than the low glyphosate and non-sprayed treatment, across both species. Furthermore, for cheatgrass, the fluazifop and quizalofop treatments were most effective. For both species, herbicide efficacy was greater on the disturbed than undisturbed accessions. Our results demonstrate the potential for these graminicides to target annual bromes where they are growing with desired vegetation including forbs and shrubs.

## **Project 2. Weeds of Horticultural Crops**

**Current Weed Management Practices and Future Weed Control Needs: A Survey of Washington Wine Grape Growers.** Lynn M. Sosnoskie\*<sup>1</sup>, Ian C. Burke<sup>2</sup>; <sup>1</sup>University of California Cooperative Extension, Merced, CA, <sup>2</sup>Washington State University, Pullman, WA (011)

Weed control is a critical component of newly established and bearing vineyards. To develop weed science-related research and extension efforts that directly benefit Washington's (WA) wine grape industry, information describing current weed management practices and future weed control need in vineyards is required. Between November 2017 and January 2018, 29 respondents responsible for managing 10,000 acres of vineyards (representing approximately 20% of the total wine grape acreage in WA) completed a voluntary 18 question survey designed to address weed-related concerns.

With respect to herbicides, 59% of respondents indicated that they had used pre-emergence (PRE) herbicides at some time during the last three years. Surflan (oryzalin, 26% of respondents), Matrix (rimsulfuron, 21%), Alion (indaziflam, 16%), and Chateau (flumioxazin, 5%) were the most commonly used product. Eighty-three percent of all respondents reported using post-emergence (POST) herbicides under the trellis system for weed control at some time during the last three years, with glyphosate containing products (43% of respondents) being the most common choice followed by Aim (carfentrazone, 20%), Rely (glufosinate, 17%), and Gramoxone inteon (paraquat, 5%). Although herbicides appeared to be important components of weed management programs in WA wine grapes, they are not the only tools employed; 38%, 32%, and 28% of respondents also reported using cultivation and hand-weeding, respectively, for weed management under the trellis system. Weed control between the rows was achieved through a combination of mowing (43% of respondents), cover cropping (25%), cultivation (19%), hand-weeding (7%), and herbicide applications (7%).

According to the respondents, summer broadleaf species (*e.g.* pigweeds) were primarily considered to be a big problem in vineyards, whereas summer (*e.g.* crabgrass) and winter (*e.g.* annual bluegrass) grasses and winter broadleaves (*e.g.* filaree) were less significant concerns. Perennial broadleaves (*e.g.* field bindweed) were, primarily, reported to be a moderate concern and perennial grasses/or grass-like species (*e.g.* horsetail) were described as a big to serious problem. When asked to identify individual species of concern, growers specifically mentioned: *Salsola tragus* (Russian thistle), *Tribulus terrestris* (puncturevine/goatheads/caltrops), *Conyza canadensis* (marestail), *Kochia scoparia* (kochia), *Amaranthus* spp (pigweed), *Centaurea* spp

(knapweed), and *Malva neglecta* (common mallow). With respect to herbicide (resistance in their vineyards, the respondents specifically noted: *Conyza canadensis*, *Kochia scoparia*, and *Salsola tragus*.

Results from this survey, which was funded by a grant from the WA Wine Grape Research Board, suggest that vineyard managers utilize a diverse set of strategies to manage weeds in their production systems. Tools include both pre- and post-emergence herbicides, mowing and cultivation, hand-weeding, and cover crop use. While the identification of new herbicides for use in wine grape systems is desirable, reducing the industry's reliance on chemical control strategies also appears to be of interest. Cultivation practices can be an effective alternate weed management strategy; however, growers appear to be interested in minimizing soil disturbance. Many of the species listed as specific concerns to growers are known to be resistant to glyphosate in other Western states, although resistance has not yet been confirmed in WA. Several of these species can also be widely dispersed by wind-blown seeds (marehail) or tumbling plants (*Kochia* and Russian Thistle). Several species (*Centaurea* spp., common mallow, *Kochia*, puncturevine, Russian thistle) are also adapted to the drier environments that characterize the Eastern side of the state.

**Stale Seedbeds for Summer Annual Weeds in Chile Pepper.** Adriana Sanchez, Brian J. Schutte\*, Leslie Beck, O. John Idowu, James Libbin; New Mexico State University, Las Cruces, NM (012)

The production of chile pepper (herein "chile") in New Mexico is challenged by high costs for labor needed for hand hoeing interventions during the middle-to-late phases of chile growing seasons. This study evaluated stale seedbeds (sequences of irrigation and tillage that eliminate weed seedlings prior to crop planting) that were designed to specifically target weed species that emerge during the middle-to-late phases of the chile growing season. The objectives of this study were to: 1) determine the effects of stale seedbeds on weed densities and hand hoeing requirements in chile, and 2) evaluate economic costs of stale seedbeds relative to economic gains in subsequent chile production. Stale seedbed treatments (0, 2 and 3 stale seedbeds) were implemented from August-September, 2015 (Run 1) and August-October, 2016, (Run 2). In April 2016 (Run 1) and April 2017 (Run 2), chile was seeded. Combinations of cultivation, hand hoeing, and herbicides (napropamide at 1.1 kg ai ha<sup>-1</sup> and clethodim at 140 g ai ha<sup>-1</sup>) were used for weed control during the chile season. Data collected during the chile season included repeated measures of weed seedling emergence, times required for individuals to hoe field sections (i.e., hoeing time) and chile yields. Hoeing time and yield data were included in cost-benefit analyses that also incorporated production expenses and prices projected by NMSU Extension. For Run 1, fewer weed seedlings emerged in the 2 and 3 stale seedbed treatments compared with the 0 stale seedbed treatment. Stale seedbed treatments did not affect cumulative weed seedling emergence in Run 2. Results from both experimental runs indicated that, compared with the 0 stale seedbed treatment, the 2 stale seedbed treatment reduced hoeing times. These reductions in hoeing time were not improved with an additional stale seedbed because hoeing times were similar between the 2 and 3 stale seedbed treatments. Except for green chile yield in Run 1, stale seedbed treatments did not affect chile yield. After accounting for costs for implementation, stale seedbeds were projected to reduce chile production costs by \$637-\$1086 ha<sup>-1</sup>. The results of this study indicated that stale seedbeds implemented the summer before planting is a promising technique for reducing hand hoeing costs in chile production.

**Organic Herbicide Efficacy in Apples.** Lynn M. Sosnoskie\*<sup>1</sup>, Ian C. Burke<sup>2</sup>; <sup>1</sup>University of California Cooperative Extension, Merced, CA, <sup>2</sup>Washington State University, Pullman, WA (013)

Weeds can affect perennial crops, directly, by competing for water, nutrients, and light. Weeds may also provide indirect interference by blocking sprinklers and altering soil wetting/drying patterns, harboring pests and pathogens, and providing habitat for rodents. Organic apple acreage continues to increase in the Washington (Washington State produces over 90% of the fresh product in the country) and growers have indicated that weed control is a significant concern. Growers have also expressed an interest in identifying effective organic herbicide options for use in their production systems. In 2017, a study was conducted to evaluate the efficacy of Suppress (32% capric acid and 47% caprylic acid) and Axxe (40% ammonium nonanoate) for use against difficult to control weeds (white clover (*Trifolium repens*) and crabgrass (*Digitaria* spp.)).

Treatments included three rates of Axxe (6, 9, and 15% v/v) and three rates of Suppress (3, 6, and 9% v/v) applied using a backpack sprayer at 40 GPA. Rates were selected according to label recommendations. Each treatment was replicated three times. Plots were 10' in width and 30' in length with an average weed cover of 51%. Weeds were less than 2" in height at the time of application (June 27, 2017). Weed cover was rated at 1, 2, 3, and 4 WAT. This study was specifically conducted to target weed growth stages that might characterize either a delayed management scenario or else weed control escapes.

Raw weed cover data indicated that both herbicides were not able to sufficiently control crabgrass and white clover (data not shown). However, an evaluation in the percent (%) change in weed cover indicated that the identity of the herbicide and the application rate can influence both herbicide injury and recovery. Axxe treated plots had lower values for percent change in weed cover as compared to Suppress, indicated that the weeds were more injured and recovered/resumed growth more slowly. The change in weed cover in the Axxe treated plots (at rates of 6-15% v/v) was <5%, <10%, 0-15%, and 10-25% at 1, 2, 3, and 4 WAT. The change in weed cover in the Suppress treated plots (at rates of 3-9% v/v) was 15-20%, 15-25%, 20-30%, and 20-40% at 1, 2, 3, and 4 WAT. A direct rate comparison indicated that Axxe at 6% v/v (2-20% change in cover) may be more injurious than Suppress at 6% v/v (15-38% change in cover). These differences may be due to differences in the solubility of the formulated products in water (Axxe = soluble, Suppress = insoluble, as reported in the product SDSs), which could affect coverage. Results from this trial and a second study (not shown) demonstrates that higher rates and spray volumes are most effective at suppressing difficult to control weeds. There are some concerns regarding the cost of the formulated products, the amounts of product that must be applied, and the need for repeated applications to ensure continuous control. Physical weed removal, mulches, and cover cropping have been explored and are being used to varying degrees in apple systems; growers do still have an interest in organic herbicide products and will likely be interested in further trials.

**Comparison of Solarization and Biosolarization for Weed Control in a Tree Seedling Nursery in Western Oregon.** Nami Wada\*, Jennifer Parke, Pete A. Berry, Lucas Kopecky Bobadilla, Carol Mallory-Smith; Oregon State University, Corvallis, OR (014)

Biosolarization combines the technology of biofumigation and solarization. Organic matter is tilled into the soil before plastic is laid. The breakdown of the organic matter increases the soil temperatures and produces anaerobic conditions which improve weed and soil borne-pathogen control. This field experiment was conducted in summer 2017 to assess the effectiveness of solarization with or without an incorporated spring cover crop. The study included 2 solarization treatments (solarized or non-solarized), 2 cover crop treatments (with or without cover crop), 2 durations (2 and 4 weeks), and 2 soil moisture levels (high and very high). The 4-week duration plots with very high moisture received additional irrigation with drip lines under the plastic mulch after 2 weeks to maintain anaerobic soil conditions, whereas, the rest of the treatments were irrigated once at the starting date. Seeds of four weed species (*Amaranthus retroflexus*, *Poa annua*, *Polygonum pensilvanicum*, *Portulaca oleracea*) were buried at 5 and 10 cm depths, removed at 2 or 4 weeks and tested for viability via germination and tetrazolium staining assays. The impact of soil moisture and cover crops varied by species. Solarization effectively controlled *P. annua* and *P. pensilvanicum* regardless of other factors. *Amaranthus retroflexus* seed viability was moderately reduced at the 5 cm depth in the very high moisture plus the cover crop treatment. None of the treatments influenced *P. oleracea* seed viability at either depth. Further research is needed to assess the long-term effect of biosolarization on weed seeds.

**Field Bindweed Response to Preemergence Herbicides in Highbush Blueberries.** Marcelo L. Moretti\*, Larissa Larocca de Souza, Ed Peachey; Oregon State University, Corvallis, OR (015)

Field bindweed (*Convolvulus arvensis* L.) is a perennial deep-rooted vine commonly found in blueberry (*Vaccinium* sp.) fields in Oregon. The current management of field bindweed relies on the repeated applications of post-emergence herbicides to suppress plant growth during the season increasing labor demand and costs for production. Previous research identified quinclorac as an effective herbicide to manage field bindweed, but registration is still pending. Although effective, quinclorac will not provide season-long control of field bindweed. Pre-emergence herbicides could complement field bindweed management. A project was initiated in 2017 to evaluate the response of field bindweed to soil-residual herbicides. Treatments were applied in May 2017 and treatments included herbicides with POST and PRE activity. All treatment was followed by (FB) carfentrazone application when weed cover in untreated plots reached approximately 60%, to mimic growers practice. A total of three FB applications were made. Treatments including sulfentrazone, quinclorac, flumioxazin, mesotrione plus simazine, and saflufenacil plus rimsulfuron provided suppression (>80%) of bindweed growth for 56 days after treatment (DAT). Field bindweed coverage of these treatments remained below 20% at all evaluations, as compared to up to 65% in the untreated. Halosulfuron, rimsulfuron, mesotrione, and saflufenacil did not provide good suppression of field bindweed. No differences in blueberry yield were observed. Evaluations will continue for the following growing season to quantify field bindweed long-term response to treatments.

**Control of Green Suckers with Herbicides in Hazelnut.** Larissa Larocca de Souza\*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (016)

Hazelnut (*Corylus avellana* L.) have prolific shoot growth in the base of the trunk, and these suckers are removed to promote the development of a single trunk, facilitating mechanization and cultural practices. Suckers can be removed manually, but in commercial scale, herbicides are a more cost-effective option. The objective of this study was to compare the efficacy of



registered herbicides, alone or in combination, for sucker control in hazelnuts. The experiment was conducted in a 10-year-old hazelnut orchard of “Jefferson” variety located in McMinnville, OR in 2017. The experiment was initiated in April, when suckers were 12 inches tall. A total of fourteen treatments plus untreated control were included. The herbicides paraquat, glufosinate, 2,4-D, carfentrazone, capric plus caprylic acid, and ammonium nonanoate were tested. Each treatment was applied four-times in an interval of four to five-weeks to simulate grower’s practices. Treatments with glufosinate, paraquat, or 2,4-D provided at least 80% sucker control after the third application. Carfentrazone, ammonium nonanoate, and capric plus caprylic acid did not provide adequate sucker control (< 50%). By the end of the season, most treatments reduced sucker growth to 50 cm height or less, a 65% reduction when compared to untreated control (140 cm). Treatments with capric plus caprylic acid, carfentrazone, or ammonium nonanoate resulted in suckers of 100 cm or greater. No crop injury was observed during the experiment. The herbicides glufosinate, 2,4-D and paraquat, alone or in combination, can be used to manage suckers in hazelnut. This research will be continued in 2018.

**Effects of Saline Water on Saflufenacil and Rimsulfuron Partitioning in California Orchard Soils.** Katie Martin\*, Brad Hanson; University of California, Davis, Davis, CA (017)

Limited surface-water availability in California has many tree nut growers using ground water resources for irrigation. In years of drought the ground water table is depleted and the salinity of the water increases. It is known that the soil pH, cationic/anionic exchange capacity (CEC/AEC), particle size, and organic matter content all influence the efficacy of herbicides but ionic strength of irrigation water in orchard systems has yet to be studied. This project examines the partitioning of two herbicides, saflufenacil and rimsulfuron, with variable saline water conditions in two types of California orchard soils. The Food and Agriculture Organization of the United Nations (FAO) have set guidelines for irrigation water quality from a crop safety standpoint; water treatment conductivities were chosen based on these guidelines. In two separate experiments, two soil types were treated with four rates of saflufenacil (0.07 to 7 oz ai/A) or rimsulfuron (0.1 to 10 oz ai/A) and extracted with water at four conductivity levels (0, 0.5, 2.5, and 5.0 dS/m). These experiments were adapted from ASTM method E1195-87 for sorption constant determination and analyzed using Orbitrap LC-MS. The data presented will give insight on herbicide availability after saline irrigation events.

**Strawponic for *Phelipanche aegyptiaca* Management in No-Till Potato.** Mustapha A. Haidar\*<sup>1</sup>, Ali M. Msheik<sup>2</sup>; <sup>1</sup>American University of Beirut, Beirut, Lebanon, <sup>2</sup>AUB, Beirut, Lebanon (018)

Strawponic is an innovative and exotic system for growing potato on soil surface (bare soil, turfgrass, any soft medium) using crop straw as a cover. A field trial was carried out last spring/summer at the American University of Beirut in Lebanon to test the efficacy of this system against *Phelipanche aegyptiaca* for small potato producers. Simply, potato tubers were placed on bare soil surface (No cultivation) containing animal manure, covered them with a blanket of crop straw, and watered through drip irrigation system. Straw was removed by hand at the end of the growing season, *P. aegyptiaca* infestation were estimated and potato tubers were picked up by hand. We suggest that no-till potato at 50 and 75 t/ha straw significantly reduced *P. aegyptiaca* shoot number and dry weight, comparing to till potato. This system found to be simple, economical (no machinery, no soil bed preparation, no digging or hilling, and

suitable potato yield), sustainable (no contamination/pollution-no herbicides), saves water, appropriate for dry and urban areas (gardens), suitable for organic farming and reduces *P. aegyptiaca*.

**Sharppoint Fluvellin Management in Horticulture Perennial Crops of Western Oregon.**  
Larissa Larocca de Souza, Marcelo L. Moretti\*; Oregon State University, Corvallis, OR (019)

Sharppoint fluvellin (*Kichixia elatina* L.) is a summer annual prostrate weed that is found in many cropping systems of Western Oregon. This creeping weed can grow to form dense mats creating problems for harvesting and competing with crops. Limited information for chemical management of sharppoint fluvellin is available. The objective of this study was to evaluate POST options for manage sharppoint fluvellin. The experiment protocol consisted of 13 treatments including an untreated control. Herbicides tested included carfentrazone, diquat, flazasulfuron, paraquat, diquat, glyphosate, rimsulfuron, glufosinate, capric and caprylic acid, and ammonium nonanoate. Two field trials were conducted in 2017 to evaluate POST control of sharppoint fluvellin, one in a blueberry field and one in a hazelnut field. Plant injury and biomass were monitored for 28 days after treatment (DAT). Sharppoint fluvellin control at 14 DAT was good to excellent (>90%) with paraquat, diquat, and glufosinate. At the 28 DAT evaluation, control with paraquat and diquat declined to 32% or less as a result of plant regrowth. In contrast, glufosinate treatments provided excellent control (>95%) at 28 DAT evaluation. Glyphosate also provided excellent control of sharppoint fluvellin. Poor control (<60%) was observed with carfentrazone, caprylic plus capric acid, and ammonium nonanoate at all evaluations. Significant reduction of aboveground biomass was observed only with glyphosate or glufosinate treatments. The herbicide glyphosate and glufosinate provided excellent control of sharppoint fluvellin and can be used to manage this weed in perennial cropping systems. This research is on-going for the next seasons.

**Injury Symptoms and Detection of Bispyribac-sodium in Walnut Leaves Following Simulated Drift.** Mariano F. Galla\*<sup>1</sup>, Kassim Al-Khatib<sup>2</sup>, Brad Hanson<sup>2</sup>; <sup>1</sup>University of California Cooperative Extension, Orland, CA, <sup>2</sup>University of California, Davis, Davis, CA (020)

English walnut and rice are among the most important crops grown in the Sacramento Valley of California. Because rice herbicides are often applied by air, there are several complains of rice herbicide drift onto walnut trees. Previous research evaluated the effect of simulated bispyribac-sodium drift on walnut growth and development but did not address the detection of bispyribac-sodium on walnut leaves after a drift event occurs. The objectives of this study were to determine if bispyribac-sodium can generate visual symptoms without leaving detectable residues on walnut leaf tissues and to determine if there is a correlation between yield and bispyribac-sodium residues on leaf tissue. The study was conducted in two different sites in a three-year-old walnut orchard. In the first site bispyribac-sodium was applied at 0.125%, 0.25%, 0.5% and 1% of the normal use rate in rice (45 g a.i. ha<sup>-1</sup>). In the second site rates were 1%, 3%, 10% and 100% of the field use rate. Bispyribac-sodium caused phytotoxic chlorosis and yellow spotting on walnut leaves even at very low concentration, as symptoms were recorded on trees exposed to rates as low as 0.125%. Based on HPLC analysis no residues, however, were detected in walnut leaf tissues sampled from trees exposed to 1% or lower rates. The lowest detection limit was at 3% of the bispyribac-sodium field rate residues 10 days after treatment. In general, symptoms may

remain constant over time or even worsen while bispyribac-sodium residues decrease and are finally not detectable. There was no impact on walnut yield.

**Cover Crop Tolerance to Herbicides: Implication for Interseeding.** Ed Peachey\*; Oregon State University, Corvallis, OR (021)

Cover crop establishment in the fall following sweet corn grown for processing can be challenging. Corn residue must be incorporated with tillage before seeding the cover crop or direct-seeded after harvest through substantial residue. An alternative is to interseed cover crops into sweet corn at V4 to V6 so that fall planting can be avoided. Successful interseeding is dependent on the weed control practices chosen in both conventional and organic systems. In conventional production, PRE herbicides such as atrazine may need to be abandoned to avoid damage to the interseeded cover crop; in organic production, the need for late cultivation may preclude interseeding of a cover crop. Several effective HPPD herbicides have been labeled for use for postemergent weed control in sweet corn over the last decade, possibly reducing the need for preemergent herbicides that might carryover and injure interseeded cover crops. Plant back recommendations have not been adequately established for these herbicides when interseeding cover crops. The objective of this study was to determine the time needed between herbicide application and cover crop seeding to avoid damage to cover crops from tembotrione, topramezone, and tolypyralate. Herbicides were applied in 2016 and 2017 at 14, 7 or 0 days before planting (DBP) to fifteen cover crops in plots arranged in a strip-plot design with three replications. Tembotrione applied at 0.082 lb ai a<sup>-1</sup> at 7 and 14 DBP had little effect on crimson clover but completely controlled red clover. Topramezone applied at 0.022 lb ai a<sup>-1</sup> at 7 and 14 DBP caused moderate injury to both crimson and red clover. Tolpyralate applied at 0.026 lb ai a<sup>-1</sup> had very little effect on growth of red and crimson clovers, but significantly injured berseem clover when applied 7 DBP. Common vetch was moderately tolerant and spring and small grains very tolerant to all three HPPD herbicides.

### **Project 3. Weeds of Agronomic Crops**

**Effect of Intensified Wheat-Based Cropping Systems on Weed Infestation.** Carolina San Martín\*<sup>1</sup>, Dan Long<sup>2</sup>, Judit Barroso<sup>1</sup>; <sup>1</sup>Oregon State University, Adams, OR, <sup>2</sup>USDA-ARS, Adams, OR (022)

Fallow (F), the practice of keeping a field out of production during the growing season, is commonly used in the semi-arid Pacific Northwest to conserve soil water for the following crop. Studies have demonstrated that cropping intensification has a negative effect on weeds. A three-year study was conducted to determine if intensifying winter wheat (WW)-F by growing spring barley (SB, *Hordeum vulgare* L.) or spring oilseed (SO, *Brassica carinata* L.) after winter wheat (WW) could benefit weed management. The experimental design was a randomized complete block design with four replications where each phase of the rotation was present every year for the three cropping systems (WW-F, WW-SB-F, WW-SO-F). Weed density and cover per species were evaluated in early-, mid- and late- season. Crop yield was also measured at physiological maturity. Differences in community biodiversity due to cropping system rotation were only

found in 2017 between WW-SB-F and WW-SO-F versus WW-F. Grass cover and density in 2017 were significantly lower in WW-SB-F (1.3% and 1.9 plants m<sup>-2</sup>) and WW-SO-F (1.8% and 3.6 plants m<sup>-2</sup>) compared to WW-F (4.1% and 13.4 plants m<sup>-2</sup>). Winter wheat yield was not affected by intensifying the rotation but was negatively affected by weed presence in 2016 and 2017. In 2017, this negative effect was significantly larger in WW-SO-RTF than in WW-F and WW-SB-F.

**Rattail Fescue and Downy Brome Control in Winter Wheat with Mesosulfuron/Thiencarbazon.** Traci Rauch\*, Joan Campbell; University of Idaho, Moscow, ID (023)

Mesosulfuron/thiencarbazon is a premix that will soon be registered in winter wheat to control grass weeds, including rattail fescue and downy brome. Rattail fescue is a significant problem in direct seed wheat cropping systems in the Pacific Northwest and is difficult to control with glyphosate. Currently, few postemergence herbicide options exist or provide effective rattail fescue control. Downy brome is troublesome in low precipitation production areas where crop rotations are limited and can reduce winter wheat yield. Studies were initiated in spring 2015, 2016, and 2017 to evaluate rattail fescue and downy brome control in winter wheat. The experiment design was a randomized complete block with four replications. In 2015 and 2016, downy brome control was similar between mesosulfuron and mesosulfuron/ thiencarbazon treatments. In 2015, 2016 and 2017, rattail fescue control was significantly better with mesosulfuron/thiencarbazon treatments compared mesosulfuron treatments either alone or combined with other broadleaf herbicides. Mesosulfuron/thiencarbazon also controlled rattail fescue better than flucarbazone, the postemergence standard for rattail fescue. Overall, mesosulfuron/ thiencarbazon will be another tool for downy brome control and an excellent postemergence herbicide option for rattail fescue control.

**Cross Resistance Patterns in Multiple ALS-Resistant Downy Brome (*Bromus tectorum* L.) Accessions from Washington.** Jeanette A. Rodriguez\*, Amber L. Hauvermale, Rachel J. Zuger, Ian C. Burke; Washington State University, Pullman, WA (024)

In the Pacific Northwest (PNW), downy brome (*Bromus tectorum* L.) is a wide spread problem in no-till wheat production and non-cropland environments. Acetolactate synthase (ALS) inhibitors are among the most commonly used herbicides to control downy brome. Heavy reliance on these herbicides is the likely cause of recently discovered ALS-resistant downy brome. Twenty-four biotypes suspected to be resistant were submitted by PNW growers for resistance testing. Biotypes were tested for cross resistance to four chemical families of the ALS inhibitors imidazolinones (IMI), sulfonyleurea (SU), sulfonyleaminocarbonyltriazolinone (SCT), and triazolopyrimidines (PTB). Results indicate a statistical difference between the susceptible and the suspected resistant biotypes including, 14 imazamox, 14 sulfosulfuron, 12 propoxycarbazon-sodium, 10 mesosulfuron, and 15 pyroxulam resistant biotypes, 8 of which had cross-resistance to all four ALS chemical families. Dose response experiments were performed on four biotypes exhibiting imazamox resistance from the initial screens. The resulting dose-response data were fit using a 3-parameter log-logistic with GR<sub>50</sub> (50% growth reduction) as one of the parameters. Imazamox provided 100% control with no survival of the susceptible biotype at the lowest application rate of 0.525 g ai ha<sup>-1</sup>. The four biotypes presented varied rates of resistance compared to the susceptible. Biotype A had a GD<sub>50</sub> of 13.6 g ai ha<sup>-1</sup>,

biotype B had a  $GD_{50}$  of 841.2 g ai ha<sup>-1</sup>, C had a  $GD_{50}$  of 831.9 g ai ha<sup>-1</sup>, and biotype D had a  $GD_{50}$  of 8.8 g ai ha<sup>-1</sup>. ALS-inhibitor resistance in Washington appears to be conferred by multiple mechanisms, based on cross resistance patterns.

### **Herbicide Systems with Pyroxasulfone for Management of Downy Brome in Winter Wheat.**

Rachel J. Zuger\*, Amber L. Hauvermale, Tara L. Burke, Henry C. Wetzel, Ian C. Burke; Washington State University, Pullman, WA (025)

Downy brome (*Bromus tectorum* L.) continues to be a problematic and widespread weed in the inland PNW wheat-fallow rotations. Acetolactate synthase (ALS) inhibitor resistance has become a critical concern among growers in Washington. ALS inhibiting herbicides are the primary herbicide option for postemergence (POST) downy brome management in a wheat-fallow rotation. Our objective was to identify one or more herbicide treatments with different modes of action for management of downy brome. Two studies were established in a winter wheat-fallow system near Anatone, WA. A winter wheat study consisting of delayed preemergence (delayed-PRE) and POST treatments arranged in a split-plot design with PRE as the whole plot and POST as the split plot, and a fallow study of PRE treatments for downy brome management without crop present. Treatments consisting of combinations of pyroxasulfone, metribuzin, diclofop, and several ALS inhibitors were applied in the fall of 2016. Downy brome control was estimated by visual assessment the following spring and summer and downy brome biomass was harvested from each plot in mid-June. Data was subjected to an ANOVA and significant differences between treatments were analyzed using Fisher's protected LSD. In the fallow study, pyroxasulfone, pyroxasulfone with sulfosulfuron, and pyroxasulfone with diclofop controlled downy brome compared to the nontreated. Downy brome biomass was significantly reduced in the pyroxasulfone, pyroxasulfone with sulfosulfuron, pyroxasulfone with diclofop, and diclofop with sulfosulfuron with 156, 271, 131, and 432 metric tons ha<sup>-1</sup>, respectively, compared to the nontreated control with 715 metric tons ha<sup>-1</sup>. In the winter wheat study, the combination of both a fall applied delayed-PRE and a spring applied POST herbicide treatment did control downy brome. Control of downy brome was greatest with PRE applied pyroxasulfone plus metribuzin and metribuzin alone. Pyroxasulfone alone had lower downy brome control compared to the fallow study, possibly due to the late timing of application with downy brome present at the 2-leaf stage. Pyroxasulfone with metribuzin and metribuzin both reduced the amount of downy brome biomass compared to the nontreated control with 326 and 813 metric tons ha<sup>-1</sup>, respectively, compared to 2281 metric tons ha<sup>-1</sup> for the nontreated, and were the only effective treatments. In conclusion, pyroxasulfone alone and in combination with metribuzin or diclofop, when applied PRE, appear to be effective options for downy brome management in winter wheat.

### **Fall and Spring Timings for Preseed Applications of Halauxifen Plus Florasulam for Spring Cereals.**

Joe Yenish\*<sup>1</sup>, Patti Prasifka<sup>2</sup>, Roger E. Gast<sup>3</sup>; <sup>1</sup>Dow AgroSciences, Billings, MT, <sup>2</sup>Dow AgroSciences, West Fargo, ND, <sup>3</sup>Dow AgroSciences, Indianapolis, IN (026)

Quelex<sup>TM</sup> herbicide is a new broadleaf herbicide product from Dow AgroSciences originally labeled for post emergence foliar applications in wheat (including spring, winter, and durum), barley and triticale, but recently received supplemental label approval for preplant applications. It is available as a water dispersible granule (WDG) containing 10% Arylex<sup>TM</sup> active (halauxifen-methyl) and 10% florasulam w/w. Arylex is a novel synthetic auxin (WSSA group 4)

active ingredient from the arylpicolinate chemical class being developed for the U.S. and many major cereal markets around the globe. Quelex is the first U.S. product containing Arylex and has a use rate of 52.5 grams of product/ha (0.75 oz product/acre) [Arylex (halauxifen-methyl 5.25 g ae/ha) + florasulam (5.25 g ai/ha)]. Quelex offers a unique broadleaf weed control spectrum and favorable flexibility with multiple application timings. Moreover, growers in the extreme Northern Plains Region of the U.S. are becoming more inclined to apply no-tillage burn-down applications in the fall prior to spring planting of cereal or pulse crops. Generally, the fall burn-down application for spring seeding provides better control of winter annual and perennial weeds and allows for earlier spring planting compared to spring-applied burn down. Field research was conducted during the 2014 to 2017 cropping seasons at multiple locations across the Northern Plains to determine the efficacy and crop safety of Quelex applied with glyphosate as a spring- or fall-applied pre-seed burndown ahead of spring cereals. Weed control efficacy and crop response of Quelex + glyphosate was compared to glyphosate plus saflufenacil, dicamba, carfentrazone, or a combination of thifensulfuron plus tribenuron. Quelex demonstrated similar or greater control of weeds such as redroot pigweed (*Amaranthus retroflexus*), volunteer canola (*Brassica rapa*), common lambsquarters (*Chenopodium album*), narrow-leaf hawksbeard (*Crepis tectorum*), and wild buckwheat (*Polygonum convolvulus*) compared with glyphosate alone or the other tank-mixes. Quelex + glyphosate also demonstrated good crop safety on spring wheat (including durum) and barley. Quelex herbicide with Arylex active will provide cereal growers with an effective multi-mode-of-action herbicide option for many difficult to control broadleaf weeds in both burndown and postemergence application timings.

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**Winter Wheat and Palmer Amaranth Competition: Seed Germination in Response to Competitor and Light.** Osama S. Saleh\*; University of Wyoming, Laramie, WY (027)

Palmer amaranth (*Amaranthus palmeri*) is considered a weed that grows and propagates quickly and prolifically. A single plant can produce over 250000 seeds which gives the ability to be weedy and invade large areas. Many biotypes have evolved resistance to several herbicide modes of action. Many studies suggest that light quality influences either promoting or suppressing seed germination, but it is unclear whether germination of palmer amaranth is affected by the presence of other species. In this study, we conducted four sets of experiments to estimate the influence of seed density, presence or absence of wheat seed, and light quality on Palmer amaranth seed germination. In addition to winter wheat cultivar 'MT1444', four different biotypes of Palmer amaranth (two were domestic and two from outside the United States) were used in this experiment. Light quality included four different spectral ranges (white, blue, red, and far-red). Germination was not affected by seed density for either wheat or Palmer amaranth when grown in the absence of other species. Light quality did not affect winter wheat germination either in the presence or absence of Palmer amaranth. Palmer amaranth germination differed in response to both light quality and the presence of wheat. Palmer amaranth germination was suppressed by the presence of wheat seeds under white (*P*- value 0.0445), and far red light (*P*- value 0.031). Speed of palmer amaranth germination was not affected by the presence of winter wheat under any light environment.

**Broad-Spectrum Postemergence Weed Control with Pyroxsulam in California Cereals.** Joe Armstrong\*<sup>1</sup>, Byron B. Sleugh<sup>2</sup>, Roger E. Gast<sup>2</sup>; <sup>1</sup>Dow AgroSciences, Fresno, CA, <sup>2</sup>Dow AgroSciences, Indianapolis, IN (028)

Pyroxsulam, sold as Simplicity® CA in California and Arizona, is an acetolactate synthase (ALS) inhibiting herbicide developed by Dow AgroSciences for use in spring wheat (including durum), winter wheat, and triticale. Pyroxsulam provides broad-spectrum postemergence control of many key grass and broadleaf weeds, including Italian ryegrass (*Lolium multiflorum*), wild oat (*Avena fatua*), and coast fiddleneck (*Amsinckia intermedia*), as well as short plant-back intervals to rotational crops. From 2010-2016, 18 field trials were conducted in California and Arizona to characterize the efficacy of pyroxsulam in comparison to other competitive small grains herbicides. Treatments evaluated included pyroxsulam (15 g ai/ha), mesosulfuron (15 g ai/ha), pinoxaden (60 g ai/ha), and carfentrazone + tribenuron (17 g ai/ha + 18 g ai/ha). Pyroxsulam provided excellent control of several weeds in these trials, including 94-100% control of Italian ryegrass, wild oat, coast fiddleneck, and common chickweed (*Stellaria media*). Control of grass weeds with pyroxsulam was comparable or superior to the standards mesosulfuron and pinoxaden, while control of broadleaf weeds was comparable or superior to the standards mesosulfuron and carfentrazone + tribenuron.

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**Barley Tolerance to Soil-Applied Herbicides.** Brian Jenks\*<sup>1</sup>, Mike H. Ostlie<sup>2</sup>, Bryan Hanson<sup>3</sup>; <sup>1</sup>North Dakota State University, Minot, ND, <sup>2</sup>North Dakota State University, Carrington, ND, <sup>3</sup>North Dakota State University, Langdon, ND (029)

Some green foxtail populations across North Dakota are known to be resistant to Group 1 herbicides like fenoxaprop, clodinafop, and pinoxaden. Currently, only Group 1 postemergence herbicides can be used in barley. Thus, a grower with Group 1-resistant green foxtail has no herbicide options for control. The objective of this study was to evaluate barley tolerance to soil-applied preemergence herbicides that provide green foxtail suppression or control. This study was conducted in Minot in 2012, 2014, 2015, and 2017, and in Langdon and Carrington in 2017 for a total of six site-years. The studies in Minot were conducted in a no-till system, while Langdon and Carrington were conducted using conventional tillage. The following herbicides were evaluated: pyroxasulfone, acetochlor (encapsulated), metolachlor, flucarbazone, pendimethalin, flumioxazin, dimethenamid, and a premix pyroxasulfone&flumioxazin. All treatments were applied preemergence (after barley was planted). Barley injury tended to increase as early-season rainfall increased. However, barley generally recovered as the season progressed with little impact on yield. Flumioxazin, metolachlor, and flucarbazone caused moderate crop injury in three or four of six site-years but did not differ in yield compared to the non-treated control. Dimethenamid caused moderate crop injury in two of five site-years where yield was reduced numerically, but not statistically different. Pyroxasulfone caused slight to moderate injury in two of six site-years but did not affect yield. Pendimethalin caused very little crop injury and did not affect yield. Acetochlor caused only slight injury in two of six site-years. In this study, barley generally recovered from early-season herbicide injury to produce nearly normal yields.

**New Flucarbazone Formulation Evaluation in Spring Wheat.** Joseph E. Mettler\*, Kirk A. Howatt; North Dakota State University, Fargo, ND (030)

Flucarbazone is an acetolactate synthase (Group 2) herbicide labeled for control of wild oat, green foxtail and other grass and broadleaf weeds in spring and winter wheat. In 2017, a new formulation of flucarbazone was released. The objective of this study was to compare the efficacy of the flucarbazone formulations to each other and to a few of the standard ALS herbicides used in spring wheat. Studies were conducted in 2016 and 2017 near Fargo, North Dakota. Each study was established as a randomized complete block design (RCBD) with three to four replicates. Studies were analyzed within year, as treatment lists varied by year. Differences were not observed in venice mallow, wild buckwheat or wild oat control between the two formulations of flucarbazone at 22.4 g ha<sup>-1</sup>. The new formulation provided better yellow foxtail control while the previous formulation gave better common lambsquarters control in the studies that were conducted. In 2016, the new formulation of flucarbazone at a higher rate of 30.8 g ha<sup>-1</sup> gave slightly less control of venice mallow than thiencazuron. Flucarbazone provided comparable control of wild oat and yellow foxtail to thiencazuron or pyroxsulam. The new formulation of flucarbazone had very similar efficacy to that of the old formulation but did give better yellow foxtail control which has been a difficulty for flucarbazone. Tankmixing with broadleaf herbicides is still necessary to adequately control some broadleaf weeds such as common lambsquarters.

**Bicyclopyrone Plus Bromoxynil Controls Mayweed Chamomile in Wheat.** Henry C. Wetzel\*, Drew J. Lyon; Washington State University, Pullman, WA (031)

Mayweed chamomile (*Anthemis cotula* L.) is an annual broadleaf weed that is competitive with small grains and pulse crops in the Pacific Northwest. It is widely distributed in eastern Washington within the high rainfall zone. The objective of these field trials was to compare crop safety and efficacy against mayweed chamomile with bicyclopyrone/bromoxynil at 213, 246 and 280 g ae/ha and to pyrasulfotole/bromoxynil at 202, 246 and 269 g ae/ha. Field studies were conducted under rainfed conditions near Pullman, WA from 2014 to 2017. Crop injury ratings were taken every 7 days for the first 28 days after treatments were applied. Visual control ratings were taken every 2 weeks after the treatments were applied for two months. A visual control rating was also taken very close to crop harvest in 2017. Plots were harvested for grain yield. Bicyclopyrone/bromoxynil applications did not result in any crop injury in the 4 studies conducted. In 2014, the trial was conducted in spring wheat and there was not a rate response to bicyclopyrone/bromoxynil or pyrasulfotole/bromoxynil treatments. Both products provided excellent control of mayweed chamomile. In the trials conducted from 2015 to 2017 in winter wheat, bicyclopyrone/bromoxynil treatments provided outstanding control of mayweed chamomile, whereas pyrasulfotole/bromoxynil treatments provided poor to fair control of mayweed chamomile. In all of these studies, there was not a significant rate response seen among either of these products. We also evaluated clopyralid/fluroxypyr in our winter wheat trials. In 2015 and 2016 clopyralid/fluroxypyr was very slow acting but at harvest resulted in outstanding control of mayweed chamomile. In 2017, mayweed chamomile injury with clopyralid/fluroxypyr was noted much sooner and also resulted in outstanding control at harvest time. We did not document any effects on grain yield with any of the herbicide treatments evaluated. Rotating between bicyclopyrone/bromoxynil and clopyralid/fluroxypyr use in winter



wheat may be an effective strategy for delaying the development of herbicide resistance in mayweed chamomile.

**Rescuegrass Management in Oklahoma Winter Wheat.** Misha Manuchehri\*<sup>1</sup>, Gary Strickland<sup>2</sup>, Kail Cole<sup>1</sup>, Jodie Crose<sup>1</sup>; <sup>1</sup>Oklahoma State University, Stillwater, OK, <sup>2</sup>Oklahoma State University, Altus, OK (032)

Rescuegrass (*Bromus catharticus* Vahl) is one of the first winter annual weeds to emerge in Oklahoma winter wheat. Growers can manage rescuegrass populations with a delayed planting date. After rescuegrass has emerged, plants can be tilled or sprayed with a herbicide prior to planting. However, land managers who use wheat for forage, prefer to plant early and often battle rescuegrass. There are few herbicides labeled for rescuegrass control and for the ones that are labelled, control can be inconsistent. To evaluate herbicide systems for rescuegrass management, two trials were conducted in Altus and Yukon, OK during the 2017-18 growing season. At both Altus and Yukon, rescuegrass control was the highest following fall postemergence applications of imazamox. At Altus, imazamox + ammonium sulfate (AMS) + nonionic surfactant (NIS) or methylated seed oil (MSO) controlled rescuegrass 93 to 96%. At Yukon, imazamox + AMS + MSO achieved 69% control while imazamox + AMS + NIS controlled rescuegrass 56%. All other treatments at Yukon performed poorly as a six-inch rain event followed PRE treatments and control with pyroxsulam was low (<10%). Conversely, at Altus, PRE treatments of glyphosate alone or glyphosate + flucarbazone-sodium or propoxycarbazine-sodium achieved 64 to 69% control. Preemergence treatments of glyphosate alone or glyphosate + flucarbazone-sodium or propoxycarbazine-sodium + pyroxsulam achieved 80 to 84% control. Trials will be repeated next growing season to further evaluate these systems.

**Harvest Weed Seed Control and Herbicide Resistance Survey of Winter Annual Grasses in Colorado.** Neeta Soni\*<sup>1</sup>, Scott J. Nissen<sup>1</sup>, Phil Westra<sup>1</sup>, Michael Walsh<sup>2</sup>, Jason K. Norsworthy<sup>3</sup>, Todd Gaines<sup>1</sup>; <sup>1</sup>Colorado State University, Fort Collins, CO, <sup>2</sup>University of Sydney, Sydney, Australia, <sup>3</sup>University of Arkansas, Fayetteville, AR (033)

Integrated weed management (IWM) tools of winter annual grasses (WAG) are required to extend herbicide effectiveness and provide more alternatives in wheat fields. Feral rye (FR), downy brome (DB), and jointed goatgrass (JGG) are problematic WAG in Colorado. Harvest weed seed control (HWSC) methods aim to remove or destroy weed seeds, thereby preventing seed bank enrichment at crop harvest. FR, DB, and JGG have a potential to be controlled with HWSC due to similarities in growth habits with wheat. Post-emergence control of WAG in wheat is limited to imazamox (Clearfield<sup>®</sup> wheat) and quizalofop (CoAXium<sup>®</sup> wheat). Currently, there is no information on the imazamox and quizalofop resistance status for FR, DB, and JGG in Colorado. Our main objectives were to assess the seed retention at harvest and destruction percentage as efficacy indicators of HWSC and to conduct an herbicide resistance survey for FR, DB, and JGG. During 2015 and 2016, 40 wheat fields in eastern Colorado were visited for collections. Four samples were collected in each field. Seed retention was quantified and compared per weed species by counting the seed above the 15 cm fraction of the wheat canopy and on the soil surface. A Harrington seed destructor (HSD) prototype was used to determine the seed destruction percentage per species. Each site was screened for quizalofop (62 g ai ha<sup>-1</sup>) and imazamox (31 g ai ha<sup>-1</sup>) resistance. Averaging across both years seed retention was DB 75%, FR 90%, and JGG 76%. Weed seed destruction percentages were  $\geq 98\%$  for the three species. No

resistance cases were found for quizalofop. Seven samples for which imazamox control was less than expected are currently under further study. HWSC showed potential as an effective IWM tool for weed control. Early detection of herbicide resistance in weeds is crucial for the successful implementation of IWM.

**Horseweed Management in Oklahoma Winter Wheat.** Jodie Crose\*<sup>1</sup>, Misha Manuchehri<sup>1</sup>, Kail Cole<sup>1</sup>, Robert Rupp<sup>2</sup>, Brad Lindenmayer<sup>3</sup>, D. Cummings<sup>4</sup>; <sup>1</sup>Oklahoma State University, Stillwater, OK, <sup>2</sup>FMC, Edmond, OK, <sup>3</sup>Syngenta, Perkins, OK, <sup>4</sup>Dow AgroSciences, Bonham, TX (034)

Quelex (florasulam + halauxifen) and Sentrallas (thifensulfuron methyl + fluroxypyr) are two new postemergence herbicides available for broadleaf weed control in winter wheat and may improve the control of horseweed (*Conyza canadensis* L.) in Oklahoma. To evaluate the efficacy of these herbicides on horseweed, a trial was conducted at Altus, Perkins, and Ponca City, Oklahoma in the spring of 2017. Visual weed control and crop tolerance were estimated every two weeks throughout the growing season. Wheat yield also was recorded at Altus. Horseweed rosette size at time of application was approximately two, four, and six inches in width at Altus, Perkins, and Ponca City, OK, respectively. End of season control of horseweed at Altus was 90% or greater in all treatments with the exception of metsulfuron + chlorsulfuron + MCPA and metsulfuron + 2,4-D. At Perkins, all treatments controlled horseweed 90% or greater with the exception of thifensulfuron methyl + fluroxypyr (low and high rates) + MCPA and 2,4-D alone. Where horseweed rosette size was the largest at Ponca City, only those treatments containing florasulam + halauxifen achieved 90% control or greater. Finally, no visual crop injury was observed following any treatment. An additional year of data will be collected to support these findings.

**The Development and Management of ACCase Resistant Italian Ryegrass in Oklahoma.** Grace Ogden\*<sup>1</sup>, Misha Manuchehri<sup>2</sup>, Adam Hixson<sup>3</sup>, Kail Cole<sup>2</sup>, Jodie Crose<sup>2</sup>; <sup>1</sup>, Stillwater, OK, <sup>2</sup>Oklahoma State University, Stillwater, OK, <sup>3</sup>BASF, Lubbock, TX (035)

Acetyl-CoA carboxylase (ACCase) resistance has been suspected in populations of Italian ryegrass [*Lolium perenne* L. spp. *multiflorum* (Lam.) Husnot] in Oklahoma winter wheat. A study was conducted in the 2016-17 and 2017-18 winter wheat growing seasons at the Cimarron Valley Research Station near Perkins, OK to evaluate weed management systems that included pyroxasulfone, flufenacet, metribuzin, and pinoxaden applied delayed preemergence (DPRE) and/or postemergence (POST). Italian ryegrass efficacy rates were 95% or above for treatments containing pyroxasulfone in 2016-17. At harvest, treatments containing pyroxasulfone had 97% control or better. Nontreated plots yielded 329 kg ha<sup>-1</sup> of Italian ryegrass seed, while pyroxasulfone treatments yielded up to 36 kg ha<sup>-1</sup>, some yielding no detectable Italian ryegrass seed at all. Pinoxaden + metribuzin applied very early POST produced 227 kg ha<sup>-1</sup> of Italian ryegrass seed on average, the most of all the treatments by over 50 kg ha<sup>-1</sup>. In 2017, rainfall was not received at the site until 37 days after application. This resulted in limited Italian ryegrass control, especially from treatments that did not include a postemergence herbicide. During the 2016-17 field season, potential ACCase resistant Italian ryegrass populations were observed within the trial. Weed seed was separated from each harvested plot, and based on observed areas of resistance, the seed was planted for a greenhouse screening. Preliminary greenhouse screens

suggest that ACCase resistant Italian ryegrass populations likely exist in the field; however, a study is in progress to confirm.

**Effects of Synthetic Auxin Herbicides on Seed Production and Seed Viability of Herbicide Resistant Populations of Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) in Western Oregon.** Lucas Kopecky Bobadilla\*<sup>1</sup>, Felipe Augusto Stella<sup>2</sup>, Dan W. Curtis<sup>1</sup>, Andy G. Hulting<sup>1</sup>, Carol Mallory-Smith<sup>1</sup>; <sup>1</sup>Oregon State University, Corvallis, OR, <sup>2</sup>University of Sao Paulo, Piracicaba, Brazil (36)

Farmers worldwide have been struggling to manage herbicide-resistance for several decades. New suppression approaches for herbicide-resistant species are needed. Italian ryegrass is a species that exhibits herbicide-resistance and causes yield loss in many crops. Synthetic auxin herbicides have been used in rangelands to suppress seed production and seed viability of annual grass weed species. The objective of this study was to test the impact of synthetic auxin herbicides on seed viability of Italian ryegrass and the feasibility of implementing this management in agricultural areas. A field trial and a greenhouse trial were conducted in 2017. Five different synthetic auxin herbicides were applied to two growth stages (45 and 65 in the BBCH scale) of both Italian ryegrass and tall fescue. In the greenhouse trial, four resistant Italian ryegrass populations were tested while in the field trial tall fescue and Italian ryegrass cultivars were used. The experimental designs were completely randomized blocks. Standard seed quality tests were conducted to determine the effects of treatment. In both experiments, only aminopyralid showed effects on seed production. A more significant effect in the tall fescue grass was quantified. Seed weight was reduced 46% (tall fescue) and 32% (ryegrass). Seed viability was reduced in 93% (tall fescue) and 65% (ryegrass). No variation in seed vigor and germination speed was observed. There was a difference in the response between the biotypes of Italian ryegrass. Results indicate that this practice is not feasible for managing Italian ryegrass in tall fescue seed production due to possible crop injury.

**Grass Weed Control in Kentucky Bluegrass and Perennial Ryegrass.** Amber L. Hauvermale\*, Rachel J. Zuger, Ian C. Burke; Washington State University, Pullman, WA (037)

Downy brome (*Bromus tectorum* L.), rattail fescue (*Vulpia myuros* (L.) C.C. Gmel.), alkali grass (*Puccinellia distans* (Jacq.) Parl.), and annual bluegrass (*Poa annua* L.) are problematic grass weeds in the Kentucky bluegrass and perennial rye grass seed production systems in the Inland Pacific Northwest. Management relies extensively on currently labeled herbicides for PRE and POST emergence control especially in the first year of crop establishment. Recent research identified two promising active ingredients, pyroxasulfone and indaziflam, for use in turfgrass, and suggested both were effective for grass weed control when applied PRE. However, the specific effects on Kentucky bluegrass and perennial ryegrass seedling emergence and stand establishment remained unclear. When following a PRE-application of mesotrione, POST applied herbicides like glufosinate also appeared to be safe for both Kentucky bluegrass and perennial ryegrass once seedlings were established while providing some control of weedy grass species. We evaluated the safety and efficacy of PRE-applications of pyroxasulfone or indaziflam in combination with mesotrione in field trials of Kentucky bluegrass, perennial ryegrass, downy brome, rattail fescue, alkali grass, and annual blue grass at Central Ferry, WA and Othello, WA, in 2017. Results indicate that both pyroxasulfone and indaziflam with or without mesotrione provide partial to complete control of all four grass weed species eight weeks

after treatment. Treatments also reduced Kentucky bluegrass and perennial ryegrass seedling emergence and stand establishment compared to untreated checks. However, perennial ryegrass was less sensitive than Kentucky bluegrass to herbicide treatments suggesting there may be some natural variation among species.

**Using a Leaf Tissue Test for Glyphosate and Dicamba Drift Injury to Field Peas and Dry Beans.** Mike H. Ostlie\*<sup>1</sup>, Gregory J. Endres<sup>1</sup>, Brian Jenks<sup>2</sup>, Harlene Hatterman-Valenti<sup>3</sup>, Andrew Robinson<sup>4</sup>, Rich Zollinger<sup>3</sup>; <sup>1</sup>North Dakota State University, Carrington, ND, <sup>2</sup>North Dakota State University, Minot, ND, <sup>3</sup>North Dakota State University, Fargo, ND, <sup>4</sup>North Dakota State University / University of Minnesota, Fargo, ND (038)

Field pea and dry bean are crops known to be sensitive to dicamba and glyphosate. The release of dicamba-tolerant soybean varieties has prompted concern about drift events to field pea and dry bean fields proximate to soybeans. Plant tissue tests are viewed as an option by producers to test for the presence of a particular herbicide. The question becomes whether the tissue tests can be predictive of yield response. Studies were conducted in 2015 and 2016 in dry bean and field pea to determine if tissue tests could be a reliable predictor of yield loss. Three sub-lethal doses of glyphosate and dicamba were applied alone and together. Visual injury ratings and leaf samples were taken and analyzed 10 and 20 DAT. Maturity, yield, and quality were measured. Field peas were not heavily affected by the herbicide doses used in this study. Yield losses were only realized with the combination of glyphosate and dicamba, but not either product alone. Maturity was delayed by the highest rates of glyphosate and dicamba alone and together. Yield was severely affected by high rates of both herbicides. Leaf tissue tests for both crop was variable, while visual injury evaluations were correlated to yield loss. The trend was that leaf dicamba concentration increased with increasing dicamba dose. However, the concentrations varied by environment. Glyphosate concentration was too erratic in tissue tests to arrive at any conclusion. Although tissue tests can be used to test for the presence of either herbicide, the concentration from any given sample is not sufficient to predict a yield response.

**Rescue Treatment Options for Glyphosate-Resistant Palmer Amaranth in Sugarbeet.** Clint W. Beiermann\*<sup>1</sup>, Nevin C. Lawrence<sup>2</sup>, Stevan Z. Knezevic<sup>3</sup>, Amit J. Jhala<sup>1</sup>, Cody Creech<sup>4</sup>; <sup>1</sup>University of Nebraska-Lincoln, Lincoln, NE, <sup>2</sup>University of Nebraska-Lincoln, Scottsbluff, NE, <sup>3</sup>University of Nebraska-Lincoln, Concord, NE, <sup>4</sup>University of Nebraska, Scottsbluff, NE (039)

Glyphosate-resistant Palmer amaranth is an emerging challenge to sugarbeet production in Western Nebraska. Premixtures of phenmedipham and desmedipham applied alone and in combination with other herbicides have demonstrated excellent control of Palmer amaranth in other sugarbeet production regions. Therefore, a study was initiated to determine the optimal timing of phenmedipham plus desmedipham based rescue treatments. Four POST herbicide treatments were applied at six timings, ranging from Palmer amaranth emergence until 28 days after emergence. Treatments included clopyralid (316g AE ha<sub>-1</sub>); phenmedipham (273g AI ha<sub>-1</sub>) and desmedipham (273g AI ha<sub>-1</sub>) applied as a prepackaged mixture; clopyralid plus phenmedipham and desmedipham; and clopyralid, phenmedipham and desmedipham, plus acetochlor (1050g AI ha<sub>-1</sub>). Plots were rated for Palmer amaranth control and sugarbeet injury each week after application. Clopyralid, phenmedipham, desmedipham, and acetochlor applied together within the first week of Palmer amaranth emergence provided 75% control two weeks

after treatment (WAT) and caused a 50% reduction in sugarbeet vigor relative to non-treated controls. However, by four WAT Palmer amaranth had recovered, while sugarbeet remained heavily injured. At four WAT the trial was ended, as the sugarbeet crop began to be displaced by Palmer amaranth. At the conclusion of the trial sugarbeet root weight, Palmer amaranth density, and biomass were recorded. There was no effect of treatment on sugarbeet yield, Palmer amaranth biomass, or density four WAT. None of the evaluated rescue herbicide treatments provided adequate control, which suggests some Palmer amaranth populations in Western Nebraska may be resistant to phenmedipham and desmedipham.

### **Variable Tolerance of Common Lambsquarters to Glyphosate in Corn-Sugarbeet Fields.**

Prashant Jha<sup>\*1</sup>, Vipin Kumar<sup>2</sup>, Don W. Morishita<sup>3</sup>, Ramawatar Yadav<sup>1</sup>, Anjani J<sup>1</sup>, Charlemagne Alexander A. Lim<sup>1</sup>; <sup>1</sup>Montana State University, Huntley, MT, <sup>2</sup>Kansas State University, Hays, KS, <sup>3</sup>University of Idaho, Kimberly, ID (040)

Common lambsquarters (*Chenopodium album*) is among the most problematic weed species in corn and sugar beet fields across the western United States. During summer/fall of 2016, two common lambsquarters biotypes (ID-13 and ID-14) surviving the field-use rates (870 g ae ha<sup>-1</sup>) of glyphosate were identified from sugarbeet fields in south central Idaho. These fields were under continuous corn–sugarbeet rotations, with frequent use of glyphosate for weed control. During spring 2017, a common lambsquarters biotype surviving glyphosate applications was also collected from a corn field near Laurel, Montana. The main objectives of this research were (1) to confirm and characterize the response of those selected common lambsquarters biotypes to glyphosate and (2) investigate the underlying mechanism(s) of enhanced glyphosate tolerance. Seeds of a known glyphosate-susceptible common lambsquarters biotype (GS) were collected from a field near Huntley, MT, with no history of glyphosate use. Seedlings from each selected biotype were grown in a greenhouse at the MSU Southern Agriculture Research Center, Huntley, MT. Whole-plant glyphosate dose-response experiments were conducted in a randomized complete block design, with 8 replications and repeated in time. Glyphosate doses include: 0, 281, 562, 870, 1125, 2250, and 4500 g ae ha<sup>-1</sup>. Ammonium sulfate at 2% wt/v was included with each treatment. Percent injury was visually assessed and shoot dry weight was determined at 21 d after treatment (DAT). To determine the underlying mechanism, the *EPSPS* (5-enolpyruvylshiki mate-3-phosphate synthase) gene was analyzed for known target-site mutations and gene duplication. Based on the visible injury and shoot dry weight response (LD<sub>90</sub> and GR<sub>90</sub> values), three selected biotypes had 2.5- to 3.0-fold elevated tolerance to glyphosate relative to the GS biotype. Sequencing of partial *EPSPS* gene at threonine 102 and proline 106 codons revealed no differences between the tolerant and GS biotypes. Furthermore, no differences in the *EPSPS* gene copy numbers were observed. Studies on [<sup>14</sup>C]-glyphosate uptake and translocation among tolerant vs. GS biotypes are currently under progress. These results confirm the evolution of common lambsquarters biotypes with enhanced tolerance to glyphosate in corn-sugar beet fields in this region. Growers should adopt diversified weed control tactics to prevent further development of common lambsquarters biotypes with an elevated tolerance to glyphosate in corn-sugar beet rotations.

**Herbicide Options for Weed Management in Dormant-Seeded Safflower.** Earl Creech<sup>\*1</sup>, Corey V. Ransom<sup>1</sup>, Mike Pace<sup>2</sup>, Clark Israelsen<sup>1</sup>; <sup>1</sup>Utah State University, Logan, UT, <sup>2</sup>Utah State University, Brigham City, UT (041)

Abstract not available

**Evaluation of Herbicide Options for Kochia Control in Western North Dakota.** Daniel Giumaraes Abe\*, Caleb Dalley; North Dakota State University, Hettinger, ND (042)

Late-emerging kochia that is not controlled during the cropping season can become problematic following harvest of small grains. Seed produced by these late flushes of kochia increase the weed seedbank and can spread infestation to neighboring farms and fields. Identification of herbicides that could be used to control kochia post-harvest, especially large kochia is needed. Trials were conducted to evaluate herbicides for kochia control post-harvest at three locations. In these trials, kochia was beyond typically recommended ideal heights for control ranging from 23 cm (9 in) at Location One to 61 cm (24 in) at Location Three. All treatments were applied using a tractor-mounted research sprayer at 94 L/ha (10 gal/A). At Location One, glyphosate (1680 g ae/ha) was ineffective at controlling kochia with only 28% control at 30 DAT. The addition of fluroxypyr (196 g ae/ha) to glyphosate (840 g/ha) increased kochia control to 53% at 30 DAT, which was better than either glyphosate alone or fluroxypyr alone. The addition of 2,4-D LV6 (392 g ae/ha) or dicamba (140 g ae/ha) to fluroxypyr treatments resulted in 45 and 55% control. The premix of fluroxypyr and clopyralid resulted in 78% control 30 DAT. Paraquat (840 g/ha) provided the greatest control of kochia with 90% control 20 DAT; however, by 30 DAT, control fell to 85% at 30 DAT due to regrowth. At Location Two, glyphosate was much more effective, resulting in 85% kochia control 30 DAT. Fluroxypyr (275 g/ha) tank mixed with glyphosate (840 g/ha), 2,4-D (785 g/ha), or dicamba (280 g/ha) controlled kochia 80, 79, and 79%, respectively 30 DAT, which was better than fluroxypyr alone (68%). Again, paraquat (840 g/ha) provided the greatest control of kochia with 98% control 7 DAT, which fell to 95% at 30 DAT. At Location Three, glyphosate was very effective at controlling kochia (99% at 30 DAT). Fluroxypyr tank-mixed with glyphosate resulted in similar control to that of glyphosate alone. Fluroxypyr alone or tank-mixed with 2,4-D, dicamba, or fluroxypyr resulted in around 70% control. Paraquat again provided excellent control (98% at 30 DAT). The differential response of kochia to glyphosate is worrisome as resistance to glyphosate is an increasing problem. The less than satisfactory response of kochia to fluroxypyr was likely related to the large size of kochia at time of application. This shows the need for following recommendations for applying fluroxypyr when kochia is less than 10 cm (4 in) in height. Paraquat was the most consistent treatment for controlling large kochia plants in this trial, although there is some concern with regrowth following treatment, especially if coverage is less than ideal.

**Variable Response of Kochia Populations to Dicamba and Fluroxypyr.** Vipin Kumar<sup>\*1</sup>, Phil Stahlman<sup>1</sup>, Randy Currie<sup>2</sup>, Ryan Engel<sup>3</sup>, Grant Boyer<sup>1</sup>; <sup>1</sup>Kansas State University, Hays, KS, <sup>2</sup>Kansas State University, Garden City, KS, <sup>3</sup>Fort Hays State University, Hays, KS (043)

Evolution and rapid spread of glyphosate-resistant (GR) kochia has escalated the utility of auxinic herbicides (dicamba and fluroxypyr) in the US Great Plains. Frequent reliance on auxinic herbicides for controlling GR kochia may also enhance the evolution of cross-resistance to these chemistries in kochia populations. The main objectives of this study were to (1) determine the variation in response to dicamba and fluroxypyr, and (2) characterize the dicamba resistance levels among kochia populations collected from western Kansas. Seeds of individual kochia plants surviving two applications of fluroxypyr at field-use rate (157 g ae ha<sup>-1</sup>) were collected from two different corn fields (designated as KS-4 and KS-10) near Garden City, KS. The

sampled fields were under wheat-fallow-wheat rotation for > 6 years followed by corn (for KS-4 field) or a wheat-corn-fallow rotation (for KS-10 field) with frequent use of dicamba and fluroxypyr herbicides. Discriminate-dose experiments with dicamba (560 g ae ha<sup>-1</sup>) and fluroxypyr (235 g ae ha<sup>-1</sup>) were conducted by using progeny seeds of each individual kochia plant. Results indicated that progeny seedlings of each collected kochia plant for KS-4 and KS-10 population had 77 to 100% and 84 to 100% survivors with dicamba and fluroxypyr treatment, respectively, at 28 d after treatment (DAT). In a separate dose-response study, two putative dicamba-resistant (DR) kochia populations (KS-110 and KS-113) and one dicamba-susceptible (SUS) population collected from field research plots near Hays, KS, were also characterized for dicamba resistance. Dose-response experiments were conducted in a randomized complete block design, with 12 replications and repeated twice. Dicamba doses ranging from 0, 280, 560, 1120, 1680, 2240, and 2800 g ae ha<sup>-1</sup> were tested. Results indicated that 5.5- and 3.1-fold higher dicamba dose was required to obtain 50% fresh weight reduction (I<sub>50</sub>) of KS-110 and KS-113 population, respectively, compared to the SUS population. Furthermore, about 1,334 and 837 g ha<sup>-1</sup> of dicamba was needed to achieve a 50% shoot dry weight reduction (GR<sub>50</sub>) in KS-110 and KS-113 population, respectively. Based on dry weight response, the KS-110 and KS-113 population had 8.2- and 5.1-fold resistance levels to dicamba, respectively. These results confirm the co-evolution of cross-resistance to dicamba and fluroxypyr in kochia populations from Garden city, and moderate to high level resistance to dicamba in Hays populations. Growers should adopt dicamba use stewardship programs and utilize multiple effective modes of action herbicides and other ecological-based approaches to prevent further evolution of cross-resistance to dicamba and fluroxypyr in kochia populations on their production fields.

**Management of Glyphosate- and Dicamba-Resistant Kochia (*Kochia scoparia*) in Roundup Ready® Xtend Soybean.** Ramawatar Yadav\*<sup>1</sup>, Prashant Jha<sup>1</sup>, Vipin Kumar<sup>2</sup>, Shane Leland<sup>1</sup>; <sup>1</sup>Montana State University, Huntley, MT, <sup>2</sup>Kansas State University, Hays, KS (044)

The recent commercialization of Roundup Ready 2 Xtend® soybean will allow growers to use dicamba (low-volatile formulations) to control glyphosate-resistant weeds, including kochia. Field experiments were conducted in 2017 at the Montana State University Southern Agricultural Research Center, Huntley, MT to develop effective herbicide programs to control glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend® soybean. Nine different herbicide combinations were evaluated, which included sulfentrazone + glyphosate or pyroxasulfone + glyphosate alone or with dicamba (Engenia™) PRE, or PRE followed by (fb) dicamba + glyphosate POST. Treatments were arranged in a randomized complete block design, with four replications. Plots were infested with an equal proportion of glyphosate- and dicamba-resistant kochia at the time of soybean planting. Only plots treated with sulfentrazone had 10 to 20% early-season visual injury to soybean. A single application of sulfentrazone PRE provided complete, season-long control of glyphosate- and dicamba-resistant kochia. Addition of dicamba with pyroxasulfone PRE program improved kochia control to 89 to 91% compared with 53 to 69% control with pyroxasulfone alone PRE at 3 to 9 WAPRE. Kochia density at 9 WAPRE, dry biomass and seed production at harvest were reduced by 94, 93 and 91%, respectively, in pyroxasulfone + dicamba PRE compared with pyroxasulfone alone PRE. Low to moderate levels of early-season soybean injury caused by sulfentrazone did not translate into yield loss. In conclusion, PRE soil-residual herbicides investigated in this study will serve as a foundation for dicamba- and glyphosate-resistant kochia management in Roundup Ready 2 Xtend® soybean.

**Desert Cotton Sensitivity to 2,4-D and Dicamba.** William B. McCloskey<sup>1</sup>, Randy Norton<sup>2</sup>;  
<sup>1</sup>University of Arizona, Tucson, AZ, <sup>2</sup>University of Arizona, Safford, AZ (045)

Experiments were conducted at the University of Arizona Red Rock Agricultural Center to measure the response of cotton to simulated drift rates of dicamba (2016) and 2,4-D (2017). The auxin herbicides were applied at 4 cotton growth stages; first square (FS; i.e., first flower bud), first square+2 weeks (FS+2WK), first flower (FF) and first flower + 2 weeks (FF+2WK). The 1X dicamba dose on dicamba-tolerant cotton is 0.5 lb ae/A; dicamba (Clarity formulation) was applied at 1X, 1/10X, 1/50X, 1/100X, 1/500X. Cotton was planted on April 20, 2016 and the treatments were sprayed on 6/15 (FS), 6/28 (FS+2WK) 7/8 (FF) and 7/28 (FF+2WK). The 1X 2,4-D dose on 2,4-D-tolerant cotton is 0.95 lb ae/A; 2,4-D (Enlist One formulation) was applied at 1/2X, 1/10X, 1/50X, 1/100X, 1/500X. Cotton was planted on April 27, 2017 and the treatments were applied on 6/23, 7/6, 7/21, and 8/7. The herbicides were applied with a CO<sub>2</sub> pressurized backpack sprayer using a boom equipped with four TTI-110015 air induction nozzles on 20-inch centers calibrated to deliver 15.6 GPA at 45 PSI. All herbicide treatments include a non-ionic surfactant at 0.25% v/v. A factorial design with four replications was used arrange the 2-row plots that were 6.67 feet by 38 feet. There were several buffer rows of cotton between plots and a shield was used to limit downwind drift from the applications. Dicamba at 1X (0.5 lb ae/A) caused substantial cotton injury and delayed flowering and boll development but did not kill the plants. The lint yield was 1,378, 994, 338 and 573 lb/A for the FS, FS+2WK, FF, and FF+2WK growth stages, respectively, compared to the control yield of 2,228 lb/A. In contrast, 2,4-D at 1/2X (0.45 lb ae/A) killed almost all of the cotton plants when sprayed at FS and FS+2WK growth stages and the lint yields at the FF and FF+2WK growth stages were 48 and 466 lb/A, respectively. Neither dicamba and 2,4-D at the 1/500 dose significantly reduced lint yield. Dicamba at the intermediate doses (1/10X, 1/50X and 1/100) caused significant to minor foliar injury symptoms but did not reduce yields except the 1/10X dose at the FF+2WK growth stage. In contrast, 2,4-D at the intermediate doses (1/10X, 1/50X and 1/100) caused substantial to severe injury and reduced lint yield 37 to 95% as the dose increased. These data are consistent with previous research and demonstrate that cotton is far more sensitive to 2,4-D than to dicamba.

**Effect of Crop Rotation, Tillage and Herbicide Diversity on R:S Ratio of Kochia Seed Bank Over Four Years.** Charlemagne Alexander A. Lim<sup>\*1</sup>, Elizabeth G. Mosqueda<sup>2</sup>, Prashant Jha<sup>1</sup>, Andrew Kniss<sup>2</sup>, Gustavo M. Sbatella<sup>3</sup>, Nevin C. Lawrence<sup>4</sup>, Shane Leland<sup>1</sup>, Anjani J<sup>1</sup>; <sup>1</sup>Montana State University, Huntley, MT, <sup>2</sup>University of Wyoming, Laramie, WY, <sup>3</sup>University of Wyoming, Powell, WY, <sup>4</sup>University of Nebraska-Lincoln, Scottsbluff, NE (046)

The increase in confirmed cases of herbicide-resistant (HR) and multiple herbicide-resistant (MHR) kochia [*Kochia scoparia* (L.) Schrad] over recent years has become a very serious concern for producers in the western US. We hypothesized that the diversity in crop rotations, tillage, and herbicide use patterns would be a viable approach to mitigate HR weed seed banks. A four-year study was conducted at the Southern Agricultural Research Center in Huntley, MT to determine the effect of tillage, crop rotation, and herbicide use diversity on an ALS inhibitor-resistant kochia seed bank. In the fall of 2013, kochia seeds with a known ALS Resistant (R): Susceptible (S) ratio (5%) were uniformly broadcasted in the field to establish an experimental Kochia seed bank. A split-split plot in a randomized complete block design with four replications was used, with tillage (conventional tillage or minimum tillage) as the whole plot factor, crop



rotation diversity (corn-corn-corn-corn, corn-sugar beet-corn-sugar beet, corn-dry bean-sugar beet-corn, or corn-dry bean-barley-sugar beet) as the split-plot factor, and herbicide use pattern (complete reliance on ALS inhibitors, mixture of ALS and non-ALS inhibitors, or annual rotation to ALS inhibitors) as the split-split plot factor. Experimental plots were 4 m wide by 15 m long, with a total of 96 plots. Data on kochia seedling density, percent control, seeds plant<sup>-1</sup>, residual soil seed bank plot<sup>-1</sup> were collected in each growing season (2014 through 2017).

Kochia from the soil samples collected plot<sup>-1</sup> in the field were divided into two sub-samples: one for exhaustive germination and other for determining the R:S ratio. Emerged seedlings per tray (plot) were sprayed with Ally Extra (thifensulfuron + tribenuron + metsulfuron) at 0.187 g ai ha<sup>-1</sup> when 8 to 10 cm tall. The proportion (%) of resistant individuals plot<sup>-1</sup> was determined by counting the number of survived and dead plants 21 days after the herbicide treatment. The third year of the study (2016) showed that the main effects of crop rotation diversity and herbicide use pattern and their interaction were significant. Tillage did not influence the R:S ratio of the seed bank. The proportion of R kochia individuals (% of total) in the soil seed bank after three years under corn-dry bean-sugar beet-corn and corn-dry bean-barley-sugar beet rotations were lower (75% and 65%, respectively) compared with the continuous corn (93%) or corn-sugar beet-corn-sugar beet rotation (89%). For the herbicide use pattern, the proportion of R in the soil seed bank of plots treated with a mixture of ALS and non-ALS inhibitors was 72% which was lower compared to plots treated with complete reliance on ALS inhibitors (89%) and annual rotation to ALS inhibitors (81%). More so, the proportion of R individuals in the soil seed bank in the presence of mixtures of ALS and non-ALS inhibitors under corn-dry bean-sugar beet-corn and corn-dry bean-barley-sugar beet rotations were 67 and 51%, respectively, which were lower compared with the soil seed bank under continuous corn, treated with ALS inhibitors only (100%), after three years of the study. A diverse crop rotation program which employs different cultural management practices (planting dates, harvest dates, crop canopy) in conjunction with the use of herbicide mixtures would be effective in reducing the R:S ratio of an herbicide-resistant weed population.

**Effects of Selected Adjuvants on Weed Control with Glufosinate-ammonium in Colorado and South Dakota.** Jim Daniel\*<sup>1</sup>, Eric Westra<sup>2</sup>, Phil Westra<sup>2</sup>, Paul Johnson<sup>3</sup>; <sup>1</sup>Daniel Ag Consulting, Keenesburg, CO, <sup>2</sup>Colorado State University, Fort Collins, CO, <sup>3</sup>South Dakota State University, Brookings, SD (047)

Abstract not available

**Influence of Shade and Drought on the Control of Junglerice (*Echinochloa colona*) with Postemergence Herbicides.** Anil Shrestha\*, Ryan Cox, Mala To, Jorge Angeles; California State University, Fresno, CA (138)

Abstract not available

#### **Project 4. Teaching and Technology Transfer**

**Kansas Mesonet Real-Time Temperature Inversion Decision Tool.** Christopher Redmond, Dallas Peterson, Curtis R. Thompson\*; Kansas State University, Manhattan, KS (048)

Temperature inversions have often been implicated in facilitating drift of herbicides to non-target sites. Several herbicide labels now prohibit application during a temperature inversion, but many applicators are not familiar with when and how frequently temperature inversions occur. Inversions are anomalies in the lowest layer of the atmosphere, when temperatures increase with height, usually correlated to the loss of longwave radiation from the Earth's surface. Unfortunately, it is often very difficult to discern the presence of an inversion in the field. For this reason, the Kansas Mesonet underwent an upgrade that included adding a second 10 meters high temperature/humidity sensor to tower stations. This upgrade coincides with the already existing 2 meter temperature/humidity sensor. With two temperature measurements at different heights, the Mesonet is able to provide a small vertical profile of the lower atmosphere. This lowest layer provides insight into the vertical mixing from inversion development and their subsequent influence on smoke dispersal, spraying results, and temperature forecasting. Utilizing the 10 and 2 meter temperature measurements, the Mesonet is able to provide regional guidance on inversion development, strength, and climatology at respective weather stations on the network. This data is provided free of charge on the Kansas Mesonet webpage ([mesonet.k-state.edu/agriculture/inversion](http://mesonet.k-state.edu/agriculture/inversion)) and is updated every five minutes. Through this tool, users can determine the presence of inversions and monitor inversion trends at each respective station. Historical inversion and wind data may also provide valuable insight regarding the average number of hours suitable for spraying during critical periods and with diagnosing possible drift problems.

**2017 EPA Tour of Western Kansas.** Dallas Peterson<sup>1</sup>, Phil Stahlman<sup>2</sup>, Curtis R. Thompson\*<sup>1</sup>, Anita Dille<sup>1</sup>, Mithila Jugulam<sup>1</sup>, Randy Currie<sup>3</sup>, Michael Barrett<sup>4</sup>, Jill Schroeder<sup>5</sup>, Lee Van Wychen<sup>6</sup>; <sup>1</sup>Kansas State University, Manhattan, KS, <sup>2</sup>Kansas State University, Hays, KS, <sup>3</sup>Kansas State University, Garden City, KS, <sup>4</sup>University of Kentucky, Lexington, KY, <sup>5</sup>USDA Office of Pest Management Policy, Washington, DC, <sup>6</sup>WSSA - Director of Science Policy, Alexandria, VA (049)

The Weed Science Society of America (WSSA) has co-sponsored a number of educational tours for EPA staff since 2009. The tours have provided a firsthand learning experience on a wide range of weed management issues, including herbicide resistance, aquatic use permits, pollinator protection, and application technologies in crop and non-crop areas that impact herbicide registrations and use guidelines. A hallmark of these tours has been the opportunity for direct dialogue between EPA personnel and growers, applicators, crop consultants, land and water managers, food processors, equipment manufacturers, and university research and extension. Previous tours have included stops in FL, NM, MO, IL, AR, MD, DE, and IA. In August 2017, a 3-day tour in western Kansas was organized by Phillip Stahlman, Kansas State University and Michael Barrett, WSSA-EPA Liaison. The arid High Plains region of the U.S. poses a unique set of challenges for weed management. Fourteen EPA staff from the Office of Pesticide Programs participated in the tour, which was hosted by Kansas State University with support from WSSA and several commodity organizations. The goals of the tour were to: 1) help EPA staff better understand dryland cropping systems and the difficulties of managing herbicide resistant weeds in rainfall-limited environments; 2) provide EPA staff an opportunity to visit with local farmers, crop advisors, and applicators about the regulatory process and the practicality of different application requirements; and 3) allow farmers and crop advisors to provide feedback on the tools they need to successfully manage herbicide resistant weeds. Some of the key points raised by farmers and applicators included: 1) the most problematic weeds in the High Plains regions

include Palmer amaranth, kochia, horseweed, and tumble windmillgrass; 2) herbicide resistant weeds are threatening the continued use of no-till cropping systems, which are critical for soil and water conservation, soil structure, soil health, crop yields, yield stability, and profitability; 3) continued availability of atrazine, dicamba, 2,4-D, and paraquat are important to help manage weeds in dryland cropping systems; 4) barriers to develop and register new herbicide sites of action need to be minimized; 5) avoid application requirements that are impractical and consider differences between geographies and different production systems; and 6) solicit input from practitioners regarding critical registration and application requirement decisions.

**Initiation of the North American Kochia Working Group.** Todd Gaines\*<sup>1</sup>, Phil Westra<sup>1</sup>, Roger E. Gast<sup>2</sup>, Rory Degenhardt<sup>3</sup>; <sup>1</sup>Colorado State University, Fort Collins, CO, <sup>2</sup>Dow AgroSciences, Indianapolis, IN, <sup>3</sup>Dow AgroSciences, Edmonton, AB (050)

Discussions during 2017 have led to the formation of the North American Kochia Action Committee. The objectives of the NA Kochia Action Committee are to 1) develop and coordinate a strategy for HR kochia research (including funding mechanisms); 2) foster industry/ government/ university collaborations, communication, and extension; 3) build stewardship guidelines, technical bulletins, and best management practices for farmers to assist in integrated management of herbicide-resistant kochia. A long term goal is to sustain existing management tools. Short term steps for the committee include developing a proposal for the scope of the committee, soliciting volunteers for planning from the US and Canada, and developing a working group charter.

**Using a Structured Decision Making Tool to Update the Utah Noxious Weed List and Guide.** Heather E. Olsen\*, Corey V. Ransom, Ralph E. Whitesides; Utah State University, Logan, UT (051)

In 1971 the Utah Noxious Weed Act (Title 4 Chapter 17) was passed into Utah state law. In 2014, the state weed board reviewed the species included on the noxious weed list and decided that changes were in order, including a restructuring of the noxious weed categories and adding new species to the list. To re-evaluate the former list -as well as assess proposed additional species from surrounding states weed lists - the Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDT) was utilized.

The IPIEDT is a structured decision making tool that runs on an Access database. It was designed and built by a partnership between Utah State University (USU) and the U.S. Fish and Wildlife Service (FWS) to help land managers prioritize weed species for inventory in a transparent and repeatable manner. For land managers using the IPIEDT, species and areas can be evaluated and ranked. However, for the re-evaluation of the noxious weeds list, only the species prioritization section was used. This section ranks plants based on invasiveness, known extent/abundance, potential for further spread, and any regional legal designations. The higher score a plant receives, the higher priority it is for inventory, or in this case a higher priority for inclusion on the noxious weed list. A total of 153 species were considered for inclusion on the new noxious weed list.

In 2016 the changes to the law were approved; all species previously on the list remained on the list and an additional 27 species were added to bring the total to 54 species. The categories for

the list were also restructured with the addition of watch species not known to be in Utah but found in adjacent states and a category to prohibit sales. A few species which would have ranked low were included on the list as Category 4 species in order to prohibit them from being sold in the state. USU partnered with the Utah Weed Supervisors Association to compile photos and distribution information to update a new Utah Noxious Weed Field Guide, which was published in 2017.

## **Project 5. Basic Biology and Ecology**

**Bindweed Root and Shoot Development and the Potential to Disrupt Dormancy and Improve Control.** Jeremy R. Thompson\*<sup>1</sup>, Lynn M. Sosnoskie<sup>2</sup>, Ian C. Burke<sup>1</sup>; <sup>1</sup>Washington State University, Pullman, WA, <sup>2</sup>University of California Cooperative Extension, Merced, CA (052)

Field bindweed (*Convolvulus arvensis*) is one of the most difficult to control perennial weeds in the world. This, in large part, is due to the characteristics that define field bindweed's root system including a deep vertical taproot, carbohydrate rich rhizomes, and dormant root buds from which the plant can regrow. Many management strategies are largely ineffective against field bindweed. Thus, a novel approach to control field bindweed is needed. The literature suggests exogenous applications of plant growth regulators can break rhizomatous bud dormancy and increase herbicide efficacy in reed canary grass (*Phalaris arundinacea*) and Japanese knotweed (*Fallopia japonica*). This exploratory study is designed to answer the following questions: 1) At what point does field bindweed perennialize? 2) Will exogenous applications of plant growth regulators force rhizomatous bud break in field bindweed? Plants were grown under greenhouse conditions, at 2 weeks after emergence (WAE), greenhouse grown plants were harvested, with biomass and rhizomatous bud data collected biweekly for 12 weeks. The results suggest that field bindweed begins to develop rhizomatous buds 4 WAE, adding approximately 4 rhizomatous buds each week. We believe field bindweed will possess adequate numbers of rhizomatous buds between 10 and 12 WAE to observe growth regulator effects on bud dormancy in the future. A second small trial was performed under field conditions to observe the effect of exogenous growth regulator applications paired with an herbicide on field bindweed control. The results suggest that exogenous applications of growth regulators paired with a systemic herbicide may improve field bindweed control. However further research is needed. The data obtained will be used to develop a phytochemical/growth regulator plus herbicide dose response to identify the most effective rates prior to moving to the field.

**Winter Wheat: Kin Recognition Under Controlled Conditions.** Osama S. Saleh\*; University of Wyoming, Laramie, WY (053)

The theory of kin recognition suggests when one of two individuals of the same species (or kin) increases its fitness, the result is increasing of its kin fitness, and this supports decreasing competition between them. Aspects of kin recognition have been observed among many different species, where individuals positively interact in benefit of their relatives compared to distantly related species (non-kin). In this study, three experiments were done under greenhouse

conditions to investigate whether winter wheat responds differently to other wheat plants compared to other grass species. Experiments all included winter wheat ‘AP503cl2’ as the main cultivar. This cultivar was grown with other wheat cultivars (‘Avery’, ‘MT1444’, and ‘Denali’) as analog kin cultivars; other crop species (barley, oat, and rye); or with weedy species (downy brome, jointed goatgrass, and foxtail barley). Measurements to assess the response in this study were leaf angles, plant height, root length, and above- and below-ground biomass. Winter wheat leaf angles were more upright when grown together with other wheat individuals ( $p= 0.0007$ ) compared to other crop species ( $p= 0.1165$ ) or weed species ( $p= 0.0645$ ). Winter wheat was more competitive to non-wheat species. Wheat roots grew longer when wheat grew with crops ( $p = 0.0196$ ) and weeds ( $p = 0.0433$ ) compared to wheat cultivars ( $p= 0.0003$ ). Winter wheat grows differently among its kin comparing to crops and weeds of other species.

**Performance of New High Loaded 2,4-D and Dicamba Acid Herbicide Formulations with Built-In Drift Reduction Technology.** Eric Westra\*<sup>1</sup>, Jim Daniel<sup>2</sup>, Phil Westra<sup>1</sup>, Scott Parrish<sup>3</sup>; <sup>1</sup>Colorado State University, Fort Collins, CO, <sup>2</sup>Daniel Ag Consulting, Keenesburg, CO, <sup>3</sup>AgraSyst, Spokane, WA (054)

Abstract not available

**Herbicide Resistance in Spring Wheat.** Tara L. Burke\*, Amber L. Hauvermale, Caleb C. Squires, Arron Carter, Ian C. Burke; Washington State University, Pullman, WA (055)

Wheat comprises one fifth of human caloric intake worldwide. Maintaining sufficient weed control in a crop of such significance is essential if we are to meet the rising demands of an expanding world. For sufficient weed control to occur in the wheat cropping system, new herbicides are needed as a response to the high rate of herbicide resistant weeds which have been able to proliferate within the wheat system. Considering how infrequently new herbicides are released, it is beneficial to utilize the genetic diversity of this polyploid crop to exploit natural tolerances to currently available herbicides from outside the wheat system. To this end, recently identified resistance to the herbicide clethodim has been investigated in spring wheat. Several resistant lines were discovered in a screen of the Washington State University Core Germplasm Collection. Here, the resistant lines were further investigated through greenhouse dose response evaluations of these lines, and of biparental F<sub>2</sub> populations developed using these lines as the resistant parent. Concurrently, clethodim response in downy brome was evaluated, revealing adequate control at levels below the threshold for the resistant wheat lines.

**Ecological Management of Kochia in Irrigated Western Cropping Systems: Approaches and Path Forward.** Prashant Jha\*<sup>1</sup>, Andrew Kniss<sup>2</sup>, Nevin C. Lawrence<sup>3</sup>, Gustavo M. Sbatella<sup>4</sup>, Ramawatar Yadav<sup>1</sup>, Charlemagne Alexander A. Lim<sup>1</sup>; <sup>1</sup>Montana State University, Huntley, MT, <sup>2</sup>University of Wyoming, Laramie, WY, <sup>3</sup>University of Nebraska-Lincoln, Scottsbluff, NE, <sup>4</sup>University of Wyoming, Powell, WY (056)

Stakeholders from across the northern and central Great Plains of the US have identified kochia (*Kochia scoparia*) as one of the most problematic and economically damaging summer annual weeds. This tumbleweed is currently a threat to sustainable crop production due to a near lack of effective herbicide options, especially in sugar beet-based crop rotations. Widespread resistance to many different herbicides (including glyphosate, PS II inhibitors, ALS inhibitors, and

dicamba) has increased the need and the desire for IWM-based solutions for managing this troublesome weed. For this multi-year (2017-2020) research conducted in Huntley, MT; Laramie/Lingle, WY; and Scottsbluff, NE; we propose: 1) quantifying temperature and moisture germination requirements of kochia populations collected from a north-south transect from Montana to Nebraska, and 2) using that information to evaluate the effectiveness of three ecologically-based, IWM strategies, including stale seedbed, cover crops, and diversified crop rotations. We will combine field-validated emergence data, hydrothermal time modeling, and climate data to evaluate non-herbicidal weed control strategies (stale seedbed, cover crops, and diversified crop rotations) that have a high likelihood of reducing kochia seed bank and exposure of this species to herbicide treatments, thereby reducing selection for herbicide resistance evolution across the three-state region. Implementation and adoption of these ecologically-based IWM strategies will reduce potential environmental impacts associated with increased herbicide use, apart from mitigating herbicide resistance. Results from this project (2019-2020) will be disseminated across geographic boundaries.

**Effect of Integrated Kochia (*Kochia scoparia*) Management in a Four Year Rotation Study.** Elizabeth G. Mosqueda\*<sup>1</sup>, Andrew Kniss<sup>1</sup>, Gustavo M. Sbatella<sup>2</sup>, Nevin C. Lawrence<sup>3</sup>, Prashant Jha<sup>4</sup>, David A. Claypool<sup>1</sup>; <sup>1</sup>University of Wyoming, Laramie, WY, <sup>2</sup>University of Wyoming, Powell, WY, <sup>3</sup>University of Nebraska-Lincoln, Scottsbluff, NE, <sup>4</sup>Montana State University, Huntley, MT (057)

Combinations of cultural, mechanical, and chemical control practices are often recommended in agricultural settings to suppress weeds; however, few field studies have quantified the impact of integrated weed management programs on the evolution of herbicide resistant weed species. Kochia (*Kochia scoparia*) is a summer annual tumbleweed which has become problematic for growers throughout western United States, in part, because of evolved resistance to numerous herbicides. A field study was established in Lingle, Wyoming in 2014 and continued through 2017 to quantify the combined impacts of crop rotation, tillage, and herbicide use on kochia. A known proportion of ALS-resistant kochia was established in summer, 2013 prior to imposition of treatments. Tillage treatments (main-plot) included annual intensive tillage or minimum tillage. Four crop rotations (split-plot) consisted of continuous corn, corn-sugarbeet, corn-dry bean-corn-sugarbeet, and corn-dry bean-wheat-sugarbeet. Herbicide treatments (split-split-plot) included complete reliance on ALS inhibitor herbicides, mixtures including ALS inhibitors and another effective mode of action, or an annual rotation between ALS herbicides and non-ALS herbicides. Kochia densities were estimated in summer of all four years of the study by counting the number of kochia plants within randomly placed 1 m<sup>2</sup> quadrants per plot. Data was analyzed using a generalized linear model. Low kochia densities were observed in 2014 (the initial year of the study) for all weed management programs. Kochia density increased steadily through 2016, predominantly in plots which were treated with ALS inhibitors only, contained less diverse crop rotations, and were minimally tilled. A severe hail storm in 2016 reduced kochia densities dramatically in 2017 for all management programs. Throughout all four years of the study, lowest kochia densities were found in plots which were treated with either a mixture including ALS inhibitors or an ALS rotation, contained the most diversified crop rotations, and were intensively tilled. Our data shows that integrating cultural and mechanical practices has the ability to suppress herbicide resistant weed populations at a manageable level just as effectively, if not better, than the best chemical weed management program alone.

## GENERAL SESSION

**Introduction – Meeting Announcements.** Andrew Kniss\*; University of Wyoming, Laramie, WY (060)

**Presidential Address.** Monte D. Anderson\*; Bayer CropScience, Spangle, WA (061)

Change is something we are seeing more often in our daily lives and in our world. This past year was no exception as related to our organization. Some of the changes we have witnessed have included moving to a new business manager, Tara Steinke with IMI, from having Phil Banks of Marathon Ag in this role since 2007. Another significant change was having a joint meeting with the Western Aquatics Plant Management Society last year in Coeur d’Alene, ID. That meeting recorded a high attendance of 330 and was financially beneficial to both organizations. We haven’t met with another organization since the 60’s when we had met jointly with the WSSA twice. Thanks to Arnold Appleby for pointing this out to me as I started my presidency. As we have sold out of Weeds of the West, I believe there’s a new reality that we need to consider more joint meetings, although the WSWS remains financially sound. To that end we are planning to meet jointly with the WSSA in 2020 in Hawaii on the island of Maui. Otherwise, the WSWS cannot afford Hawaii as we’ve done in the past. Together with with Tara Steinke and Eric Gustafson with IMI (WSSA executive manager) and Phil Banks holding upcoming committee or treasurer positions in the WSWS and WSSA, respectively, I am confident that a 2020 joint meeting will be successful financially as well as exciting for our membership.

Change in industry is rapidly changing the makeup of the chemical companies. The landscape of both seed and chemical companies has dramatically changed. Media’s perception of the “big six” manufacturers is quickly becoming the “big four” with the mergers of Dow and DuPont and the plans of Bayer acquiring Monsanto. Syngenta has also been impacted by the purchase by Chem China. Due to regulatory issues and insuring competitiveness of the industry, portions of combining companies end up bolstering other companies. It is unknown what these changes will mean to resulting companies and their ability to support organizations such as ours.

If not for many changes in my life and career, I wouldn’t be here as your president. I had no clue growing up that identifying weeds, participating in crops judging, and working in the seed lab would lead to where I am today. Surviving five different company names and the associated moves has been incredible and unexpected. I do enjoy everything about evaluating new herbicides and technologies, as well as the “show and tell” aspects of bringing them to fruition. As president, I view serving the Western Society of Weed Science as a way of giving back to all those who helped me learn about weeds, crops, and herbicides. Looking back and going forward I foresee always “removing a weed” and “planting a seed”. Thanks for the opportunity to serve as your president.

**Washington Update.** Lee V. Van Wychen\*; Weed Science Society of America, Alexandria, VA (062)

## **Director of Science Policy Report**

**WSWS Annual Meeting. Garden Grove, CA, March 8, 2018**

**Congress Avoids Sequestration with 2-Year Budget Agreement:** Congress approved a two-year budget plan on February 9 (Senate 71-28; House 240-186) that was signed into law by the President that raises the sequestration caps on defense and nondefense discretionary spending by nearly \$300 billion over two years. Nondefense discretionary spending (the biggest source of research funding) will get a \$63 billion boost in FY 2018 and an additional \$68 billion in FY 2019. While Congress now has a budget blueprint, they still have to modify and pass an FY 2018 omnibus appropriations bill. Federal agencies will continue to operate on a Continuing Resolution (CR) at FY 2017 levels through **March 23, 2018**. If an appropriations package has not been passed by March 23, we'll have some more March Madness (i.e. gov't shutdown).

**FY 2019 Budget Needs Work:** The President released his FY 2019 budget a few weeks ago and while some parts of it are ok for weed science issues (Hatch Act, Smith Lever, IR-4, AFRI), we will need to work with Congress to restore cuts to USDA-ARS and the Crop Protection and Pest Management programs, as well as several programs important for aquatic weed research and management (GLRI, Sea Grant, APCRP). I will be circulating a letter to the National and Regional Weed Science Society presidents within the next week for their signature, which asks key House and Senate ag appropriators to restore USDA-ARS funding cuts and oppose the 20 ARS lab closures that would be devastating for ARS weed scientists.

**WSSA-EPA Liaison:** Mike Barrett has served as WSSA-EPA Liaison for the past 4 years and made his last visit to EPA in December. I cannot express enough my sincere thanks and appreciation for his incredible service to WSSA in this role! The new liaison, Greg Kruger from the University of Nebraska, has hit the ground running and has already made several visits to EPA, which overlapped with Mike. There is no shortage of weed science issues to deal with and I have complete confidence that Greg will pick things up where Mike left off.

**WSSA-NIFA Fellow:** Donn Shilling has served as WSSA's first USDA-NIFA Fellow for nearly 3 years now working to increase NIFA's understanding of weed science issues and vice-versa. Donn feels the time is right to step down in this role and allow the next NIFA Fellow to build on his efforts. WSSA is currently soliciting applicants for the next NIFA Fellow. **Application deadline: May 1, 2018.** Please contact me if interested.

**USDA Leadership Positions Confirmed:** USDA Secretary- Sonny Perdue (GA); Deputy Secretary- Steve Censky (MN); Under Secretary for Trade and Foreign Agriculture- Ted McKinney (IN); Under Secretary for Marketing and Regulatory Programs- Greg Ibach (NE); Under Secretary for Farm Production and Conservation – Bill Northey (IA).

**2018 Farm Bill Recommendations:** Congress will begin work on a new Farm Bill shortly. Some of the Science Policy Committee recommendations I have been working on include: 1) promote Areawide IPM programs and funding within USDA-NIFA (WSSA & ESA will hold a Congressional briefing on May 10); 2) incentivize cover crop use and crop insurance programs



for weed resistance management; 3) require a National Program Leader for Weed Science in both USDA-ARS and USDA-NIFA (I submitted “guidance language” to this effect in the FY 2019 appropriations bill through Rep. Tulsi Gabbard’s office); 4) continue support for the Foundation for Food and Agricultural Research (FFAR) and add “invasive species” to its list of priorities; and 5) increasing research funding for weed genomics and genetic biocontrol and “intelligent” weed removal technologies (i.e. precision spraying, self-learning weed removal robots, CO<sub>2</sub> lasers, etc..).

**IR-4 Project Contributes \$9.4 Billion to GDP:** A recently updated study out of Michigan State University shows that the IR-4 Project supports over 95,000 U.S. jobs and contributes about \$9.4 billion to annual gross domestic product (GDP). Dr. Jerry Baron, Executive Director of the IR-4 Project will be presenting a seminar on Capitol Hill on March 12 titled “Keeping the Good Food, Good” where he will discuss the role of the IR-4 Project in preventing pest damage and food waste in specialty crops

**Divisive Dicamba:** Without a question, the most divisive issue I have faced in my 12+ years as Director of Science Policy. [EPA announced label changes](#) for Extendimax, Engenia, and Fexapan on Oct. 13, 2017. EPA’s objective is to minimize the number of off-target incidents in 2018, while also recognizing the utility of the technology in weed resistance management. EPA has made it clear that a repeat of 2017 (i.e. 2700+ complaints) is unacceptable. A common theme in all the dicamba related meetings I’ve participated in is EPA’s need for more research and information. I am currently working with Greg Kruger and others to convene a research workshop in Washington DC in mid-April to identify data gaps and develop research protocols that will help all stakeholders better understand and manage factors contributing to dicamba off-target movement.

**Glyphosate Not Carcinogenic:** EPA released its [human health draft risk assessment and supporting documents](#) that concludes that glyphosate is not likely to be carcinogenic to humans and found no other meaningful risks to human health when the product is used according to the label. On February 27, EPA officially opened a 60 day comment period on these draft risk assessments. Comments are due **April 30, 2018**. Details are at: <https://www.regulations.gov/docket?D=EPA-HQ-OPP-2009-0361>

**EPA Finalizes Herbicide Resistance Management Guidance:** Referred to as [PRN 2017-2](#), this applies to all herbicide uses, except for those applied in residential settings (i.e. lawns). Weed resistance management guidance will be required on labels for any new herbicide products as well as existing herbicides that go through registration review. The registrants will be responsible for reporting new cases of suspected and confirmed resistance to EPA and users, and in certain circumstances, may be required to follow additional guidance such as “apply only with another MOA”. In addition, the weed management stakeholder community is expected to provide educational and training materials for applicators and users **at the local level**. Guidance for developing these resistance management and remedial action plans are provided in Appendix 1 of PRN 2017-2.

**USDA Will Re-engage Stakeholders on Revisions to Biotechnology Regulations:** APHIS withdrew its proposed rule on biotechnology regulations revisions in November and will re-engage with stakeholders to determine the most effective, science-based approach for regulating the products of modern biotechnology while protecting plant health. The National and Regional Weed Science Societies submitted [comments](#) on the proposal in June. While we complimented APHIS on the many positive aspects of the proposal, we encouraged APHIS to re-propose a rule that minimizes regulatory uncertainty related to their weed risk assessment model.

**Weed-Free Certification Programs:** What is the role of the weed science societies in promoting weed-free certification programs such as the [North American Weed Free Forage Program](#) that was developed by the North American Invasive Weed Management Association (NAISMA)?

**Monarch Overwinter Numbers Down Again:** On March 5, the overwintering area for monarch butterflies in Mexico was reported as 2.48 ha, which is down for the second year in a row from the 4.01 ha occupied in 2015-16. By all accounts, there were some excellent monarch numbers reported in the upper Midwest last summer, but the occurrence of two tropical storms and three hurricanes during the monarch fall migration was attributed to the decline. The USFWS is working to [assess the effectiveness of monarch conservation efforts](#) and is expected to make a determination of threatened or endangered status in June 2019.

**Federal Rule Delays 2015 WOTUS “Applicability Date” to Feb. 6, 2020:** The EPA and the Army Corps of Engineers (The Agencies) finalized a rule on January 31 that delays the “Applicability Date” of the 2015 Waters of the United States (WOTUS) rule. The “Applicability Date” Rule was intended to avoid confusion with a recent Supreme Court ruling regarding federal court jurisdiction and to give the Agencies additional time to carry out the President’s Executive Order on WOTUS issued last year. The second step of that Executive Order, where the Agencies will propose a revision to the definition of “waters of the United States” is expected out later this year.

**NPDES Fix Legislation:** There is a renewed effort in the Senate to pass a NPDES fix bill, S. 340, which is the companion bill to H.R. 953 on the House side that was passed on May 24, 2017. The six national and regional weed science societies endorsed letters of support to both the [House on H.R. 953](#) and the [Senate on S. 340](#) and recently endorsed a letter urging the House Ag Committee to include the NPDES-fix language in the 2018 Farm Bill.

**National Invasive Species Awareness Week (NISAW) was February 26 – March 2, 2018:** We had another successful NISAW that was held in conjunction with a [3 day meeting](#) of the federal Invasive Species Advisory Council (ISAC). Please visit [www.nisaw.org](http://www.nisaw.org) to check out the activities that occurred during the week. One Capitol Hill seminar that I was particularly excited about was “Gene Drives 101: Perspectives on Potential Invasive Species Management” - led by Heath Packard, Director of Government and Public Relations for Island Conservation. Next year will be the 20<sup>th</sup> NISAW! If you are interested in getting involved with NISAW or would like to sponsor events during the week, please contact me at [Lee.VanWycken@wssa.net](mailto:Lee.VanWycken@wssa.net)

**Weed Bingo:** The WSSA Public Awareness Committee is investigating the possibility of creating a new board game called “Weed Bingo”, which would be similar to “[Bug Bingo](#)”. We’ve been investigating initial costs to set up, produce and manufacture such a game, which is supposedly around \$25K. I am reaching out to each of the regional weed science societies to gauge their interest in sharing costs/profits and identifying some of weeds important and unique to their region.

**2018 Weed Survey Now Available:** <https://www.surveymonkey.com/r/2018weedsurvey>

The 2018 survey focuses on the most common and troublesome weeds in the following areas: 1) Aquatic: irrigation & flood control; 2) Aquatic: lakes, rivers, reservoirs; 3) Aquatic: ponds; 4) Forestry; 5) Natural Areas: parks, wildlife refuges; 6) Ornamentals: field nursery crops, outdoor containers, Christmas trees; 7) Right-of-Ways: railways, roads, public utilities.

**Land Acknowledgement & Contemporary Indigenous Issues in Science.** Lydia Jennings\*; University of Arizona, Tucson, AZ (063)

**Growing Disneyland.** David Marley\*; California State University, Fullerton, CA (064)

## **PROJECT 1: WEEDS OF RANGE, FOREST, AND NATURAL AREAS**

**The Science of Miconia Management in the East Maui Watershed: A Brief History and Bioeconomic Projection of the Future.** James Leary\*<sup>1</sup>, Kimberly Burnett<sup>2</sup>, Chris Wada<sup>2</sup>, Brooke V. Mahnken<sup>3</sup>; <sup>1</sup>University of Hawaii at Manoa, Kula, HI, <sup>2</sup>University of Hawaii, Honolulu, HI, <sup>3</sup>Maui Invasive Species Committee, Makawao, HI (065)

*Miconia calvescens* DC) is dubiously recognized among “100 of the World’s Worst Invaders”. This mid-canopy species is native to South and Central America and invasive to many other tropical regions of the Pacific Rim, including Tahiti and Australia. This species is highly competitive to island, endemic communities and known for destabilizing functional forest ecosystems with catastrophic consequences. It was introduced to Hana, Maui as a botanical specimen in the early 1970s (i.e., founder population) and not realized as a major forest invader until two decades later. With plant maturity achieved in as little as four years, it stands to reason that several generations were reproduced within that 20-yr period leading up to the first management intervention. The very first volunteer effort, in 1991, removed 9320 miconia plants, around the original point of introduction. Since then we have archived an almost complete 30-year management history with ~300K miconia eliminated across the 50,000-ha East Maui Watershed. Bioeconomic modeling, originally from fisheries research, predicts population dynamics dictated by management (harvest) intensity, in concert with the biological constraints of the species and habitat. The bioeconomic goal against miconia is to tip the balance with management outpacing the biology, forcing population extinction. We report on measured and estimated life-history traits of miconia (e.g., dispersal, recruitment and fecundity) imposed in a future strategic scenario retreating from eradication and containment to most cost-effective

priority watershed protection with focused eradication of incipient (i.e., founder) individuals colonizing novel landscapes.

**Water Temperature as an Environmental Driver of Waterhyacinth (*Eichhornia crassipes*) Growth.** John D. Madsen\*; USDA-ARS, Davis, CA (066)

Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) has been rated as the worst aquatic weed worldwide, and a recurring management issue in tropical and subtropical freshwater bodies in the United States. In the western United States, the most significant infestation is in the Sacramento / San Joaquin River Delta. A 26,000 ha (65,000 acre) freshwater estuary, the Delta has had recurring problematic infestations that interfere with commercial and recreational navigation and disrupt pumping of irrigation and domestic water into the California Water Project. The rapid growth rate and vegetative reproduction drive the nuisance problem. A greenhouse study under controlled water temperature levels found that waterhyacinth growth is significantly increased by water temperatures of 25 °C to 30 °C. These experimental findings support field growth measurements, with annual growth initiating at 15°C and rapid growth with warm water temperatures.

**Developing a Detection Method for New Invaders at the Landscape Scale.** Lisa C. Jones\*, Tim Prather; University of Idaho, Moscow, ID (067)

The ability to predict plant invasions and detect them early in the process are important considerations for invasive plant management. While agencies and land-owners typically take the approach of on-the-ground searches and some may utilize habitat suitability models, these tools may not facilitate detection of incipient infestations when the species is unknown. We set out to develop a method to identify where to look for a new invader to assist managers in focusing search efforts to areas more prone to invasion. We used habitat suitability models (also referred to as species-specific susceptibility models) of seven plant species to investigate whether creating weed “hotspots” of overlapping models was an effective tool to infer areas more invaded within the boundaries of a 4,200-ha ranch in southern Idaho. We tested this by sampling vegetation cover by species, in five, 0.125 m<sup>2</sup> quadrats placed along each of 24 transects located in areas modeled to be suitable habitat for either zero, two, four, or six weed species located in the northeast section of the ranch. Since it is well-documented that roads and trails provide corridors for dispersal, we located transects either near (within 60 m) or far (more than 60 m) from unimproved roads. We hypothesized that non-native species richness and/or cover would be higher in hotspots where a greater number of suitability models overlapped closer to roads. Of the 46 unique species in our quadrats, five species (11%) were non-native, of which Japanese brome (*Bromus japonicus*) and downy brome (*Bromus tectorum*) were the most abundant. Among non-native species, there was no significant difference in richness or foliar cover between hotspots or proximity to roads. Among native species, richness and foliar cover were not significantly different between hotspots, but they were curiously greater in transects closer to roads. To further aid the development of a detection method for new invaders, we examined indicator species that are positively or negatively associated with Japanese and downy brome. Notably, when downy brome cover was high, two perennial native forbs were in greater abundance, and when downy brome was not present, Sandberg’s bluegrass (*Poa secunda*) cover was high. There were no positive indicator species for Japanese brome, though there were 11 native species negatively associated with it. Overall, our initial foray to develop a detection

method using existing weed habitat suitability models was not successful in identifying areas at greater risk of invasion as evidenced by current diversity and cover of non-native species. However, we recognize the limits of our small sample size and narrow extent of the area surveyed (15% of the ranch). Identifying sites at high risk to invasion when the life history traits and environmental niche of the invader is unknown is a complex challenge, but one that has the potential to help land managers prioritize areas for invasive plant monitoring. Future tests will investigate if there are specific modeled weed species combinations that are suggestive of areas generally susceptible to invasion; for example, more non-native species were along transects located where leafy spurge (*Euphorbia esula*) habitat was predicted. Further, indicator species may be used to reveal which models are better candidates for estimating invasibility.

**Scotch Broom Germination and Growth Responses to Red and Far-Red Light: Implications to Logging Debris Effects After Forest Harvesting.** Timothy B. Harrington\*; USDA Forest Service, Olympia, WA (068)

Scotch broom (*Cytisus scoparius*) is a large nonnative, leguminous shrub that threatens native plant communities of the Pacific Northwest by rapidly invading recently disturbed sites and by competing vigorously for soil water and nutrients. In western Washington, retaining logging debris after forest harvesting (i.e., stem-only harvesting; 20-25 Mg ha<sup>-1</sup> of debris) strongly reduced density and cover of Scotch broom seedlings relative to that following conventional whole-tree harvesting (10-15 Mg ha<sup>-1</sup> of debris). Debris retention also improved survival and growth of planted seedlings of coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), and it fostered the development of a native plant community. A series of studies were conducted to determine some of the mechanisms by which logging debris modifies microclimate to limit Scotch broom development. In the debris weight study, frames constructed of PVC and metal screen were used to study effects on microclimate and Scotch broom development from simulated debris levels for stem-only harvesting (i.e., “heavy” debris) and whole-tree harvesting (i.e., “light” debris). Compared to light debris, heavy debris caused biologically meaningful reductions in air temperature, photosynthetically-active radiation (PAR), and red: far red light ratios (R/FR), especially during the period when needles from the Douglas-fir debris were green. Scotch broom germination did not differ significantly between heavy and light debris; however, values of seedling root and shoot biomass in heavy debris were only 9% and 75% of that observed under light debris, respectively. To identify potential R/FR responses of Scotch broom from logging debris, experiments were conducted to compare Scotch broom germination and growth in paired germinators outfitted with either red LED lights (660 nm) or far red LED lights (730 nm). Twenty-day germination of Grand Rapids leaf lettuce averaged 97% and 12% under red and far red light, respectively, confirming that experimental protocols were adequate to test for potential Scotch broom responses. Scotch broom germination did not differ significantly between the red and far red light treatments; however, values of seedling root and shoot biomass under far red light were only 16% and 34% of that observed under red light, respectively. Research results suggest that heavy debris limits Scotch broom development by reducing both PAR and R/FR relative to conditions in light debris. These reductions in light intensity and quality resulted in severe limitations in seedling biomass development, particularly for roots, which likely increased seedling vulnerability to summer drought or other stressors. Retention of logging debris after forest harvesting has potential application on sites likely to be invaded by Scotch broom. Additionally, scheduling forest harvesting for late winter will result in the

presence of green logging debris during the spring warm-up period to fully modify the light environment and maximize suppression of Scotch broom seedling biomass.

**A Plant Pathologist Looks At Rangeland Ecology Pre and Post Wildfire.** William T. Cobb\*; Cobb Consulting Services, Kennewick, WA (069)

The 1,000 plus acre tract of sagebrush steppe which is the focus of this presentation is located immediately south of the City of Kennewick, Washington and immediately east of Hwy 395. Based on the representations of other knowledgeable individuals in the community, my own casual observations for the last 44 years and a cursory review of what records are available, this tract appears to have not been farmed, grazed or burned for the last 70 or more years. Historically, this tract of land and much of the area surrounding it was submerged numerous times by the waters of glacial Lake Lewis during the Missoula floods of the last Ice Age; and the area is strewn with artifacts of these floods. The tract is bordered on the north and west by actual or planned business development. The tract is bordered on the south by another tract of land which was taken out of production as dryland wheat and converted to the Conservation Reserve Program (CRP) more than 20 years ago. The diverse grass, forbs and brush species inhabiting this sagebrush steppe tract were inventoried in the fall of 2013. In September of 2016, an intense wildfire of unknown origin burned over 365 acres in the middle of this sagebrush steppe site. The winter following the fire event was unusually harsh and cold and the tract was under continuous snow cover in excess of 65 days, which was the longest period of continuous snow cover on record for the area. Pathology in the form of virus infections of tumble mustards was suspected, observed, and confirmed within the site during 2015 and in 2016 prior to the fire. The 2016/2017 snow cover as well as an inordinately cool wet spring provided an environment conducive for additional pathology in the form of pink snow mold and powdery mildew on native and invasive grass species. This will be the first of three planned annual presentations based on the comparison of the burned v. non-burned areas of the site and other related topics of interest.

**Herbicide Application Using a Pulse Sprayer for Invasive Weed Control in Pasture and Rangeland.** Rod Lym\*; North Dakota State University, Fargo, ND (070)

Pulse Width Modulation spraying system (PWM) is a technology developed to improve precision application of pesticides. PWM flow control involves switching an electrically-actuated spray nozzle on and off very quickly in order to control the flow rate of the nozzle. This cycling takes place quickly, so the flow often appears to be constant and the coverage remains reasonably uniform. Controlling flow rate by adjusting duty cycle and cycling frequency of an electric nozzle while maintaining a constant pressure provides advantages over controlling flow by adjusting pressure. Normally, increasing spray pressure results in increased flow rate. However, increased pressure also changes the spray angle and drop size and may result in increased particle drift. PWM flow control provides an extremely wide range of flow rates from a single nozzle, maintaining a consistent spray angle and droplet size without adjusting pressure.

Five experiments were established to evaluate leafy spurge and Canada thistle control using PWM. Various nozzles were used with the PWM sprayer to apply herbicides so that the majority of the spray pattern consisted of 150, 300, 450, 600, 750, or 900 micron droplets. A tractor mounted boom sprayer with 8002 nozzles was used as the control treatment for

comparison. All treatments were applied at 17 gpa and 35 psi. Picloram plus 2,4-D at 4 + 16 oz/A was applied in the leafy spurge study while aminopyralid at 1.25 oz/A was applied for Canada thistle control. Separate spring or fall studies were established on June 23, 2016 or September 14, 2016 for each weed species. Leafy spurge was in the true flower or fall-regrowth stage, at the time of the spring or fall treatment, respectively. Canada thistle was in the rosette to bolting stage when the spring treatments were applied and in the rosette growth stage in the fall.

Leafy spurge and Canada thistle control was similar when herbicides were applied with the PWM system compared to a standard boom sprayer at all droplet sizes except 150 microns. For example, Canada thistle control averaged 98% 12 months after treatment (MAT) with all treatments except when application was made with nozzles that applied primarily 150 micron droplets which only averaged 36%.

The fifth study evaluated leafy spurge control with quinclorac applied at 12 oz/A with the PWM sprayer at three application speeds, 5, 10, and 15 mph. The droplet size was held constant at 600 microns for all application speeds. The study was established on the Sheyenne National Grassland near Anselm, ND on June 20, 2017 when leafy spurge was in the flowering growth stage. Leafy spurge control averaged 95% 2 MAT regardless of application speed.

The PWM sprayer can be used to apply herbicides in pasture and rangeland at a variety of travel speeds while maintaining medium sized or larger droplets resulting in reduced drift and more uniform coverage compared to traditional boom sprayers. The adoption of this technology by landmangers will allow more precise chemical application reducing herbicide over- and under-application resulting in consistent invasive weed control on a variety of terrain.

**Treatment Life of Mesquite Herbicides; Beyond Two Years After Application.** Case R. Medlin\*<sup>1</sup>, Allan McGinty<sup>2</sup>, Wayne Hanselka<sup>3</sup>, Robert Lyons<sup>4</sup>, Megan Clayton<sup>5</sup>, William Thompson<sup>6</sup>; <sup>1</sup>Bayer, Paradise, TX, <sup>2</sup>Texas A&M AgriLife Extension (Emeritus), San Angelo, TX, <sup>3</sup>Texas A&M AgriLife Extension (Emeritus), Corpus Christi, TX, <sup>4</sup>Texas A&M AgriLife Extension, Uvalde, TX, <sup>5</sup>Texas A&M AgriLife Extension, Corpus Christi, TX, <sup>6</sup>Texas A&M AgriLife Extension, San Angelo, TX (071)

Mesquite species (*Prosopis sp.*) continue to plague rangeland in the south-central and southwestern United States. Invasive brush infestations have continued to expand, impacting livestock production enterprises, reducing wildlife habitat, negatively impacting the environment, and frustrating land managers. The foundations of current chemical control measures for mesquite in the region include various combinations of clopyralid, triclopyr, and aminopyralid herbicides. Aminocyclopyrachlor, a pyrimidine carboxylic acid herbicide, has been evaluated in brush control programs since 2005. Results indicate aminocyclopyrachlor plus triclopyr amine (ACP+T) herbicides provide effective, long-term control of honey mesquite (*Prosopis glandulosa*) and other invasive brush species on southwestern rangelands. Mesquite canopy cover assessments of broadcast treatments applied between 2007 and 2013 were collected in 2017 (i.e. four to ten years after application) from ten trial locations. Treatments evaluated were ACP+T, the untreated check, and the industry standard of aminopyralid plus clopyralid, or clopyralid plus triclopyr ester. At four to ten years post-treatment, mean mesquite canopy cover across all locations was 2% and 21% in the ACP+T and industry standard treatments, respectively. ANOVA indicated a significant difference in mesquite canopy cover

between the ACP+T and industry standard treatments. Regression analyses indicated a stronger trend between increased mesquite canopy cover and years after treatment with the industry standard than the ACP+T treatment. From the models developed, predicted mesquite canopy cover 10 years after application of the industry standard treatments would be 29%, compared to less than 3% with ACP+T at 10 years after application. The net present value (discounted cash flow generated by additional grazing resulting from each brush management program) for ACP+T and the industry standard were calculated (up to 24 years after application) from additional animal unit months generated by each brush management treatment, herbicide and application cost, and the estimated leasehold value of the animal unit month. The net present values of the ACP+T treatment and the industry standard treatment were similar until 8 years after application. At that time, a sequential application of the industry standard would be required to continue sufficient forage production to maintain the optimum stocking rate on the land, however, the ACP+T treatment did not warrant a follow-up treatment through 24 years after application. These long-term brush management studies indicate ACP+T has the potential to reduce re-treatment intervals, reduce input costs, and reduce the total herbicide load on the land compared to currently available industry standards and thus restore unproductive, brush-infested lands to productive grasslands.

**Herbicide Residues in Unexpected Places: Does Aminopyralid Leak from Treated Plants After Basal Bark Application?** Gino Graziano\*<sup>1</sup>, Steven S. Seefeldt<sup>2</sup>, Patrick Tomco<sup>3</sup>, Mingchu Zhang<sup>4</sup>; <sup>1</sup>University of Alaska Fairbanks, Anchorage, AK, <sup>2</sup>Washington State University, Mount Vernon, WA, <sup>3</sup>University of Alaska Anchorage, Anchorage, AK, <sup>4</sup>University of Alaska Fairbanks, Fairbanks, AK (072)

Invasive plant managers have reported off target impacts on vegetation in the root zone of invasive plants that were treated with herbicides applied with direct methods such as stem injection, cut stump, frill, or basal bark treatments. These treatments are often applied in order to reduce off target impacts. Little attention has been given to the potential for an herbicide to be released from the target plant into the environment. Our hypothesis is that directly applied herbicides could be released to the soil through decomposition of treated plant material, transfer through root to root contact, and/or leakage from roots. We conducted a study to determine if basal bark treatments of *Prunus padus*, an invasive tree in Alaska, with aminopyralid results in off target impacts to sensitive species due to leakage from roots of treated trees. We treated 24 rooted cuttings (0, 5 and 10X label rates), and recorded herbicide injury to plants 3 weeks after treatment. Soil from the treated plants was divided for use in bioassay and chemical extraction. Chemical extraction work is pending. Germination rates of *Crepis tectorum* were not impacted by treatments. After one week of post-emergence growth *Crepis tectorum* plant biomass was reduced in plants grown in the 5x and 10x treatments compared to the control. Follow up research will determine if longer post-emergence growth in the bioassay will result in plant death and obvious auxin analog injury symptoms and whether or not decomposition of treated *P. padus* results in release of aminopyralid.

**A Comprehensive Summary of Long-Term Invasive Winter Annual Grass Control with Esplanade 200 SC.** Derek J. Sebastian\*<sup>1</sup>, Harold Quicke<sup>2</sup>, Shannon L. Clark<sup>3</sup>, Scott J. Nissen<sup>3</sup>; <sup>1</sup>Bayer, Fort Collins, CO, <sup>2</sup>Bayer, Windsor, CO, <sup>3</sup>Colorado State University, Fort Collins, CO (073)



Invasive annual grass species such as cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), ventenata (*Ventenata dubia*) and red brome (*Bromus rubens*) are changing western natural areas and rangeland in a cycle that favors their spread at the expense of desirable vegetation. They compete with desirable grasses, forbs and shrubs by germinating in late-summer and winter, continuing root development over winter, starting rapid above ground growth in late-winter and stealing moisture and nutrients before desirable perennials start to grow in spring. Restoration activities such as reseeding and replanting are expensive and difficult. The best time to control invasive annual grasses is when viable populations of desirable perennials are still present, increasing the success of ecosystem restoration. Over 100 replicated field trials across the western US (Colorado State University, University of Wyoming, University of Idaho, Montana State University, Washington State University, University of Nebraska, University of California Davis) have documented that Esplanade 200 SC Herbicide is a highly effective tool for long-term control of many invasive annual grasses. While other products are available for annual grass control, they are inconsistent or only provide a relatively short duration of control. Annual grass seed can remain viable in the soil and thatch layer for many years and other products do not provide enough residual control to adequately address the total number of viable seeds, known as the soil seed bank. A single application of Esplanade can prevent germination of annual grasses for multiple years. This provides land managers with a new opportunity to start the process of eliminating the annual grass seed bank. Additionally, most alternative products have the same herbicide site of action (Group 2, ALS inhibitors) and there are reported cases of annual grass resistance to this group. Esplanade is a new site of action (Group 29, cellulose biosynthesis inhibitor) and is an effective tool for managing herbicide resistant weeds. Directions for using Esplanade for the release or restoration of desirable vegetation are currently available on a Supplemental Label that is approved in all states (EPA Reg. No. 432-1516). This label allows for use of Esplanade in non-crop areas such as: parks and open space, wildlife management areas, recreation areas, fire rehabilitation areas, prairies and fire breaks. As invasive winter annual grasses continue to degrade western landscapes, new tools for long-term control are needed to deplete the soil seed bank and allow the opportunity for successful ecosystem restoration.

**Does a Dry Herbicide Delivery System Provide Increased Downy Brome Control Beneath a Shrub Canopy?** Clay W. Wood\*<sup>1</sup>, Brian A. Meador<sup>2</sup>; <sup>1</sup>University of Wyoming, Laramie, WY, <sup>2</sup>University of Wyoming, Sheridan, WY (074)

Imazapic is commonly used to manage downy brome (*Bromus tectorum*) on rangelands, but herbicide reaching its target site may be reduced via shrub canopy interception. We evaluated liquid and granular formulations of imazapic for downy brome control beneath shrub canopies in greenhouse and field studies. In the greenhouse, we applied both imazapic formulations at five preemergent rates to pots seeded with downy brome – with and without a sagebrush canopy. Downy brome biomass did not differ by formulation or canopy treatments ( $p>0.2$ ). We aerially applied liquid imazapic at 123 g ai·ha<sup>-1</sup> and granular imazapic at 135 g ai·ha<sup>-1</sup> at four field sites in Wyoming. Downy brome biomass was not reduced one YAT at Hyattville or Sheridan for either herbicide formulation ( $p>0.4$ ). Herbicide treatment reduced downy brome biomass one YAT at Saratoga and Pinedale ( $p<0.05$ ), irrespective of shrub canopy ( $p>0.68$ ). One YAT at Saratoga, both imazapic formulations similarly reduced downy brome biomass, but at Pinedale, the liquid formulation reduced downy brome biomass more than the granular. Saratoga was the only site with biomass reduction beneath shrubs for both formulations two YAT ( $p<0.05$ ). We

quantified herbicide deposition at the soil surface at Hyattville and Sheridan during aerial herbicide applications. Liquid imazapic coverage (%) was greater in interspaces than under shrubs ( $p < 0.001$ ). Granular imazapic weight ( $\text{g}\cdot\text{ha}^{-1}$ ) was consistent at both sites ( $p > 0.7$ ). Our results indicate that although granular imazapic may provide greater herbicide deposition beneath shrub canopies than liquid, similar reductions in downy brome biomass may be achieved.

**Use of the Bioherbicide D7 to Manage Cheatgrass Invasions.** Dan R. Tekiela\*; University of Wyoming, Laramie, WY (075)

Abstract not available

**Herbicide Susceptibility of Garden Loosestrife (*Lysimachia vulgaris*).** Timothy W. Miller\*; Washington State University, Mount Vernon, WA (076)

Garden loosestrife (*Lysimachia vulgaris* L.) is a rhizomatous perennial species that has been widely planted as an ornamental, frequently beside water features such as ponds, lakes, and streams. It has escaped from many of these intentional plantings and now is established throughout the northeastern United States and adjacent Canada, and west to Minnesota. Escaped garden loosestrife has become particularly troublesome in the Pacific Northwest, however, with plants up to 2 m tall growing in dense infestations in western Washington, Oregon, and British Columbia. The species is currently listed as a Class B noxious weed in Washington and a List A noxious weed in Oregon. In order to identify potentially effective treatments for managing garden loosestrife at these field sites, a greenhouse herbicide screen was conducted at Washington State University Northwestern Washington Research and Extension Center from 2014 through 2017. Garden loosestrife rhizomes were dug each year from the same field location, transplanted into potting soil, grown until bud stage, then treated with herbicide applied alone and in several combinations. All treatments were mixed with 0.5% mso, v/v prior to application. Garden loosestrife injury was visually estimated at 3 weeks after treatment (WAT), after which above ground foliage was removed and plants were allowed to regrow. Re-growing plants were clipped and shoot dry weight determined at 2 and 3 months after treatment (MAT). Garden loosestrife plants in the first iteration (2014-15) were statistically less injured than in the second and third iterations (2015-16 and 2016-17), so those were considered “worst case” and are reported here. Single herbicides causing the greatest garden loosestrife injury at 3 WAT were triclopyr (1 or 2%) and aminopyralid (0.25%). Combinations of glyphosate (1%) with triclopyr (1%), aminopyralid (0.25%), or aminocyclopyrachlor (0.16%), or triclopyr (1%) mixed with imazapyr (0.5%) or imazamox (0.5%) also injured garden loosestrife. By 2 MAT, most treatments had reduced regrowth by 90% compared to the nontreated check. Exceptions were glyphosate (1% or 2%) and imazamox (0.75%). At 3 MAT, treatments failing to reduce garden loosestrife biomass by at least 90% included the same three treatments from 2 MAT plus imazamox (0.5%) and triclopyr (1%). Under the conditions of this greenhouse trial (foliar herbicide application followed by removal of garden loosestrife shoot growth at 3 WAT and 2 MAT), five treatments prevented regrowth in all three iterations. These treatments were imazapyr (0.5 or 0.75%), glyphosate (1%) + aminocyclopyrachlor (0.16%), glyphosate (1%) + aminopyralid (0.25%), and imazapyr (0.5%) + triclopyr (1%).

**Indaziflam Effects on Seed Production and Viability for Various Rangeland Grasses.** Beth Fowers\*, Brian A. Meador; University of Wyoming, Sheridan, WY (098)

Annual weeds, like downy brome (*Bromus tectorum* L.), negatively impact grass seed production by directly competing for resources and contaminating seed lots. Herbicide options in grasses grown for seed are relatively limited, and for one to be useful it must provide acceptable weed control with little reduction in seed production and viability. Indaziflam controls annual grasses and other weeds, but we do not know if it affects seed production and germinability. Our objective was to evaluate the effects of indaziflam on grass seed production and germinability across a range of plant materials. Eighteen different grass species (or varieties) were seeded in a randomized complete block design with four replicates at WYarno, WY in 2013. We applied indaziflam (73 g ai·ha<sup>-1</sup>) and glyphosate (420 g ai·ha<sup>-1</sup>) to one half of each plot on March 27, 2017. Downy brome was actively growing and some of the perennial grasses had broken dormancy at the time of application. We harvested, counted, and weighed mature inflorescences on July 3, 2017 from three bunchgrasses per plot or from within a 0.25 m<sup>2</sup> frame for rhizomatous grasses. We evaluated cumulative germination using 50-seed lots in petri dishes with filter paper in a growth chamber set at 21° C daytime and 10° C nighttime temperatures for one month. We analyzed data as a two-way ANOVA with plant material and herbicide as the two treatments. While herbicide application controlled annual grasses across the site ( $p < 0.0001$ ), it also negatively impacted the perennial grasses, depending on the species. Inflorescence number was reduced for many wheatgrasses and wildryes and one bluegrass ( $p = 0.0001$ ). Similar trends were observed with inflorescence weight, both of which are related to overall seed production. While herbicide application affected overall germination ( $p = 0.01$ ), germinability of most species was not impacted. Herbicides noticeably reduced germination in two varieties: ‘Opportunity’ Nevada bluegrass (100%) and ‘Washoe’ basin wildrye (greater than 49%;  $p < 0.0001$ ). First year herbicide impacts on seed production and germinability should be interpreted cautiously since we could not separate glyphosate from indaziflam effects in this study.

**Using a New Natural Areas Herbicide to Control Winter Annual Grasses and Establish Native Species.** Shannon L. Clark\*<sup>1</sup>, Derek J. Sebastian<sup>2</sup>, Scott J. Nissen<sup>1</sup>; <sup>1</sup>Colorado State University, Fort Collins, CO, <sup>2</sup>Bayer, Fort Collins, CO (099)

Invasive winter annual grasses (IWAG), including downy brome (*Bromus tectorum* L.) and feral rye (*Secale cereale*), are considered one of the most problematic invasive species in rangeland and natural areas in the western United States. Indaziflam, a new pre-emergent herbicide alternative for weed management in natural areas and open spaces, provides long-term control of both downy brome and feral rye. The post-emergent herbicide glyphosate can be mixed with a residual control product while desirable perennials are dormant to control germinated IWAG seedlings. Field trials were conducted to evaluate glyphosate dose to provide adequate post-emergent IWAG control. Additionally, residual control herbicides indaziflam and imazapic were compared for long-term downy brome and feral rye control. Lastly, subsequent native species establishment through drill seeding was assessed. Applications were made in March 2014 and treatments included increasing levels of glyphosate tank mixed with indaziflam (44, 73, 102 g·ai·ha<sup>-1</sup>) and imazapic (123 g·ai·ha<sup>-1</sup>). Sites were then drill seeded with native species 9 months after herbicide application. Yearly visual control evaluations, IWAG biomass, and drilled species stand counts were collected. Glyphosate at 474 g·ae·ha<sup>-1</sup> provided the most consistent initial downy brome control while glyphosate at 631 g·ae·ha<sup>-1</sup> was needed to provide the same level of

feral rye control. Only plots treated with indaziflam had significant native species establishment compared to non-treated plots. Three years after treatment, only treatments containing indaziflam at 44, 73 and 102 g·ai·ha<sup>-1</sup> had significant reductions in IWAG biomass compared to the non-treated check. These results provide valuable information for land managers trying to restore sites severely impacted by IWAG and establish native species.

**Medusahead and Ventenata in the Northern Great Plains Ecoregion: Invasion History and Management Efforts.** Brian A. Meador\*<sup>1</sup>, Beth Fowers<sup>1</sup>, Luke Sander<sup>2</sup>; <sup>1</sup>University of Wyoming, Sheridan, WY, <sup>2</sup>Sheridan County Weed and Pest, Sheridan, WY (100)

The invasive winter annual grasses medusahead and ventenata have a relatively long history of spread and impact in the Intermountain West. In 2016, self-sustaining populations of both species were documented in Sheridan County, Wyoming, representing the first known populations of each species in the Great Plains region. The Northeast Wyoming Invasive Grasses Working Group formed in direct response to these new invasive grass populations with a primary goal of minimizing impacts to rangelands for wildlife and agriculture by reducing, containing, or eradicating medusahead and ventenata in northeast Wyoming. The working group is implementing an EDRR approach by collecting and sharing distribution data, strategically implementing control actions, and monitoring efficacy of treatments. In 2017, more than 22,000 acres were intensively surveyed for presence of medusahead and ventenata, with significantly more acreage informally added to the species distribution via collaborators and citizen-scientists. While the current known distribution of medusahead is relatively restricted, the outer boundaries of the known ventenata range in Wyoming went from one observation prior to 2016 to well over 1 million acres of gross acres in February 2018. Observations from the collaborative working group emphasize the importance of education and outreach in EDRR programs to the contributions of diverse partnerships in such an effort. Future efforts will incorporate vector-pathway analysis coupled with remote sensing to prioritize high-likelihood sites of future invasion for medusahead.

**Needles in a Haystack: Identifying Thresholds in Annual Grass-Dominated Rangelands.** Clay W. Wood\*<sup>1</sup>, Brian A. Meador<sup>2</sup>; <sup>1</sup>University of Wyoming, Laramie, WY, <sup>2</sup>University of Wyoming, Sheridan, WY (101)

Invasive species have an ever-increasing impact on the ecological and economic functions of ecosystems. Downy brome (*Bromus tectorum*) is an invasive annual grass that is widely distributed throughout most of the western United States. Downy brome produces high amounts of fine fuels that can increase fire frequency, altering vegetation composition and structure. Determining thresholds within downy brome-invaded rangelands may help conserve native plant communities. The objective of this research is to determine if there is a direct, predictable relationship between pre-treatment vegetation condition and post-treatment increases in perennial grass biomass following treatment with two formulations of imazapic (liquid and granular). We sampled locations representing a gradient of downy brome to perennial grass ratios prior to, and following, herbicide application across multiple sites. At the Saratoga and Pinedale, Wyoming field sites, we collected pre-treatment data in 2015, aerially applied herbicides in September 2015, and collected post-treatment data in 2016 and 2017. Prior to treatment, perennial grass biomass decreased with increasing downy brome cover ( $p < 0.001$ ). Post-treatment downy brome cover was reduced by both herbicide treatments two years after

treatment (YAT) at Pinedale ( $p < 0.001$ ) and Saratoga ( $p = 0.017$ ). In Pinedale 1 YAT, perennial grass biomass response to herbicides depended on relative downy brome cover prior to treatment ( $p = 0.038$ ), but we did not observe this interaction 2 YAT. Herbicide treatment increased perennial grass biomass 2 YAT at Pinedale ( $p < 0.001$ ), but not at Saratoga ( $p = 0.949$ ). Inter-annual variability in vegetation and herbicide efficacy makes identifying thresholds difficult in these systems.

**Aminopyralid in Combination with Picloram and Fluroxypyr for Pricklypear Control in Texas.** James Jackson<sup>\*1</sup>, Morgan Russell<sup>2</sup>, Charles Hart<sup>3</sup>; <sup>1</sup>Texas A&M AgriLife Extension, Stephenville, TX, <sup>2</sup>Texas A&M AgriLife Extension, San Angelo, TX, <sup>3</sup>Dow AgroSciences, Stephenville, TX (102)

Paper withdrawn

**Timing Aminopyralid Applications to Prevent Medusahead (*Taeniatherum caput-medusae* (L.) Nevski) Seed Production Controls the Invader and Increases Forage Grasses.** Matthew J. Rinella<sup>\*1</sup>, Josh S. Davy<sup>2</sup>, Guy B. Kyser<sup>3</sup>, Vanelle F. Peterson<sup>4</sup>, Fadzayi E. Mashiri<sup>5</sup>, Jeremy J. James<sup>6</sup>; <sup>1</sup>USDA-ARS, Miles City, MT, <sup>2</sup>University of California Cooperative Extension, Red Bluff, CA, <sup>3</sup>University of California, Davis, Davis, CA, <sup>4</sup>Dow AgroSciences, Ft Collins, CO, <sup>5</sup>University of California Cooperative Extension, Mariposa, CA, <sup>6</sup>UC Sierra Foothill Research and Extension Center, Browns Valley, CA (103)

Exotic annual grasses dominate millions of hectares of grasslands in the western U.S. Among other herbicides, growth regulators such as picloram and aminopyralid have been tested against these invaders. Recent studies demonstrate growth regulators applied at late growth stages drastically reduce seed production in annual grasses such as *Bromus tectorum* L. and *Taeniatherum caput-medusae* (L.) Nevski. In eight experiments in California annual grasslands, aminopyralid was applied to determine if reducing *T. caput-medusae* seed production translated into reduced *T. caput-medusae* cover. Aminopyralid was applied at 55, 123 and 245 g ae ha<sup>-1</sup> just prior to *T. caput-medusae* heading in spring, and the two higher rates were also applied pre-emergence in fall to allow comparisons to this previously tested timing. When applied at just 55 g ae ha<sup>-1</sup> in spring, aminopyralid dramatically reduced seed production and consistently reduced *T. caput-medusae* cover to near zero. Fall applications of aminopyralid were less effective, even at the 245 g ae ha<sup>-1</sup> rate. Unlike spring treatments, fall treatments sometimes reduced cover of desirable winter annual forage grasses shortly after application. At later time points after treatment, both spring and fall treatments tended to increase forage grass cover, but spring treatments tended to cause larger increases. Compared to other herbicide options, aminopyralid applied just prior to heading appears to be a relatively inexpensive, more effective way to manage *T. caput-medusae* in annual grasslands.

## PROJECT 2: WEEDS OF HORTICULTURAL CROPS

**Developing Pest Management Applications with Unmanned Aerial Systems.** James Leary<sup>1</sup>, Ken Giles\*<sup>2</sup>, Roberto Rodriguez<sup>3</sup>, Daniel Jenkins<sup>3</sup>; <sup>1</sup>University of Hawaii at Manoa, Kula, HI, <sup>2</sup>University of California, Davis, Davis, CA, <sup>3</sup>University of Hawaii, Honolulu, HI (127)

This is a collaborative project with a research and technology objective to develop, validate and certify unmanned aerial systems with Herbicide Ballistic Technology (HBT) capabilities (UAS-HBT) in remote pest target elimination. We have developed a first-generation prototype HBT gimbal with controlled flight tests proving concept with a vertical takeoff and landing (VTOL) octocopter able to lift the 6 kg payload and an independent operator able to remotely engage and accurately discharge projectiles to target. Accuracy and precision of the treatment system is <6 cm within a 10 m range. Limitations of this system continue to be lift capacity and endurance of the aircraft, necessary for conducting effective operations in the field. We will be performing new tests on this gimbal mounted on a large class VTOL UAS with up to 60 minutes of sustained flight. We have further developed a basic training course for practitioners to prepare for CFR14 part 107 certification as remote pilots and we're also pursuing amendments of our current 333 exemption for the purpose of conducting agricultural aircraft operations using sUAS, including deployment of HBT for controlling invasive species. This would be a historic event for Hawaii and potential game-changer for conservation.

**Soil Solarization in Oregon: The Impact of Solarization Duration and Soil Moisture on Weed Control in a Tree Seedling Nursery.** Nami Wada\*, Jennifer Parke, Pete A. Berry, Lucas Kopecky Bobadilla, Carol Mallory-Smith; Oregon State University, Corvallis, OR (128)

Soil solarization is a pre-plant soil disinfestation method used to manage weeds and soil-borne pathogens. Plastic film is laid over moist soil to capture solar energy to heat the soil. Efficacy is influenced by quality and quantity of incoming solar radiation. The duration affects accumulated soil temperatures needed to control a target species. Soil moisture also plays a key role, for seed imbibition and conducting heat deeper into the soil profile. This study was conducted during the summers of 2016 and 2017 in Boring, OR, to determine the most effective duration (0, 3, 6, 9 weeks) and initial soil moisture level (low, medium, high, very high). Seeds of four weed species (*Amaranthus retroflexus*, *Poa annua*, *Polygonum pensilvanicum*, *Portulaca oleracea*) were buried at 5 and 10 cm depths, removed at 3, 6 or 9 weeks, and tested for viability. Warmer temperatures and less cloud coverage during 2017 was reflected in weed response. In 2016, 6 weeks or more of solarization controlled *P. annua* while 3 weeks worked equally well in 2017. In both years and both depths, *P. pensilvanicum* seeds were killed under all durations with medium or higher moisture. *Amaranthus retroflexus* required 6 to 9 weeks with medium or higher moisture for moderate control at the 5 cm depth. *Portulaca oleracea* seed viability was not impacted by the treatments, and seeds recovered from 2017 plots had increased dormancy. These results suggest that soil moisture level and duration of treatment significantly affect successful solarization when weather conditions are less than ideal.

**Effect of Glyphosate and Dicamba Residues in Russet Burbank Seed.** Andrew Robinson\*<sup>1</sup>, Nelson Geary<sup>2</sup>, Harlene Hatterman-Valenti<sup>2</sup>, Gary Secor<sup>2</sup>, Asunta Thompson<sup>2</sup>, Rich Zollinger<sup>2</sup>; <sup>1</sup>North Dakota State University / University of Minnesota, Fargo, ND, <sup>2</sup>North Dakota State University, Fargo, ND (129)

The release of dicamba-tolerant soybean is concerning to seed potato growers as potato seed tubers have been reported to be affected by glyphosate or dicamba when the mother plants have been exposed to glyphosate or dicamba. The objective of this study was to determine the effects of planting ‘Russet Burbank’ potato seed tubers from mother plants that were exposed to dicamba (4, 20 and 99 g ae ha<sup>-1</sup>), glyphosate (8, 40 and 197 g ae ha<sup>-1</sup>) and the combination of dicamba and glyphosate during tuber initiation the previous growing season. Daughter tubers were planted back near Oakes and Inkster, North Dakota in 2016 and 2017, at the same research farm they were grown the previous year. The highest rates of dicamba (99 g ha<sup>-1</sup>), glyphosate (197 g ha<sup>-1</sup>) and the combination caused 17 to 72% reduction in emergence and 23 to 57% reduction in total yield when compared to the non-treated check. Dicamba applied at 20 g ha<sup>-1</sup> reduced yield 11 to 33%. Dicamba and glyphosate can reduce emergence and total production when residues are carried over in seed potatoes. ‘Russet Burbank’ was more susceptible to dicamba than glyphosate.

**Ethalfuralin Potato Tolerance: Processor and Specialty Varieties.** Pam Hutchinson\*<sup>1</sup>, George Newberry<sup>2</sup>, Brent Beutler<sup>3</sup>; <sup>1</sup>University of Idaho, Aberdeen, ID, <sup>2</sup>Gowan Company, Boise, ID, <sup>3</sup>University of Idaho, American Falls, ID (130)

In 2017, six special variety potato were planted at the University of Idaho Aberdeen Research and Extension Center: Atlantic (At), Dark Red Norland (DRN), Huckleberry Gold (HG), Yukon Gold (YGo), Yukon Gem (YGe), and La Ratte (LR) in a replicated field trial. In a separate trial that year, six processor potato varieties were planted: Russet Burbank (RB); Clearwater (CR), Umatilla (UR), and Ranger Russet (RR); Russet Norkotah (RN), and Shepody (Sh). Ethalfuralin was applied in both trials at 0, 0.75, or 1.13 lb ai/A. Treatments were arranged in a three rate x six variety factorial strip block with 4 replications. All plots were kept weed-free throughout the entire growing season. Plant injury ratings and height measurements were collected periodically during the season. Injury was less than 5% regardless of rating time. Tubers were harvested at season-end and tuber quality and total yields were determined. Least squares estimate (p=0.05) analyses was conducted on the injury and height data, as well as tuber yields. In both trials, the rate x variety interaction was not significant, and combined across rate or variety, rate was not significant, but as expected, variety was significant. U.S. No. 1 (tubers 4 oz or greater with no defects) and total tuber yields (all tubers harvested) were as follows in the specialty variety trial: At and DRN> YGo and HG>YGe >LR. In the processor variety trial, only U.S. No. 1 was significant and were as follows: CR, RB, RR>UR>Sh>RN.

**Weed Control in Pacific Northwest Potatoes.** Steven S. Seefeldt\*<sup>1</sup>, Pam Hutchinson<sup>2</sup>, Timothy W. Miller<sup>3</sup>; <sup>1</sup>Washington State University, Mount Vernon, WA, <sup>2</sup>University of Idaho, Aberdeen, ID, <sup>3</sup>Washington State University, Mount Vernon, WA (131)

Common lambsquarters (*Chenopodium album*) resistant to metribuzin has been confirmed in Michigan (1975), Bulgaria (1989), Norway (1994), Greece (2000), Sweden, and Washington (2010). Metribuzin is a group 5 (c1) herbicide that is widely used PRE or POST emergence in potatoes to control annual broadleaf weeds including common lambsquarters, pigweed spp., and some annual grasses. A study funded by the Northwest Potato Research Consortium was conducted to compare control of annual broadleaf weed species and impact on potato yield using combinations of herbicides with and without metribuzin at four locations in the Pacific Northwest in 2016 and 2017. All herbicides were applied PRE emergence after the first hilling.

At each location a different potato variety was used and timing of weed response measurements varied. Some fields were irrigated, and others were not. Despite differences in methodologies, herbicide combinations without metribuzin controlled common lambsquarters, redroot pig weed and hairy nightshade equally as herbicide combinations with metribuzin. With the exceptions of 2017 in eastern Washington and 2016 in western Washington, potato yields at each location were improved when herbicides were used compared to untreated controls. Because similar weed control and potato yield results can be obtained with and without the use of metribuzin, effective proactive measures, such as using herbicides with different mechanisms of action can be used to delay the onset of metribuzin resistant weeds.

**Efficacy of Dormant Season PRE Herbicides for Spring/Summer Weed Control in Apples.**  
Lynn M. Sosnoskie\*<sup>1</sup>, Ian C. Burke<sup>2</sup>; <sup>1</sup>University of California Cooperative Extension, Merced, CA, <sup>2</sup>Washington State University, Pullman, WA (132)

Weeds can directly impact apples via competition for water, nutrients, and light. Weeds may also affect tree growth and yield indirectly by serving as alternate hosts for insect pests and pathogens and by providing habitat for rodents. Physically, weeds can interfere with crop management and harvest operations when they block irrigation emitters, inhibit the deposition of other pesticides, or impede the movement of workers and equipment. Successful weed management can best be achieved by employing a combination of strategies. One tactic is the use of dormant-season, PRE herbicides. A benefit of fall- or early spring-applied herbicide treatments is that growers can take advantage of naturally occurring rain events to incorporate/activate these products. Additionally, cooler soil temperatures may help to reduce chemical loss (and diminished herbicide efficacy) through dissipation and degradation. Furthermore, the use of residual herbicides may reduce the need for spring and summer POST weed control that could interfere with other time-sensitive, pest management efforts (*i.e.* fire blight or codling moth sprays).

In November of 2016, a research trial was established at the Washington State University Sunrise Orchard (Rock Island, WA) to evaluate the effects of PRE herbicides on weed cover and density. Treatments included: (1) non-treated check, (2) Durango 3 pt/A, (3) Alion 2 oz/A + Pindar GT 2 pt/A, (4) Alion 3.5 oz/A + Matrix 2 oz/A, (5) Alion 4.5 oz/A + Matrix 2 oz/A, (6) Alion 4.5 oz/A + Princep 2 lb ai/A, (7) Pindar GT 2 pt/A + Prowl H2O 3 qt/A, and (8) Pindar GT 2 pt/A + Surflan 3 qt/A. The residual herbicide tank-mixes also included Durango at 3 pt/A for the burndown of standing vegetation. All herbicides were applied with a backpack sprayer at a volume of 10 GPA. The predominant weeds in the study were annual bluegrass (*Poa annua*) (winter/spring) and crabgrass (*Digitaria* spp.) (spring/summer) followed by white clover (*Trifolium repens*) and several summer broadleaf annuals.

Weed emergence was largely unobserved during the winter months because of winter snowfall. In 2017, weed cover in the untreated check was < 1%, 4%, 7%, 23%, and 34% on April 12, April 26, May 8, May 20, and June 13, respectively. Fall-applied Durango controlled emerged bluegrass at the time of application but did not prevent new weed emergence (crabgrass and broadleaves) in the spring/summer; weed cover on April 12, April 26, May 8, May 20, and June 13 was 0%, < 1%, < 1%, 3%, and 6%, respectively. The PRE tank-mixes suppressed grass emergence, as well as the emergence of broadleaves; weed cover did not exceed 2% on any observation date. Weed densities increased with time with the greatest number of weeds occurring in the untreated check plots (7 to 32 plants/m<sup>2</sup>), followed by the Durango treatment



(< 1 to 19 plants/m<sup>2</sup>) and the residual herbicide plots (0 to 4 plants/m<sup>2</sup>). Results from this study suggest that PRE herbicides can be useful for providing residual weed control in apples. Before selecting PRE herbicides for use in tree fruits, growers should consider what crops they will be applied in, the age of the trees in the orchard, what weeds are present, the soil conditions at a site, how and when the products will be incorporated, and if litter or standing vegetation could impede deposition in order to maximize crop safety and weed control.

**Weed Management in Western Pecans with Penoxsulam+Oxyfluorfen.** Jesse M. Richardson<sup>\*1</sup>, William B. McCloskey<sup>2</sup>, Richard K. Mann<sup>3</sup>; <sup>1</sup>Dow AgroSciences, Hesperia, CA, <sup>2</sup>University of Arizona, Tucson, AZ, <sup>3</sup>Dow AgroSciences, Franklin, IN (133)

Effective weed management is crucial for maximizing nut yield and quality in Western pecans, particularly in the early years of tree establishment. Two studies were established in San Simon, Arizona in 2017 to investigate the spectrum of weeds controlled, as well as the length of residual control provided by Pindar<sup>TM</sup> GT (penoxsulam+oxyfluorfen) and GoalTender<sup>®</sup> (oxyfluorfen), applied alone and in combination with other herbicide products. Treatments were applied on April 20 and 21, 2017 in orchards owned by FICO and A&P Pecans. Herbicide treatments were applied with a tractor-mounted boom at a spray volume of 20 gallons of water per acre. The A&P study consisted of 10 treatments: 1) no PRE program, 2) Prowl H2O (pendimethalin) at 3.8 lb a.i./acre + Chateau (flumioxazin) at 0.191 lb a.i./acre, 3) Prowl H2O at 3.8 lb a.i./acre + GoalTender at 1.5 lb a.i./acre, 4) Prowl H2O at 3.8 lb a.i./acre + Matrix (rimsulfuron) at 0.0625 lb a.i./acre, 5) Pindar GT at 1.5 lb a.i./acre, 6) GoalTender at 1.5 lb a.i./acre, 7) GoalTender at 1.5 lb a.i./acre + Trellis (isoxaben) at 1.0 lb a.i./acre, 8) Prowl H2O at 3.8 lb a.i./acre + Broadworks (mesotrione) at 0.188 lb a.i./acre, 9) GoalTender at 1.5 lb a.i./acre + Broadworks at 0.188 lb a.i./acre, and 10) Chateau at 0.191 lb a.i./acre + GoalTender at 1.5 lb a.i./acre. All treatments included Roundup WeatherMAX (glyphosate) at 1.13 lb a.e./acre + ammonium sulfate at 1.5% (w/w). The FICO study consisted of similar treatments, with the exception of treatment 10, which was Surflan (oryzalin) at 4.0 lb a.i./acre + GoalTender at 1.5 lb a.i./acre. Both studies were arranged in a randomized complete block design, with 6 replications per treatment. Individual plots in the A&P study consisted of 5 trees, with plot dimensions of 20 by 125 ft. Individual plots in the FICO study consisted of 6 trees, with plot dimensions of 20 by 120 ft. At the A&P site, control of broadleaf and grass weeds was visually assessed 96, 131 and 189 days after application (DAA) and photographically assessed with nadir images 46, 96, 130, and 188 DAA. At the FICO location, weed control was assessed by counting weed species present in each plot 96, 103 and 169 DAA. Dominant weed species at both locations included prostrate spurge (*Euphorbia prostrata*), Palmer amaranth (*Amaranthus palmeri*), green foxtail (*Setaria viridis*) and bermudagrass (*Cynodon dactylon*). In plots not treated with preemergence herbicides, weeds rapidly reinfested the plots. All preemergence herbicide treatments suppressed weed emergence compared to the treatment without a residual herbicide. Treatments containing oxyfluorfen (Pindar GT and GoalTender) were superior and provided effective weed control for 4 months or more. Southwestern pecan growers are increasingly incorporating Pindar GT and GoalTender into their residual weed control programs, ensuring that trees reach their optimum potential to produce high yields of quality nuts.

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**Evaluation of Preemergence and Postemergence Herbicides for the Control of Panic Liverseedgrass (*Urochloa panicoides*) in Desert Turf.** Kai Umeda\*; University of Arizona, Phoenix, AZ (134)

Panic liverseedgrass (*Urochloa panicoides*) is a relatively new problem weed occurring in turfgrass in the low desert region of Arizona. The USDA Plants Database shows it as an introduced annual grass in Texas, New Mexico, and Arizona. It is invasive and federally listed as a noxious weed. Small plot field experiments were conducted at a cemetery with common bermudagrass infested with liverseedgrass in Phoenix, AZ during the summer of 2016 to evaluate postemergence herbicides and winter 2016-17 for preemergence herbicides. Herbicide sprays were applied using a backpack CO<sub>2</sub> sprayer equipped with a hand-held boom with three 8003LP flat fan nozzles. Sprays were applied in 50 or 58 gpa water pressurized to 30 or 40 psi. A methylated seed oil surfactant was added to all postemergence sprays. Granular preemergence products were applied using a shaker jar with holes in the lid for the granules to pass through. Postemergence herbicides were not effective on liverseedgrass when applied to mature weeds during June to August. Quinclorac and combination pre-mix herbicides; metsulfuron; and sulfosulfuron were not effective against liverseedgrass. Mesotrione and topramezone alone or in combinations exhibited short term control of 2-3 weeks following sequential applications. Preemergence applications in December of proflam on fertilizer granules and granular pendimethalin controlled liverseedgrass into July. Proflam was equally effective with a preemergence application in February. Pendimethalin and pendimethalin plus dimethenamid controlled liverseedgrass for a slightly shorter period from February to June. Preemergence herbicides were effective when applied prior to liverseedgrass emergence before early March. Indaziflam, flumioxazin, dithiopyr, and oxadiazon provided much shorter duration liverseedgrass control in the spring season.

**Effect of Herbicides on Newly Transplanted Red Raspberry Plugs.** Wiharti O. Purba\*<sup>1</sup>, Steven S. Seefeldt<sup>1</sup>, Timothy W. Miller<sup>2</sup>; <sup>1</sup>Washington State University, Mount Vernon, WA, <sup>2</sup>Washington State University, Mt Vernon, WA (135)

Two baby raspberry trials were conducted in 2016 and 2017 at the Washington State University Northwestern Washington Research and Extension Center in Mount Vernon. In 2016, tissue culture 'Cascade Harvest', 'Meeker', 'Squamish', and 'Wakefield' red raspberry plugs were transplanted by hand May 16, then treated over-the-top with herbicides May 18. Tested herbicides were sulfentrazone at 0.28 kg ai/ha, flumioxazin at 0.21 kg ai/ha and 0.43 kg ai/ha, flumioxazin + pyroxasulfone at 0.14 kg ai/ha + 0.18 kg ai/ha, napropamide at 4.48 kg ai/ha, pendimethalin at 1.26 kg ai/ha, oryzalin at 6.72 kg ai/ha, isoxaben at 1.26 kg ai/ha, rimsulfuron at 0.07 kg ai/ha, halosulfuron-methyl at 0.11 kg ai/ha, and simazine at 1.89 kg ai/ha. Crop injury was exceeded 50% with both rates of flumioxazin and flumioxazin + pyroxasulfone, while primocane length was reduced by flumioxazin at both rates, flumioxazin + pyroxasulfone, and rimsulfuron in July and September. In 2017, 'Meeker', 'Squamish', and 'Wakefield' red raspberry plugs were transplanted May 24. Treatments were the same as in 2016, except flumioxazin at both rates and flumioxazin + pyroxasulfone were applied May 23 prior to transplanting, and napropamide was replaced by post-transplant indaziflam at 0.07 kg ai/ha. Post-transplant herbicides were applied May 24. Raspberry primocane growth was not significantly influenced by herbicide treatment in mid-season but was maximized by flumioxazin, indaziflam, oryzalin, isoxaben, and halosulfuron-methyl treatments by the end of

the season. When analyzed by cultivar, primocane growth was greatest with ‘Meeker’ at both mid- and late-season evaluations in 2016. In 2017, ‘Wakefield’ had the longest primocanes in July, although primocane length did not differ among cultivars by October.

**Saflufenacil and Pyridate Efficacy and Tolerance in Western Mint Production.** Rick A. Boydston<sup>\*1</sup>, Robert Wilson<sup>2</sup>, Andy G. Hulting<sup>3</sup>; <sup>1</sup>USDA-ARS, Prosser, WA, <sup>2</sup>University of California, Tulelake, CA, <sup>3</sup>Oregon State University, Corvallis, OR (136)

Pyridate was tested at 1 kg ai ha<sup>-1</sup> in peppermint or Scotch spearmint in Washington, California and Oregon studies in 2017 and compared to all postemergence applied broadleaf herbicides currently registered in mint. Pyridate, terbacil and bentazon were consistently safe on mint at all locations, whereas some transient mint injury was observed following bromoxynil, clopyralid, or MCPB application. Mint hay and oil yields were never reduced by pyridate applications and sometimes increased due to control of broadleaf weeds. Pyridate controlled kochia well in California and Washington trials and controlled redroot pigweed well in Washington and Oregon trials if applied when pigweed was less than 10 cm tall. Tolerance of peppermint and native spearmint to saflufenacil at 0.05 and 0.1 kg ai ha<sup>-1</sup> was tested in Washington, California, and Oregon trials. Saflufenacil was applied alone or in combinations with other herbicides and applied when mint was dormant in February or applied to double cut mint just after the first harvest and prior to mint regrowth. In Washington, saflufenacil at both rates did not injure native spearmint applied alone or in combinations terbacil, pendimethalin and pyroxasulfone and mint hay and oil yields were not reduced. In California trials, saflufenacil controlled prickly lettuce, dandelion, and tansy mustard better than a paraquat dormant treatment. Saflufenacil controlled lambsquarters and kochia preemergence when applied to dormant mint in Oregon trials. Saflufenacil initially controlled redroot pigweed in double cut peppermint in Washington when applied just after the first harvest, but residual control did not last season long and some redroot pigweed emerged in August. Sulfentrazone at 0.145 kg ai ha<sup>-1</sup> controlled redroot pigweed season long when applied just after the first peppermint harvest.

**Flumioxazin for Postemergence-Directed Applications in Chile Pepper.** Brian J. Schutte\*; New Mexico State University, Las Cruces, NM (137)

The chemical control catalogue for chile pepper is lacking in residual herbicides that can be applied after crop emergence. This study evaluated POST-directed, hooded applications of flumioxazin in chile pepper by (1) comparing pre-emergent control from flumioxazin against control from soil-applied herbicides currently registered for this crop, and (2) identifying conditions that foster flumioxazin-induced yield losses. Multi-year field studies were conducted at university research farms near Las Cruces, NM and Los Lunas, NM. Soils at Las Cruces were fine-textured (silty-clay to clay), whereas soils at Los Lunas were coarse-textured (sandy-clay loam to sandy loam). At Las Cruces, pendimethalin and S-metolachlor provided greatest control of grass weeds, flumioxazin and pendimethalin provided greatest control of broadleaf weeds. At Los Lunas, the fewest broadleaf and grass weeds occurred in plots treated with flumioxazin, pendimethalin and a tank mix combination of napropamide and clomazone. Chile pepper yield at Las Cruces was not reduced by two POST-directed applications of flumioxazin at 70 g ai ha<sup>-1</sup> or one application at 107 g ai ha<sup>-1</sup>. Chile pepper yield at Los Lunas was occasionally reduced when flumioxazin was applied to raised beds at 107 g ai ha<sup>-1</sup>. Flumioxazin applied to row middles did not reduce yield. A follow-up greenhouse study indicated that chile pepper susceptibility to

flumioxazin on coarse-textured soil was negatively associated with soil organic matter content. The results of this study indicated that (1) flumioxazin can provide control that is equivalent to, or greater than, soil-applied herbicides currently registered for chile pepper in New Mexico, and (2) registration recommendations for POST-directed applications of flumioxazin will need to be soil type-specific.

### PROJECT 3: WEEDS OF AGRONOMIC CROPS

**New Broad-Spectrum Pyroxsulam + Fluroxypyr Herbicide for Grass and Broadleaf Weed Control in Wheat.** Mike Moechnig\*<sup>1</sup>, Patti Prasifka<sup>2</sup>, Joe Yenish<sup>3</sup>, Roger E. Gast<sup>4</sup>; <sup>1</sup>Dow AgroSciences, Toronto, SD, <sup>2</sup>Dow AgroSciences, West Fargo, ND, <sup>3</sup>Dow AgroSciences, Billings, MT, <sup>4</sup>Dow AgroSciences, Indianapolis, IN (077)

OpenSky™ (pyroxsulam + fluroxypyr) herbicide, a new grass and broadleaf herbicide product from Dow AgroSciences, received US EPA approval in November 2017 for post-emergence applications in winter and spring wheat (including durum) and triticale. OpenSky is an improved formulation with similar weed control spectrum as GoldSky™ (pyroxsulam + fluroxypyr + florasulam) herbicide that will eventually replace GoldSky in the market. Like GoldSky, OpenSky will be intended for broad-spectrum grass and broadleaf weed control, particularly in areas where sensitive rotational crops preclude the use of clopyralid-containing products. OpenSky is a suspo-emulsion (SE) formulation with improved storage and handling characteristics relative to GoldSky, an oil-dispersion (OD) formulation. OpenSky has an expanded application window, from the three leaf stage to just prior to flag-leaf emergence (Zadok 37), whereas most other pyroxsulam-containing products may be applied up to the wheat jointing growth stage (Zadok 31). OpenSky is labeled at 1.17 liters/ha (16 fl oz/A) for spring wheat which provides 15 g ai/ha pyroxsulam and 133 g ae/ha fluroxypyr-meptyl. Relative to the same labeled rate of GoldSky, this OpenSky rate provides an equivalent amount of pyroxsulam per ha, but 33% more fluroxypyr. In field trials conducted from 2015-2017 across MT, ND, and SD, OpenSky provided equal or superior efficacy as GoldSky on key broadleaf weeds such as wild buckwheat (*Polygonum convolvulus*), kochia (*Kochia scoparia*) and brassicaceae species. Control of grass weed species, including wild oats (*Avena fatua*), yellow foxtail (*Setaria pumila*), and green foxtail (*Setaria viridis*), was also similar between OpenSky and GoldSky. Spring and winter wheat (*Triticum aestivum*) tolerance to OpenSky applications was equal to that of GoldSky and other competitive products. In summary, OpenSky is an improved alternative to GoldSky for broad-spectrum grass and broadleaf weed control in the northern U.S. wheat growing region.

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**Utility of Arylex™ Active Herbicides for Control of Emerging Weed Threats in Western Canadian Cereal Crops.** Rory Degenhardt\*<sup>1</sup>, Jamshid Ashigh<sup>2</sup>, Len T. Juras<sup>3</sup>, Laura Smith<sup>4</sup>, Andrew MacRae<sup>4</sup>; <sup>1</sup>Dow AgroSciences, Edmonton, AB, <sup>2</sup>Dow AgroSciences, London, ON, <sup>3</sup>Dow AgroSciences, Saskatoon, SK, <sup>4</sup>Dow AgroSciences, Winnipeg, MB (078)

Arylex™ active (halauxifen-methyl) is a synthetic auxin herbicide from the new arylpicolinate chemical family that has now been developed into four commercial herbicide products, Pixxaro™, Paradigm™, Rexade™ and Cirpreme™, for use in Western Canadian cereal crops. By pairing Arylex with other active ingredients, these herbicide products provide multiple modes of action, with complementary, or in many cases overlapping, activity against a broad spectrum of annual, winter annual and perennial weeds. Between 2010 and 2017, Dow AgroSciences evaluated Arylex-containing herbicide products in small plot field research trials conducted across Western Canada for control of emerging weed threats, including field horsetail (*Equisetum arvense*), American dragonhead (*Dracocephalum parviflorum*), field violet (*Viola arvensis*), nightshade (*Solanum spp.*), round-leaved mallow (*Malva pusilla*), henbit (*Lamium amplexicaule*) and barnyard grass (*Echinochloa crus-galli*). All of these weeds have shown increasing abundance in recent weed surveys, and for most there is very little information available to producers about herbicide control options. Arylex-containing herbicide products showed strong activity against these weeds, ranging from suppression to excellent control depending on the weed species and the product. These Arylex-containing herbicides will provide Western Canadian farmers with new tools to control weeds such as field horsetail, American dragonhead, field violet, nightshade species, round-leaved mallow, henbit and barnyard grass in their cereal crops.

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**AccuDrop™ - A New Drift Control and Deposition Adjuvant.** Ryan Edwards\*<sup>1</sup>, Greg Dahl<sup>1</sup>, Thomas A. Hayden<sup>2</sup>, Jo A. Gillilan<sup>3</sup>, Eric Spandl<sup>4</sup>, Joe V. Gednalske<sup>1</sup>, Ray L. Pigati<sup>5</sup>; <sup>1</sup>WinField United, River Falls, WI, <sup>2</sup>WinField United, Owensboro, KY, <sup>3</sup>WinField United, Springfield, TN, <sup>4</sup>WinField United, St Paul, MN, <sup>5</sup>WinField United, Shoreview, MN (079)

AccuDrop™ is a non-oil, NPE free surfactant based drift and deposition adjuvant from Winfield® United. AccuDrop™ is designed to maximize pesticide performance by improving spray deposition onto the intended target. Also, being surfactant based, AccuDrop™ can be used with many herbicides, fungicides or insecticides with minimal expected crop injury. The use rate of AccuDrop™ is 3 fl oz/A. As part of the testing program, Winfield® United conducted 126 field efficacy trials as well as screening through the Winfield® United Spray Analysis System, a patented recirculating low speed wind tunnel. In numerous field trials, herbicide plus AccuDrop™ performance versus the herbicide alone showed significantly increased weed control. Field drift studies also showed significant drift reductions; 9.9 ft with the addition of AccuDrop™ compared to 22.4 ft with no drift control added. Wind tunnel testing was utilized to evaluate spray particle size with various pesticides and nozzle tips. AccuDrop™ added to glyphosate and sprayed through XR11003 nozzles reduced the percent of spray particle droplet fines from 16% to 6%. Likewise, with a AIXR 11004 nozzle, percent fines were reduced from 16% to 4% vs glyphosate alone.

**HSMOC Adjuvants - Commercial Brands or Make Your Own?** Rich Zollinger\*, Jason W. Adams, Devin A. Wirth; North Dakota State University, Fargo, ND (080)

Glyphosate is highly water-soluble and controls many weed species but efficacy on large or drought stressed weeds may not be adequate. Several weed biotypes have developed resistance to glyphosate. Tank-mixes with glyphosate are used for broad-spectrum weed control. Most

herbicides preferentially used with glyphosate are highly lipophilic requiring oil adjuvants for optimum weed control. Adjuvant selection with mixtures of glyphosate and lipophilic herbicides may be difficult as nonionic surfactants (NIS) are generally least effective with lipophilic herbicides and emulsified oil adjuvants antagonize hydrophilic glyphosate. High surfactant oil concentrate (HSOC) adjuvants contain greater than 50% oil and 25 to 50% emulsifier/surfactant and enhance lipophilic herbicides but not antagonize glyphosate. HSOC adjuvants are petroleum oil (HSPOC) or methylated seed oil (HSMOC) based. HSMOC are more effective than HSPOC. The high cost of HSMOC is much greater than NIS or petroleum oil based concentrate adjuvants (PO). The high cost is a major factor deterring use and rates are reduced to lower cost. Studies were conducted from 2010 to 2017 in North Dakota to determine efficacy of mixtures of different commercial MSO and NIS adjuvants with glyphosate plus tembotrione, dicamba, or 2,4-D and to find effective MSO plus NIS combinations that are lower in cost. Herbicide efficacy was greatest when MSO, HSMOC, or mixtures of MSO plus NIS was applied on an area (volume per area, pt/A) basis than a volume basis (% v/v). A 60:40 ratio of MSO:NIS was optimum. Commercial surfactants differed in reducing oil antagonism and/or enhancing glyphosate. It is thought the emulsifier formulated with oil adjuvants may be an indicator of compatibility with glyphosate. Several MSO plus NIS combinations increased herbicide efficacy. The effect of mixtures of commercial formulations of MSO plus NIS to create a less expensive HSMOC cannot be determined with prior unbiased experimental testing as not all NIS are glyphosate friendly. Increasing HSOC rates may improve herbicide efficacy and reduce enhancement variability in this adjuvant class.

**Use of Extender Adjuvants with Soil Applied Herbicides.** Jason W. Adams\*, Rich Zollinger; North Dakota State University, Fargo, ND (081)

Extender adjuvants are a relatively new class of adjuvant designed to improve residual control of soil applied herbicides. The adjuvants improve activity in various ways including reduction of volatility, forming a coating to reduce degradation, and improving movement into and retention in the soil profile. Experiments were conducted near Mayville, ND in 2017 in order to evaluate the effect of extender adjuvants on soil applied herbicide efficacy. Study 1 had ethalfluralin applied at 840 g ha<sup>-1</sup> with 9 different extender adjuvants and incorporated 2 days after application. Study 2 had EPTC applied at 2940 g ha<sup>-1</sup> with 9 extender adjuvants and incorporation delayed for 2 hours after application. Study 3 had increasing rates of EPTC with 1 extender adjuvant and bentazon, halosulfuron, and fomesafen applied following EPTC at 980 g ha<sup>-1</sup> plus ethalfluralin at 840 g ha<sup>-1</sup> with 1 extender adjuvant. The addition of extender adjuvants to the herbicides generally increased weed control in both studies 1 and 2. However, there was significant variability in the results. Many extender adjuvants increased control, while others provided less control compared to the herbicide alone. Residual control increased with the addition of an extender adjuvant in study 3 with increasing rates of EPTC. For example, lambsquarters control was increased from 80 to 87 % control when an extender adjuvant was added to EPTC applied at 1960 g ha<sup>-1</sup>. The addition of extender adjuvants also increased and retained weed control when POST herbicides were applied. In summary, extender adjuvants generally increased weed control when applied with soil applied herbicides. However, more research is needed to achieve more consistent results when using extender adjuvants.

**Prolonging the Activation Window for Preemergence Herbicides with an At-Cracking Treatment of Paraquat in Chickpeas.** Rachel J. Zuger\*, Amber L. Hauvermale, Jeanette A.

Rodriguez, Lindsay E. Koby, Henry C. Wetzel, Ian C. Burke; Washington State University, Pullman, WA (082)

Chickpeas (*Cicer arietinum* L.) are a low growing, relatively noncompetitive crop due to slow canopy development. As there are no postemergence (POST) broadleaf herbicide options in chickpeas, weed management is dependent preemergence (PRE) herbicide activation by rainfall, and there has been significant variation in rainfall during and after chickpea establishment in the inland Pacific Northwest. In peanut, paraquat is an effective herbicide when applied within 3 weeks of ground crack and may be an effective tool for early season weed management in chickpea. The objectives were to evaluate: 1) chickpea crop tolerance to paraquat applied at chickpea ground crack and at intervals following ground crack with and without a nonionic surfactant, 2) weed management utilizing paraquat in combination with preemergence herbicides. Treatments of paraquat (140 g ai ha<sup>-1</sup>) and paraquat with NIS (140 g ai ha<sup>-1</sup>, 0.25% v/v) were applied at four different timings; at ground crack, and at 4, 7 and 10 days after ground crack, in two separate cropping scenarios; a weedy and a weed free environment. Both studies were conducted in 2016 and 2017. Visual estimates of crop injury, common lambsquarters and Italian ryegrass control were recorded, and yield was harvested both years. All studies were treated with dimethenamid-P (1103 g ai ha<sup>-1</sup>) and linuron (1401 g ai ha<sup>-1</sup>) applied PRE. Weed free studies were placed in areas with low relative weed pressure, and were hand weeded as needed. Crop injury, in the form of necrosis, was observed 1 to 2 weeks after the last paraquat treatment however, plants recovered, and necrosis was no longer present later in the growing season. In the weed free study, yields were the greatest for the at-cracking treatments of paraquat (<1550 kg ha<sup>-1</sup>) compared to the nontreated control (1350 kg ha<sup>-1</sup>). For most of the timings in the weed free study, the addition of NIS caused lower yields although not significantly different except for the latest timing (10 days after cracking) which had yields of 1550 kg ha<sup>-1</sup> and 1320 kg ha<sup>-1</sup>. Paraquat significantly increased control of common lambsquarters (*Chenopodium album* L.) and Italian ryegrass [*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot]. The addition of NIS did not increase or decrease the weed efficacy of paraquat. In the weedy studies, yields were higher when paraquat was applied regardless of application timing, compared to the nontreated control. In conclusion, paraquat applied early in chickpea establishment can increase weed control and although crop necrosis occurs, injury does not result in yield loss.

**Potential Fit for New Products for Broadleaf Weed Management in Grasses Grown for Seed.** Dan W. Curtis\*, Kyle C. Roerig, Andy G. Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (083)

Recent research results have shown that two new herbicide products have a fit in the crop grouping 'grasses grown for seed' in Western Oregon. In field studies conducted in perennial ryegrass and tall fescue seed crops, halauxifen/florasulam (Quelex) and bicyclopyrone/bromoxynil (Talinor) have provided control of several important weed species with no apparent negative effects to the crop. A non-replicated test application on a roadside in 2014 indicated that halauxifen/florasulam had potential for wild carrot control. In a 2014-15 study initiated that fall along the edge of a commercial tall fescue planting, halauxifen/florasulam applied at 0.75 oz/A (product) controlled 93% of the wild carrot population present compared to 40% for tribenuron (Express) + 2,4-D/dicamba acid (Latigo). In a 2017 study conducted in a grass field road, wild carrot was controlled 87% with halauxifen/florasulam compared to 63 % with fluroxypyr/trichlopyr + 2,4-D/dicamba acid and 35 % control with tribenuron + 2,4-

D/dicamba acid. Two perennial ryegrass studies in 2015 and in 2016 resulted in no yield difference between an untreated check treatment and halauxifen/florasulam applied at 0.75 oz product/A. A perennial ryegrass study in 2016 also resulted in no differences in yield between an untreated check treatment and bicyclopyrone/bromoxynil applied at 13.7 oz product/A. Bicyclopyrone/bromoxynil controlled corn spurry, white clover, sticky chickweed, annual knawel, shepherd's purse and redmaids greater than 90% in the perennial ryegrass. A study conducted in 2017 in spring seeded tall fescue, bicyclopyrone/bromoxynil applied at 18.2 oz/A product + co-actA (buffer), provided 99% control of a mayweed chamomile which was comparable to pyrosulfotole/bromoxynil (Huskie) + 2,4-D/dicamba acid with 98%. Studies in spring seeded tall fescue had no growth reduction from applications of these products. In conclusion, both herbicide mixtures are safe to both perennial ryegrass and tall fescue and would be useful for weed management in grass seed crops.

**Pre and Early Postemergent Control of Dock spp. with Flumetsulam and 2,4-DB in Clover spp. Grown for Seed.** Kyle C. Roerig\*, Andy G. Hulting, Dan W. Curtis, Carol Mallory-Smith; Oregon State University, Corvallis, OR (084)

Curly dock (*Rumex crispus* L.) and broadleaf dock (*Rumex obtusifolius* L.) are problematic weeds in red and white clover grown for seed. Curly and broadleaf dock are persistent, perennial species that develop a deep tap root and are very difficult to control in clover. Dock can significantly reduce clover seed yield through competition for resources and contaminates clover seed. Even though dock is not difficult to control in most crops grown in rotation with clovers grown for seed, it remains a problem due its seed longevity in soil. Currently registered herbicides fail to provide adequate control of dock in clover grown for seed. Previous studies indicate that 2,4-DB has excellent crop safety and provides approximately 70% control of curly and broadleaf dock in established clover. Flumetsulam applied to established clover has excellent crop safety, but no activity on dock. This study evaluated applications of 2,4-DB on seedling clover and flumetsulam applied preemergent and to seedling clover. Red clover was planted in the fall with two rows of a mixture of curly and broadleaf dock planted across each plot. Flumetsulam provided 99-100% control of dock with preemergent and early postemergent applications at 75.5 and 149.1 g ai/ha. However, clover seed yield was 13-16 and 35-42% less than in the untreated plots, respectively. Flumetsulam applied in the spring did not affect yield, however, dock control was only 30-43%. Yield in plots treated with 2,4-DB was not significantly different than in the untreated control (p-value 0.05). Control ranged from 23-74%; the best control occurred with higher rates and later timings. Flumetsulam applied at lower rates and 2,4-DB are being evaluated on red and white clover in 2018.

**Commercial Launch of the CoAXium Wheat Production System.** Chad Shelton\*<sup>1</sup>, Todd Gaines<sup>2</sup>, Eric Westra<sup>2</sup>, Scott Haley<sup>2</sup>, Curtis M. Hildebrandt<sup>2</sup>, Phil Westra<sup>2</sup>; <sup>1</sup>Albaugh, LLC, Rosalia, WA, <sup>2</sup>Colorado State University, Fort Collins, CO (085)

Three major agricultural organizations have established a strategic collaboration towards innovative and novel solutions for wheat producers. The partnership targets the development and distribution of wheat varieties with a non-GMO trait conferring tolerance to a new herbicide for wheat to control winter annual grasses. The collaborating partners include Colorado Wheat Research Foundation, Inc. (CWRF), Albaugh LLC, global leader for post-patent agri-chemicals, and Limagrain, a farmer-owned international seed group. This unique three-way partnership will



deploy the use of this technology exclusively on a worldwide basis. This innovative technology will help deliver new grass and broadleaf control to farmers across the North American cereal market and around the globe. In the fall of 2018 the commercial launch of the CoAXium™ Wheat Production System including Aggressor Herbicide™ will include two new hard red winter wheat varieties, PlainsGold Incline AX and LCS Fusin AX. The launch of the CoAXium Wheat Production System will combine public and private trait introgression into elite varieties. Aggressor herbicide will provide the wheat industry with a new tool for control of tough winter annual grasses including Group 2 (ALS) insensitive or resistant grassy weed biotypes. The CoAXium Wheat production System will be driven by a robust stewardship program to help maintain the performance and utility of the system. The CoAXium™ Wheat Production System including Aggressor Herbicide™ is driven by grower innovation, performance and value.

**Application Methods to Improve Herbicide Spray Deposition in Wheat Residue.** Cody Creech\*, Luana Simao; University of Nebraska, Scottsbluff, NE (086)

Wheat residue when properly managed provides increased soil water conservation and erosion control. The viability of this system depends on an effective chemical weed control that reduces reliance on tillage. The objective of this study was to evaluate the spray deposition of a glyphosate (2.24 kg ha<sup>-1</sup>) and dicamba (0.56 kg ha<sup>-1</sup>) tank mixture applied (140 L ha<sup>-1</sup>) used in different heights of wheat residue, nozzle types, and application direction of travel. The treatments consisted of three different heights (0, 35 and 68 cm) of wheat stubble, four nozzles types (AIXR, TTJ, TTI and XR), and three different spraying directions in relation to the wheat stubble rows (parallel, angular, and perpendicular). Collectors were placed on the ground between wheat stubble rows and nozzles spaced 52 cm apart. The experiment was conducted as a split-split plot design in two wheat fields near Sidney, NE with four replications. The spray deposition of the AIXR nozzle was similar to the TTI and 13 and 21% greater than the TTJ and XR nozzles, respectively. Tall and medium wheat stubble reduced herbicide spray deposition relative to the no-stubble treatment in one field by 41 and 26%, respectively, and 28 and 13%, respectively, in the other field. Spray application direction of travel in a parallel or angular to the wheat row increased the amount of herbicide deposition in one field 30 and 14%, respectively. The results of this study suggest that increasing amounts of wheat residue can reduce the amount of spray droplets that are able to reach targets near the soil surface. This can be overcome by using an AXIR nozzle and by not spraying perpendicular to the wheat rows.

**Controlling Glyphosate Resistant Kochia in Wheat Stubble.** Curtis R. Thompson\*<sup>1</sup>, Alan J. Schlegel<sup>2</sup>, Dallas Peterson<sup>1</sup>; <sup>1</sup>Kansas State University, Manhattan, KS, <sup>2</sup>Kansas State University, Tribune, KS (087)

Glyphosate resistant kochia is wide spread across western Kansas. In a no-till system, there has been heavy dependence on glyphosate for weed management. As a result, kochia has developed resistance to glyphosate and become a serious problem for wheat-corn or wheat-sorghum rotations. In these rotations, wheat is harvested in June and the wheat residue must be maintained free of weeds until the subsequent row crop is planted in April (corn) or late May to early June (sorghum) the following spring. Experiments were conducted each year beginning fall of 2012 and ending summer of 2017. Hard red winter wheat was planted at 45 kg ha<sup>-1</sup> early October of each year. During Nov/Dec kochia seed was gathered and spread over the planted wheat to ensure a kochia stand could be obtained to evaluate treatments for kochia control.

Dicamba + triasulfuron premix at 165 g ha<sup>-1</sup> was applied with pyroxasulfone at 123 g ha<sup>-1</sup> during November of 2014, 2015, and 2016. Herbicides applied to pre-joint wheat were applied during April of 2013, 2014, 2015, 2016, and 2017. In these same years, an herbicide containing clopyralid & fluroxypyr at 280 g ha<sup>-1</sup> was applied to emerging flag-leaf wheat during early May of each year. Only seven treatments occurred in all 5 years of this experiment. Averaged over 5 years, dicamba diglycolamine salt (DGA) at 140 g + 2,4-D LV ester at 280 g ae ha<sup>-1</sup> applied to pre-joint wheat provided only 62% control of kochia in the wheat crop evaluated just prior to harvest. Dicamba DGA at 140 g ae+ pyrasulfotole & bromoxynil at 258 g ha<sup>-1</sup> provided 71% kochia control. Dicamba & triasulfuron at 165 g ha<sup>-1</sup> applied pre-joint to wheat and clopyralid & fluroxypyr applied to emerging flag leaf wheat each provided 75% control. In the wheat stubble phase of this experiment, fallow treatments were applied 2 to 3 weeks following wheat harvest. Treatments that included dicamba DGA at 560 g ae + atrazine at 1120 g ha<sup>-1</sup> or dicamba DGA at 560 g ae + 2,4-D LV ester at 560 g ae ha<sup>-1</sup> did not provide adequate control of kochia in fallow ranging from 58 to 74% 4 weeks after fallow treatment (WAT). Atrazine at 1120 g ha<sup>-1</sup> + saflufenacil at 50 g ha<sup>-1</sup> + methylated seed oil and urea ammonium nitrate provided 90 to 94% control of kochia 4 WAT. This treatment always followed an in the wheat crop herbicide program. When no herbicides were applied to the wheat crop, only paraquat at 840 g ha<sup>-1</sup> provided adequate kochia control in fallow at 93% 4 WAT. Fallow only treatments of dicamba 560 g ha<sup>-1</sup> + atrazine at 1120 g ha<sup>-1</sup> or dicamba at 560 g ha<sup>-1</sup> + 2,4-D LV ester at 560 g ha<sup>-1</sup> provided 61 to 68% control of kochia 4 WAT, which was not adequate. During 2015, 2016, and 2017 pyroxasulfone was added to three different herbicide programs applied in November or to wheat PRE-joint to evaluate the effect of pyroxasulfone residual on kochia control. Treatments with and without pyroxasulfone were contrasted. Triasulfuron & dicamba + pyroxasulfone applied in November provided 95% control of kochia compared to 78% from triasulfuron & dicamba + surfactant based on the evaluation just prior to wheat harvest. The addition of pyroxasulfone at 123 g ha<sup>-1</sup> to dicamba DGA compared to dicamba DGA + 2, 4-D LV ester increased kochia control from 62 to 79%, which also lead to improved control in the fallow phase from 75 to 96% control 4 WAT. The addition of pyroxasulfone to dicamba+pyrasulfotole and adjuvants did not increase kochia control at the preharvest rating as both treatments provided 70% control, while in fallow 4 WAT control ranged from 91 to 92%. Controlling kochia in the wheat crop will help kochia management during the fallow period. Paraquat + atrazine + adjuvants provided the best level of kochia control during the fallow period.

**Are Auxinic Premixes That Include Fluroxypyr Safer to Wheat?** Kirk A. Howatt\*, Joseph E. Mettler; North Dakota State University, Fargo, ND (104)

Dicamba is used to control kochia and other broadleaf weeds in wheat and barley, but dicamba can potentially injure these small grain crops if applied under adverse weather or at later growth stages. Some premix herbicides were observed to produce less severe injury when fluroxypyr was part of the premix. Trials were established to evaluate severity of crop injury relative to inclusion of fluroxypyr. In 2015, dicamba & 2,4-D&fluroxypyr resulted in about half as much injury in wheat than dicamba & 2,4-D at equivalent dicamba rates. In 2016, this difference was recorded again, but the added factor of application timing indicated severity increased as application occurred at later growth stage and difference was not as divergent with application at later growth stage. Wheat yield demonstrated the greater injury as 10% less yield without inclusion of fluroxypyr in treatments applied to fully tillered wheat. Differential response in barley was less prominent and not as often significant. In 2017, visible wheat or barley injury

was marginally different when comparing dicamba & 2,4-D to dicamba & 2,4-D & fluroxypyr, but yield was 25 to 50% less when herbicides were applied at later growth stage compared with untreated checks. The fluroxypyr premix generally resulted in less injury to wheat or barley than dicamba & 2,4-D. This work did not attempt to separate possible formulation effect from active ingredients. While the fluroxypyr premix often reduced the observed injury to foliage and plant development, sufficient safety was not achieved to pursue later application timing.

**Characterizing Putative Fluroxypyr Resistance in *Kochia Scoparia*.** Olivia E. Todd\*, Todd Gaines, Phil Westra, Dean Pettinga, Eric Westra; Colorado State University, Fort Collins, CO (105)

The synthetic auxin Fluroxypyr (group O [4]) mimics the plant growth regulator indole acetic acid (IAA), a hormone that is integral to metabolic regulation and phenotypic responses to photo- and gravitropism. Considering all reported cases of resistance to the synthetic auxin group, only five individual cases of fluroxypyr resistance have been reported across four different species. A *Kochia scoparia* field survey around Colorado in 2014 yielded one putative fluroxypyr resistant population from eastern Colorado (CO-R). This population after initial resistance screening exhibited an R:S ratio 3X higher than the population described from North Dakota in 2006, and 9.5X higher than the known susceptible inbred population (S). However, this population was still highly segregating. Stable inheritance of resistance has been confirmed after repeating the dose response with bulk pollinated survivors from the first dose response, (B<sub>1</sub>). This first generation population exhibited an R:S ratio of a 2.74 fold difference between the survival rate of the CO-R and S lines. The objective of this study is to determine mode of heritability in this population, as well as quantify the difference in fluroxypyr-meptyl and fluroxypyr-acid metabolism between CO-R and S using LCMS/MS techniques.

**Fluroxypyr Control of *Kochia (Kochia Scoparia)* in the North America Northern Plains From 1990 to 2014 - A Historical Perspective.** Roger E. Gast\*<sup>1</sup>, Len T. Juras<sup>2</sup>, Don Hare<sup>3</sup>, Joe Yenish<sup>4</sup>, Rory Degenhardt<sup>5</sup>; <sup>1</sup>Dow AgroSciences, Indianapolis, IN, <sup>2</sup>Dow AgroSciences, Saskatoon, SK, <sup>3</sup>Dow AgroSciences (retired), Edmonton, AB, <sup>4</sup>Dow AgroSciences, Billings, MT, <sup>5</sup>Dow AgroSciences, Edmonton, AB (106)

Abstract not available

**Crop Tolerance and Weed Control in Direct Seeded Onion with Bicyclopyrone.** Tara L. Burke\*, Rachel J. Zuger, Amber L. Hauvermale, Lindsay E. Koby, Caleb C. Squires, Jeanette A. Rodriguez, Tim Waters, Ian C. Burke; Washington State University, Pullman, WA (107)

Bicyclopyrone is a new hydroxyphenylpyruvate dioxygenase (HPPD) inhibitor herbicide registered for use in corn, which would represent a novel herbicide within the onion cropping system. Washington is the third highest ranking producer of onions within the United States, and onions rank second in the vegetable crops produced in Washington, with the majority produced in central Washington. In this study, bicyclopyrone was evaluated as a new herbicide for weed control in onions. A high, medium, and low application rate of bicyclopyrone was evaluated at preemergence, delayed preemergence, and postemergence application timings, across two years. Data collected on weed control, crop response, and yield metrics revealed significant differences between treatments. Bicyclopyrone applied as a postemergence treatment behaves similarly to

the commercial standard post-emergence treatment with few exceptions. Consistent, and frequently dose dependent differences between the preemergence and delayed preemergence bicyclopyrone treatments and the commercial standard were evident. Crop injury, reduced crop emergence, and lower yield for certain quality grades was observed when bicyclopyrone was applied preemergence or delayed preemergence, when compared to the commercial standard applied preemergence or delayed preemergence. Overall, bicyclopyrone may be an effective weed control tool for use in direct seeded onion. However, lower rates will be required when applied preemergence or delayed preemergence, as high field rates may have detrimental effects on crop productivity.

**Impact of Winter Rye Cover Crop on Weed Control and Pinto Bean Production.** Gregory J. Endres\*, Mike H. Ostlie; North Dakota State University, Carrington, ND (108)

A field study was initiated at the NDSU Carrington Research Extension Center to examine the impact of winter rye grown as a cover or companion crop on weed management and production of pinto bean. Experimental design was a randomized complete block with four replications. 'ND Dylan' rye was solid-seeded on September 20, 2016 and 'Lariat' bean were direct planted in 21-inch rows into rye or rye residue on May 31, 2017. Rye (tillering stage) was preplant (PP) terminated by tillage on April 28 (treatment 1). Also, rye was PP terminated by sequentially applied glyphosate (0.77-1 lb ae/A) on April 28 and May 11 (treatment 2). Rye (boot stage) was late PP terminated by glyphosate on May 27 (treatment 3). Treatment 4 plots were land rolled on June 6 with rye in the flowering stage. Imazamox (0.03 lb ai/A) was POST applied on June 26 for terminating rye (dough stage) in treatments 4 and 5, and general weed control across the trial. With the exception of black medic control with early PP treatments, grass (rye plus green and yellow foxtail) and broadleaf control 54 days after planting (DAP) bean was generally good to excellent (79-97%) with POST imazamox plus rye residue among all treatments. The late PP terminated rye treatment provided 84-99% control of all weeds 40 and 54 DAP bean. Bean seed yield was highest with early PP rye termination likely due to greater soil moisture availability from reduced rye growth compared to yield with delaying rye termination, especially POST.

**Frequency and Distribution of Herbicide Resistant Biotypes of Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) in the Willamette Valley of Western Oregon.** Lucas Kopecky Bobadilla\*<sup>1</sup>, Felipe Augusto Stella<sup>2</sup>, Pete A. Berry<sup>1</sup>, Andy G. Hulting<sup>1</sup>, Carol Mallory-Smith<sup>1</sup>; <sup>1</sup>Oregon State University, Corvallis, OR, <sup>2</sup>University of Sao Paulo, Piracicaba, Brazil (109)

Modern agriculture is facing many challenges including management of herbicide-resistance. Spatial surveys of the presence of herbicide-resistant weed biotypes can help us to better understand their frequency and distribution in the landscape. The objective of this study was to document the distribution and frequency of herbicide-resistant Italian ryegrass and to understand the relationships between abiotic factors and resistance presence. A second objective was to document the ploidy diversity within biotypes in western Oregon. The CropScape/NASS database was used to randomly select fields at least five miles from each other. Mapping was focused on tall fescue and wheat fields, but other crops were also surveyed. Sixty-nine fields were sampled in 2017. Variables collected were the presence of the weed and density. Seeds were collected and grown into plants to test for resistance. A screening test with nine herbicides (glyphosate, glufosinate, paraquat, flufenacet + metribuzin, pyroxasulfone, quizalofop-methyl, pinoxaden, clethodim and pyroxsulam) was used to identify resistance presence. Presence of

resistance was classified into three levels (resistant, developing resistance and susceptible). In the surveyed fields, 67% had Italian ryegrass present. Of those fields, 60% had herbicide-resistant populations. Resistance varied with weed density and was more common with greater densities. Only 2% of the populations were tetraploid and resistance was found only in diploids. There was no evidence of clusters of resistant populations related to abiotic factors, such as precipitation and temperature. The predominant resistance observed was to Group 1, 2, 3 and 15 herbicides. Resistance to pyroxasulfone and glufosinate was not quantified.

**The Effect of Climate Conditions on Weed Competition and Wheat Yields in the Northern Great Plains.** Tim Seipel\*<sup>1</sup>, Sue Ishaq Pelligrini<sup>2</sup>, Fabian Menalled<sup>1</sup>; <sup>1</sup>Montana State University, Bozeman, MT, <sup>2</sup>University of Oregon, Eugene, OR (110)

Crop yield is influenced by agricultural practices, climate conditions, and biological interactions. Winter wheat yield and weed communities across three farming systems and contrasting climate conditions were compared at the Fort Ellis Research Farm near Bozeman, MT. Farming systems included a conventional no-till system reliant on chemical inputs for nutrient and weed management (conventional), an organic farming system reliant on tillage for weed control and cover crop termination (tilled-organic), and an organic system that uses sheep grazing to control weeds and terminate cover crops (grazed-organic). Environmental treatments included an ambient climate condition, a hotter climate condition that was created using open-top chambers that increased temperatures, and a hotter and drier climate condition that was achieved using open-top chambers and rain-out shelters that block approximately 50% of precipitation. We modeled the response variables using generalized linear mixed-effects models and used ANOVA and post-hoc Tukey tests to determine if farming systems and climate conditions caused variation in yields and weed biomass.

Open-top chambers increased temperature most from the early spring until late May before a dense wheat canopy developed. The modified climate conditions were warmer compared to ambient conditions during spring when wheat was smaller and most susceptible to weed competition. Soil moisture was affected by the rain-out shelters and was drier than ambient or warmer conditions during grain filling beginning in mid-May through harvest at the end of July.

Winter wheat yield varied in response to climate conditions, farming system, years and their interactions (Farming system X Climate X Year  $\chi_4=20$ ,  $P < 0.001$ ). In conventional plots, wheat yield in the hotter and drier climate condition declined 35% ( $P=0.002$ ) when compared to the ambient conditions in the conventional farming system. In contrast, in 2016, wheat yield in the tilled-organic system and the grazed-organic system remained at 99% and 89% relative to ambient under the hotter and drier conditions ( $P=0.17$  and  $P=0.14$ , respectively). In 2017, yield declined more in the in the tilled-organic and grazed-organic farming systems (80% yield reduction;  $P < 0.001$ ) because of the interaction of warmer and drier conditions and increased weed competition when compared to the conventional system. Weed biomass varied between the two years of the study and by farming system. There was greater weed biomass in the organic systems, especially in 2017. In the tilled-organic system, warmer and warmer and drier conditions lead to greater weed biomass than ambient tilled-organic plots. Overall warmer and drier climate conditions reduced yields through climate stress and increased weed competition. Biotic interactions of crops and weeds are important for predicting yield loss in addition to direct effects of climate in agricultural ecosystems of the Northern Great Plains.

**Using an Unmanned Aerial Vehicle to Detect Herbicide Damage with a Multispectral Camera.** Pete A. Berry\*, Dan W. Curtis, Andy G. Hulting, Carol Mallory-Smith; Oregon State University, Corvallis, OR (111)

Crop injury and herbicide efficacy are metrics used to assess the potential for an herbicide to be labeled for a crop. Weed scientists assess crop injury and efficacy using visual ratings to compare differences between herbicide treatments; however, quantifying crop damage using this system can be difficult when crop responses to the herbicides are similar. UAVs and multispectral cameras can capture crop reflectance at high-resolution which enables quantification of plant health based on specific spectral indices. A perennial ryegrass seed crop (*Lolium perenne*) was treated with six different herbicides and imaged using a micasense RedEdge multispectral camera attached to a Solo quadcopter. Images were mosaiced, radiometrically calibrated, row crop pixel reflectances averaged, and displayed within each herbicide treatment using Agisoft photoscan, Pix4D, R, and ESRI ArcMap, respectively. Herbicide treatments were analyzed to determine crop damage based on the percent reflectance compared with the untreated control. Weed populations were determined using a binary present/absent NDVI index once the crop rows were masked. The binary system quantified percent weed coverage based on the total number of pixels in a treatment. The study found that UAVs and high-resolution cameras can be used to quantify herbicide damage and assess weed populations. Image analyses detected differences in crop damage among treatments based on reflectance values and was compared with the visual assessments of the herbicide treatments to validate results. However, due to the processing and multiple software programs required, simpler and more efficient procedure is needed for the implementation of these technologies.

**Soybean Variety Sensitivity to Dicamba.** Mike H. Ostlie<sup>1</sup>, Gregory J. Endres<sup>1</sup>, Kirk A. Howatt<sup>2</sup>; <sup>1</sup>North Dakota State University, Carrington, ND, <sup>2</sup>North Dakota State University, Fargo, ND (112)

Since the release of dicamba-tolerant soybeans, nearby sensitive soybean field have had varying reports of plant growth regulator injury symptoms. The degree of symptom expression and area affected varied widely throughout the 2017 growing season. At the Carrington Research Extension Center, all soybean variety trials exhibited some degree of growth regulator symptomology. The overall level of injury was relatively low with leaf cupping and wrinkling but no growing point damage. Injury ratings were taken on the native PGR (plant growth regulator) symptoms throughout the trials. Tissue and grain samples were collected from the trial area and sent for dicamba residue testing. Harvested grain was also grown in the greenhouse to test for effects on subsequent generation. Injury levels observed in the trial were not sufficient to decrease yield. There was actually a positive correlation between injury rating and yield. Even though this first appears to indicate yield enhancement, year-over-year evaluations show same-ranking of varieties. Leaf and grain residues showed no presence of dicamba. It is possible that increased symptom expression is related to more vigorous varieties at the time of herbicide exposure, which was sufficient to enhance PGR symptom expression and not severe enough to reduce yields.

**Effect of Seeding Rate and Herbicides on Weed Control of Dry Bean in Narrow Rows.** Don W. Morishita, Kathrin LeQuia\*; University of Idaho, Kimberly, ID (113)

Previous research has found advantages of higher seeding rates with black bean planted in narrow rows. Currently, there is no research evaluating seeding rates of pinto bean planted in narrow rows. The objectives of this study were to: 1) determine the optimum dry bean plant population in a narrow row planting configuration for growth and yield; 2) compare five dry bean plant populations grown in narrow rows to dry bean grown in standard rows; and 3) compare the weed control in response to dry bean planted in narrow rows at five seeding rates. The experiment was a 5 x 6 factorial randomized complete block design. The 5 seeding rates were equivalent to 25, 31, 37, 43, and 49 seeds/m<sup>2</sup> in 19-cm rows, plus 1 treatment planted at 25 seeds/m<sup>2</sup> in 56-cm rows. The five weed control treatments consisted of an untreated control, handweeded control, EPTC + ethalfluralin applied preemergence (PRE), EPTC + ethalfluralin applied PRE followed by dimethenamid-P applied after the first trifoliolate growth stage, and EPTC + ethalfluralin applied PRE followed by bentazon + imazamox applied after the first trifoliolate growth stage. The yield was higher in the handweeded control than any other weed control treatment in 2016. The yield was higher in the 37 and 49 seeds/m<sup>2</sup> rates than in the 25 seeds/m<sup>2</sup> rate in 19- or 56-cm rows in 2017. Increased seeding rate in narrow rows is a cultural method that can increase yield in dry pinto bean.

**Characterization of Palmer amaranth Populations from Kansas with Resistance to Multiple Herbicides.** Vipin Kumar\*, Phil Stahlman, Grant Boyer; Kansas State University, Hays, KS (114)

Multiple herbicide-resistant (MHR) Palmer amaranth pose a serious management concern for growers across the United States. Since 2014, several random field surveys have been conducted to determine the frequency and distribution of MHR Palmer amaranth in Kansas. The main objective of this study was to characterize the resistance level to glyphosate, chlorsulfuron, mesotrione, and atrazine and determine the sensitivity to dicamba and 2,4-D in four previously confirmed MHR populations (BT12, SH1, KW2, and PR8) compared with a known susceptible (SUS) population in dose-response experiments. Greenhouse experiments were conducted at the Kansas State University Agricultural Research Center near Hays, KS during fall 2017. Seedlings from each selected population were grown in 10-cm diam plastic pots containing commercial potting mixture. Herbicide doses ranging from 0 to 16X for glyphosate (1X = 1260 g ha<sup>-1</sup>), chlorsulfuron (1X = 26 g ha<sup>-1</sup>), mesotrione (1X = 105 g ha<sup>-1</sup>), atrazine (1X = 1120 g ha<sup>-1</sup>), 2,4-D LV6 (1X = 870 g ha<sup>-1</sup>), and dicamba (1X = 560 g ha<sup>-1</sup>) were used along with recommended adjuvants. Actively growing Palmer amaranth plants (8- to 10-cm) from each selected population were treated with these herbicides by using cabinet spray chamber. All experiments were conducted in a randomized complete block design with 12 replications. Data on percent visible injury were recorded at 7, 14, and 21 days after treatment (DAT), while fresh and shoot dry weights were determined at 21 DAT. Based on percent injury and shoot dry weight response (LD<sub>50</sub> and GR<sub>50</sub> values), the PR8 and BT12 populations had 7- to 13-fold levels of resistance to glyphosate, and up to 20-fold levels of resistance to chlorsulfuron. Based on GR<sub>50</sub> values, the KW2 and BT12 population showed 5- and 16-fold resistance to atrazine compared with the SUS population, respectively. Furthermore, the BT12, KW2, and PR8 populations also showed 2- to 5-fold level of resistance to mesotrione based on LD<sub>50</sub> values. Based on fresh weight response, the SH1 population was 2-fold less sensitive to dicamba compared with SUS population. Experiments with 2,4-D dose-response on these populations are still under progress and results will be presented in the conference. These results report the first confirmation of a Palmer amaranth population (BT12) with multiple resistance (four ways resistant) to glyphosate,

chlorsulfuron, atrazine, and mesotrione in Kansas. Future studies will investigate the underlying mechanism (s) of multiple herbicide resistance in these populations. Growers should adopt multiple control tactics, including chemical and non-chemical (tillage, crop rotation, cover crops) to manage these MHR Palmer amaranth populations on their fields.

**Integrating Crop Rotation and Herbicide Programs to Improve Control of Problematic Weed Species in Sugarbeet.** Clint W. Beiermann\*<sup>1</sup>, Nevin C. Lawrence<sup>2</sup>; <sup>1</sup>University of Nebraska-Lincoln, Lincoln, NE, <sup>2</sup>University of Nebraska-Lincoln, Scottsbluff, NE (115)

With few effective herbicides registered in sugarbeet, production relies heavily on glyphosate for weed control. Glyphosate-resistant kochia (*Kochia scoparia*) has become prevalent within the High Plains sugarbeet production region and glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) is an emerging issue. Integration of multiple-year cultural and herbicide management strategies is necessary to control glyphosate-resistant kochia and Palmer amaranth in sugarbeet. In 2016 different herbicide combinations were applied within three common rotational crops: corn, dry bean, and a small grain cereal, to evaluate which crop and herbicide combination would be the most effective at suppressing kochia and Palmer amaranth the year before sugarbeet are planted. In 2017 the previous year's study was planted to sugarbeet. Sugarbeet plots received two applications of glyphosate or were untreated. At the end of the season weed density and biomass, and sugarbeet yield were assessed. Weed density and biomass in the 2017 sugarbeet crop was influenced by the previous crop, but not by the previous herbicide treatment. Plots which contained a small grain in 2016 had the lowest kochia density and biomass in 2017. Dry bean plots resulted in the second lowest kochia biomass in 2017. Plots that contained small grain or corn in 2016 resulted in the lowest Palmer amaranth density and biomass in 2017. Planting dry bean in 2016 resulted in the highest Palmer amaranth density and biomass in 2017. There was no effect of 2016 herbicide treatment on weed biomass in 2017. The presence or absence of glyphosate in 2017 effected sugarbeet yield.

**Seed Retention of Major Weed Species at Harvest in the PNW.** Judit Barroso\*<sup>1</sup>, Carolina San Martín<sup>1</sup>, Mark E. Thorne<sup>2</sup>, Drew J. Lyon<sup>2</sup>; <sup>1</sup>Oregon State University, Adams, OR, <sup>2</sup>Washington State University, Pullman, WA (116)

Global wheat production is threatened by the escalating selection of herbicide resistant weed populations. The continuing evolution of herbicide resistance in major crop weeds is a driving force to develop new weed control strategies in field crops such as harvest weed seed control (HWSC). The potential of HWSC practices is dependent on having a significant proportion of total weed seed retained at crop maturity. The objective of this study was to evaluate seed production, height, and retention at harvest of important weed species in wheat-production systems of the semi-arid region of PNW such as, downy brome (*Bromus tectorum* L.), feral rye (*Secale cereale* L.), and rattail fescue (*Vulpia myuros* L.). Seed production, height, and retention were evaluated before and during harvest season in 2016 and 2017 in several locations. In general, seed shedding patterns followed a negative exponential model ( $Y = Y_0 * e^{-bX}$ ) better than a linear model. Once the seeds were mature, a larger amount of seeds was shed early in the harvest season than later. However, the percentage of seed retained at harvest (parameter  $Y_0$ ) and the rate of seed shedding (parameter  $b$ ) depended on the weed species, year, and site. On average, the rate of seed shedding was similar for downy brome and rattail fescue and a little bit slower for



feral rye. The percentage of seed retention at the beginning of harvest season was lower in 2016 (59% on average) than in 2017 (77% on average) for the three species.

**Brassicaceae Seed Persistence Under Different Tillage Regimes in The Willamette Valley.** Gabriel D. Flick\*, Carol Mallory-Smith; Oregon State University, Corvallis, OR (117)

The persistence of Brassicaceae seeds in the seedbank has been studied in most major canola (*Brassica napus*) producing regions. Recent interest in canola production within the Willamette Valley of Oregon presents a unique coexistence challenge because the region produces many *Brassica* vegetable seeds. Concerns of vegetable seed contamination arising from volunteer canola prompted an investigation of seed persistence by crop species and tillage regime. A study, which included three tillage treatments (no-till, shallow, and deep tillage) and three crops (radish (*Raphanus sativus*), turnip (*Brassica rapa*), and canola), was conducted near Corvallis, Oregon, from 2014 to 2017. Seed was spread at rates equivalent to average harvest losses observed in commercial fields, and tillage treatments were conducted annually. Volunteer seedlings were counted and killed so that no plants set seed. After 36 months no interaction between crop species and tillage regime was found. There was no difference between crops within a tillage treatment; however, there were differences between tillage regimes. No seeds of any crop persisted under the no-tillage treatment. Deep tillage resulted in the greatest seed persistence for all crops. The percentage of seed recovered from the seedbank was 3.4, 1.6, and 1.4% of the original seed spread for canola, radish, and turnip, respectively, under the deep tillage treatment. Based on this 36-month study, seed persistence is not different for these three Brassicaceae crops but is affected by the tillage regime applied after harvest. Growers concerned about seed persistence should avoid deep tillage.

#### **PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER**

**Effect of Fallow Management on Weed Infestation.** Carolina San Martín\*<sup>1</sup>, Dan Long<sup>2</sup>, Judit Barroso<sup>1</sup>; <sup>1</sup>Oregon State University, Adams, OR, <sup>2</sup>USDA-ARS, Adams, OR (088)

Two-year rotation of winter wheat (WW)/fallow is the most common cropping system in the low precipitation region of U.S. Pacific Northwest (PNW). A three-year experiment was conducted to evaluate the impacts of different fallow managements on weeds infesting the subsequent WW. A commonly used fallow management with several tillage operations, known as summer fallow (SF), was compared with reduced tillage fallow (RTF) consisting of one tillage operation, which has proved to help with soil erosion and soil health. The experimental design was a randomized complete block with four replications, where each phase of the rotation was present every year. Environmental conditions and fallow management both affected weed infestations. In general, RTF decreased grass weed density and cover that mainly consisted of downy brome (*Bromus tectorum* L.) and total weed cover in WW more than SF. Lower cover of total weeds with a similar density indicated that weed plants were larger in WW following SF than following RTF, probably due to earlier or faster emergence. Accordingly, yield losses were higher in WW following SF versus WW following RTF for a similar weed infestation although differences

were not significant. Reduced tillage fallow appears to improve weed management in WW/fallow cropping systems of PNW, particularly if the most problematic species are grasses.

**Multi-Species Herbicide Efficacy Screens: A Tool for Teaching Herbicide Mode of Action Principles to Agronomists.** Andy G. Hulting\*, Dan W. Curtis, Kyle C. Roerig, Carol Mallory-Smith; Oregon State University, Corvallis, OR (118)

Many times over recent years the OSU Weed Science Group establishes a “multi-species” herbicide evaluation trial at a university owned research facility near Corvallis, OR. This study consists of approximately 20 crop and weed species of local importance which are treated with approximately 25 herbicides at various application timings ranging from preemergence to postemergence. Tours of this trial are hosted annually and made available to interested producers or industry groups. These tours are organized in such a fashion that individual crop consultant/input companies (individuals representing Valley Agronomics, Crop Production Services, Wilbur-Ellis, Marion Ag Service, Inc., Fitzmaurice Fertilizer Inc., Oregon Vineyard Supply and others) can tour the site and have open discussions with weed science Extension faculty and research staff. Individual tours are better received than one large tour because of the increased interaction among participants and University staff. The tours usually center on a discussion of herbicide mode of action/activity as well as on discussions of potential new uses for established herbicide products in the diverse cropping systems of Oregon. New registered uses of herbicides that are a direct result of the findings of these trials include the use of mesotrione or pyrasulfotole for control of *Glyceria* spp. in grasses grown for seed and the use of mesotrione for suppression of *Agrostis* spp. in grasses grown for seed among others.

**Wyoming Restoration Challenge: Winners, Losers, and Lessons Learned in Invasive Grass Restoration.** Brian A. Meador\*<sup>1</sup>, Beth Fowers<sup>1</sup>, Clay W. Wood<sup>2</sup>; <sup>1</sup>University of Wyoming, Sheridan, WY, <sup>2</sup>University of Wyoming, Laramie, WY (119)

The Wyoming Restoration Challenge started in 2015 with 11 teams engaged in a competition to determine who could best restore a degraded pasture dominated by downy brome to a more diverse, productive state. Team diversity was high, ranging from a rotating slate of undergraduate students to ranchers to experienced weed management professionals. Each team was allowed to restore their randomly-assigned plot using any legal means. Their results were evaluated based on downy brome reduction, forage production, desirable species diversity, scalability of their approach, educational activities, and economics. While some teams only implemented a single practice (i.e. herbicide), most teams integrated multiple control methods. Some teams finished the three year competition with more downy brome than when they started, and some teams realized significant downy brome reductions accompanied by increased species diversity. The winning team's approach incorporated targeted livestock grazing/impact and seeding of cover crops. The challenge combined features from demonstration plots, quiz bowls, and reality television to generate educational dialogue around one of the most challenging natural resources in the western U.S.

**Updates to the WSU Tree Fruit Weed Science Webpage - Weed Science Extension Outreach in the Columbia Basin.** Lynn M. Sosnoskie\*; University of California Cooperative Extension, Merced, CA (120)

Abstract not available

**Turning a New Leaf: Engaging Industries in Policy Decision-Making for Prevention of Invasive Plant Introductions.** James Leary<sup>1</sup>, Chelsea Arnott\*<sup>2</sup>, Linda Cox<sup>3</sup>, Christy Martin<sup>3</sup>, M Randa Sandlin<sup>3</sup>; <sup>1</sup>University of Hawaii at Manoa, Kula, HI, <sup>2</sup>University of Hawaii, Kaneohe, HI, <sup>3</sup>University of Hawaii, Honolulu, HI (121)

Hawaii's extreme isolation resulted in the evolution of over a thousand native plants, most of which are found nowhere else in the world. With human arrival, the number of naturalized plant species more than doubled with the introduction of non-native plants. There are benefits to importing non-native plants, but there are the few that become invasive and current regulations do little to prevent further invasive plant introductions. One way to address this problem is developing the Restricted Plant list written into Hawaii Revised Statutes 150-A that would restrict the import and sell of plant species listed. To determine how plant restrictions may impact stakeholders, a survey was distributed to 443 businesses and individuals throughout the state in 2017. We received a 22% response rate with the largest category of respondents (42.7%) identifying themselves as wholesale nurseries. Over 50% of respondents indicated that importing new plant species was not important to their operation. On general topics, 90% thought themselves knowledgeable about invasive plants and would not sell a plant known to be invasive. Current regulations were considered inadequate by over half the respondents (67%), yet many were not familiar with existing regulations (60%) and voluntary practices (46%) for invasive plant prevention. With that in mind, 87.5% were supportive of the proposed policy with stakeholder participation and indicated impact by this law would not be significant. The information from this survey will guide the next steps toward creating an outreach strategy that engages stakeholders in rule-making for listing plants for restriction.

## PROJECT 5: BASIC BIOLOGY AND ECOLOGY

**Phylogenetic Analysis of Native and Invasive *Phragmites australis* Haplotypes in Colorado.** Neeta Soni\*, Eric Patterson, Todd Gaines; Colorado State University, Fort Collins, CO (089)

*Phragmites australis* (common reed) is a cosmopolitan species distributed across continents worldwide. In the United States, *Phragmites* haplotypes have been identified in 3 main groups: (1) introduced (Eurasian origin); (2) native (North American origin); and (3) Gulf Coast (cryptogenic origin). Native *Phragmites* haplotypes represents an important component of the natural ecosystem, whereas introduced *Phragmites* haplotypes reduce biodiversity by rapidly displacing native *Phragmites* haplotypes and other species. Moreover, native *Phragmites* have an important cultural contribution to our current society. Due to the ecological repercussions of invasive *Phragmites* the Colorado Department of Agriculture is considering whether to declare introduced *Phragmites* a noxious weed. Invasive and native *Phragmites* are very similar in phenotype, thus using morphological characteristics for visual classification of these groups is not possible. In addition, a detailed genetic analysis of the Colorado region has not been conducted. The main goal of this study is to classify 189 *Phragmites* individuals from a diverse geographic range in Colorado by sequencing 2 non-encoding chloroplast DNA regions (rbcL-

psaI and trnT-trnL) and compare them against reported sequence databases. Additionally, the generated sequences will be used to construct a phylogenetic tree to describe relatedness and possibly to discover new haplotypes. PCR and sequencing procedures were used to obtain and analyze sequence alignments, followed by tree building. Preliminary results classified 22 individuals as native and 25 as invasive. The information generated by this study is expected to provide land managers with better tools for conservation and appropriate management of native *Phragmites*.

**Shade Avoidance in Sugarbeet: Tragedy of the Commons?** Albert T. Adjesiwor\*, Andrew Kniss; University of Wyoming, Laramie, WY (090)

Studies on shade avoidance (response to low red (R) to far-red (FR) light ratio) often recommended early weed removal to reduce the effects of shade avoidance on crop yield. Since sugarbeet (*Beta vulgaris* L.) is planted at high densities, if crops are unable to distinguish reflected light quality of kin (plants of the same species) from non-kin (plants of different species), there may be effects on development even in the absence of weeds. We evaluated the response of sugarbeet to reflected FR light from sugarbeet, common lambsquarters (*Chenopodium album* L.), Kentucky bluegrass (*Poa pratensis* L.), alfalfa (*Medicago sativa* L.), and bare soil (control) in 2016 and 2017. Treatments were completely randomized with 10 replications. The study methods ensured there was no resource competition. Plant species reflected less than 20% of incoming R light and about 36 to 56% of incoming FR light. R:FR of reflected light ranged from 0.06 (common lambsquarters) to 0.24 (sugarbeet) compared to 0.7 for bare soil. Presence of neighboring plants resulted in more erect sugarbeet leaf orientation compared to bare soil ( $P < 0.001$ ). Presence of neighboring species reduced the number of sugarbeet leaves by 1 to 3 leaves compared to the control treatment ( $P < 0.0001$ ). Neighbor presence delayed the time to reach 10 true leaves by at least two days in both years. Presence of neighboring species reduced leaf area (23 to 37%), shoot dry weight (26 to 38%), and root diameter (20 to 35%) in 2016. In 2017, there was up to 47, 57, 43, and 23% reduction in leaf area, shoot dry weight, root diameter, and root dry weight, respectively. Sugarbeet could not discriminate reflected light quality of kin from that of non-kin.

**Effect of Water Potential on Germination of Kochia (*Kochia scoparia*) Accessions from the US Great Plains.** Ramawatar Yadav\*<sup>1</sup>, Prashant Jha<sup>1</sup>, Andrew Kniss<sup>2</sup>, Gustavo M. Sbatella<sup>3</sup>, Nevin C. Lawrence<sup>4</sup>; <sup>1</sup>Montana State University, Huntley, MT, <sup>2</sup>University of Wyoming, Laramie, WY, <sup>3</sup>University of Wyoming, Powell, WY, <sup>4</sup>University of Nebraska-Lincoln, Scottsbluff, NE (091)

Occurrence of multiple herbicide-resistant kochia across the US Great Plains coupled with a near lack of effective herbicide options, especially in sugar beet-based rotations, necessitate the need for ecological weed management tools. This requires improved forecasting of kochia germination patterns. Experiments were conducted in 2017 at the MSU-SARC, Huntley, MT to quantify germination requirements of 44 kochia accessions collected from sugar beet fields in Huntley, MT; Powell, WY; Lingle, WY; and Scottsbluff, NE (North-South transect). To develop hydrotime models, eight water potential ( $\Psi$ ) treatments from 0 to  $-1.2$  MPa were used to determine the time taken for median germination ( $T_{50}$ ), optimum water potential ( $\Psi_0$ ), and base water potential ( $\Psi_b$ ) for kochia accessions at 24 C using a time-event, 3-parameter log-logistic model. With a decrease in  $\Psi$ , the germination rate ( $1/T_{50}$ ) for all accessions decreased. All

accessions had the highest germination rate at  $\Psi$  of 0 MPa (no water stress), considered to be  $\Psi_0$ . The  $\Psi_b$  varied across accessions (−0.84 to −1.13 MPa). At the moderate water stress (−0.5 MPa),  $T_{50}$  values ranged from −0.5 to −1.8 MPa. However, at the high-level water stress (−1.2 MPa  $\Psi$ ), kochia accessions from Huntley and Powell took only 4 to 6 days to achieve  $T_{50}$  compared with 14 to 25 days for Lingle and Scottsbluff accessions. This indicates that kochia from the north are well adapted to dry soil conditions and a more extended emergence of kochia can be expected under dry soil conditions in the southern end of the region.

**Effect of Crop Canopy and Herbicide Treatment on Kochia (*Kochia scoparia*) Density and Seed Production.** Elizabeth G. Mosqueda\*<sup>1</sup>, Andrew Kniss<sup>1</sup>, Gustavo M. Sbatella<sup>2</sup>, Nevin C. Lawrence<sup>3</sup>, Prashant Jha<sup>4</sup>, David A. Claypool<sup>1</sup>; <sup>1</sup>University of Wyoming, Laramie, WY, <sup>2</sup>University of Wyoming, Powell, WY, <sup>3</sup>University of Nebraska-Lincoln, Scottsbluff, NE, <sup>4</sup>Montana State University, Huntley, MT (092)

Previous studies have shown impacts of crop canopy on weed species development, however, there are few direct comparisons between different crop canopies and chemical management practices to suppress weed populations. Kochia (*Kochia scoparia*) is a summer annual tumbleweed which has become problematic for growers throughout western United States, in part, because of evolved resistance to numerous herbicides. Field studies were established in 2014 in Wyoming, Nebraska, and Montana to quantify the impact of crop canopies and herbicide regimes on kochia density and seed production. Crops used in this study were spring wheat, dry bean, sugarbeet, and corn. Herbicide treatments included ALS inhibitors, herbicide mixtures including ALS inhibitors with another effective mode of action, or a non-ALS herbicide effective for kochia control. A known proportion of ALS-resistant kochia was established summer of 2013 prior to imposition of treatments. Kochia density was collected mid-way through crop maturity, and kochia seed production was estimated at crop maturity. Generalized linear mixed effects model and Tukey HSD were used to analyze data and separate means. Plots treated with an ALS mixture or a non-ALS herbicide usually contained less kochia on average than plots treated with an ALS inhibiting herbicide only. Within plots treated with an ALS mixture or a non-ALS herbicide, spring wheat and corn were usually the most competitive crops in suppressing kochia compared to dry bean and sugarbeet, which usually had higher kochia densities on average. Germinable kochia seed production was usually lowest in plots treated with an ALS mixture or a non-ALS herbicide than plots treated with an ALS inhibiting herbicide only. Within plots treated with an ALS mixture or a non-ALS herbicide, those planted with spring wheat had significantly less germinable kochia seed production on average compared to all other crops.

**Why is Inhibition of Glutamine Synthetase Toxic to Plants?** Hudson K. Takano\*, Phil Westra, Franck E. Dayan; Colorado State University, Fort Collins, CO (093)

Glufosinate inhibits glutamine synthetase (GS) by stopping the amination of glutamate into glutamine, causing rapid accumulation of ammonia within leaf tissue. Although the inhibition of GS is the main glufosinate's mode of action, the reason why plants show rapid injury after being exposed to this herbicide might be associated with other changes in metabolism such as inhibition of photosynthesis. Therefore, the objective of this research is to understand what causes phytotoxicity when GS is inhibited by glufosinate, which may provide opportunities to enhance its herbicidal effect. *Lolium rigidum* (C3) and *Amaranthus palmeri* (C4) were evaluated for visual phytotoxicity, enzyme activity *in vitro* and *in planta*, accumulation of ammonia *in*

*in vitro* and *in planta*, carbon assimilation, levels of glutamine, glutamate and glufosinate, and glutamine translocation. *A. palmeri* was 18-fold more sensitive than *L. rigidum* in visual phytotoxicity. GS activity and accumulation of ammonia were similar between these two species *in vitro*. However, when these assays were conducted *in planta*, *A. palmeri* accumulated more ammonia and showed more GS inhibition than *L. rigidum*. A lower glufosinate concentration was found in leaves of *L. rigidum* than leaves of *A. palmeri*. Inhibition of photosynthesis was stronger in *L. rigidum* than in *A. palmeri*. Although both species showed reduction in glutamine and glutamate levels, depletion of these amino acids was stronger for *A. palmeri* than *L. rigidum*. The transport of glutamine from leaves to roots was also affected by glufosinate treatment in *A. palmeri*.

**Mechanism of Resistance to Glyphosate in Annual Bluegrass from California Perennial Crops.** Caio Augusto Brunharo\*, Sarah Morran, Brad Hanson; University of California, Davis, Davis, CA (094)

*Poa annua* is a widespread weed species in California, competing directly and indirectly with crops for resources. Recently, poor control of this species with glyphosate was reported in the San Joaquin Valley of California in an almond orchard with a history of repetitive glyphosate use. We hypothesized that the control failures were due to the selection of a glyphosate-resistant population *P. annua* and generated F<sub>4</sub> selfed lines from the suspected R population and an susceptible population collected from the same area to confirm and characterize the resistance. Whole-plant dose-response and shikimate accumulation bioassays were conducted to characterize resistance levels of a suspected-resistant *P. annua* (R) line compared to a known-susceptible line (S). Glyphosate absorption, translocation, and metabolism were assessed to study the involvement of non-target-site-based mechanisms of resistance, whereas *EPSPS* cloning and sequencing were performed to study the involvement of target-site mechanisms. R exhibited an 18-fold higher glyphosate dose necessary to achieve 50% growth reduction compared to S. Lower levels of shikimate accumulated in R compared to S, corroborating with whole-plant dose-response data. It seems that non-target-site mechanisms are not involved in the resistance to glyphosate in this population of *P. annua*, as no differences in absorption, translocation and metabolism of glyphosate were observed between the lines. A missense single nucleotide polymorphism was observed in the *EPSPS* at coding position 106, resulting in a leucine to proline substitution. Interestingly, *Poa annua* is an allotetraploid and this polymorphism was observed exclusively in *P. supina* homeologs of *P. annua*, whereas only wild-type alleles were detected in *P. infirma* homeologs. Future research will explore the allelic contribution in the mechanism of resistance in *P. annua* from California.

**First Case of Imazamox-Resistance Jointed Goatgrass (*Aegilops cylindrical* Host.) in the Pacific Northwest.** Jeanette A. Rodriguez\*, Amber L. Hauvermale, Rachel J. Zuger, Caleb C. Squires, Lindsay E. Koby, Arron Carter, Ian C. Burke; Washington State University, Pullman, WA (095)

Wheat growers have limited herbicide options to manage jointed goatgrass (*Aegilops cylindrical* Host), with many relying on imazamox or mesosulfuron in combination with Clearfield™ winter wheat. Both imazamox and mesosulfuron inhibit acetohydroxyacid synthase/acetolactate synthase (AHAS/ALS). In 2015, a suspected imazamox resistant biotype of jointed goatgrass was found in eastern Washington. In an effort to understand the mechanism of resistance,

mesosulfuron and imazamox were applied to the suspected resistant and susceptible jointed goatgrass biotypes in increasing concentrations to evaluate dose response as a function of biomass reduction. The resulting dose-response data were fit using a 3-parameter log-logistic with GR<sub>50</sub> (50% growth reduction) as one of the parameters. Our response data indicates that mesosulfuron provided 100% control with no survival of the susceptible biotype at the lowest application rate of 0.15 g ai ha<sup>-1</sup>, whereas the resistant biotype had a GR<sub>50</sub> of 21.72 g ai ha<sup>-1</sup>. Likewise, when treated with imazamox, the resistant biotype had a GR<sub>50</sub> of 308.53 g ai ha<sup>-1</sup> that is 4,400 times more resistant to the known susceptible biotype with a GR<sub>50</sub> of 0.07 g ai ha<sup>-1</sup>. Additionally, sequencing efforts in the *ALS* gene identified an Ala<sub>122</sub>Thr substitution in the herbicide binding region of the *ALS* gene on the D-genome of the resistant goatgrass biotype. Thus, our data indicate that the newly discovered Ala<sub>122</sub>Thr substitution on the D genome in the resistant goatgrass biotype appears to confer a high level of resistance to imazamox as well as cross resistance to mesosulfuron.

**Surfactant Effects on Absorption and Translocation of Metsulfuron in Smooth Scouringrush (*Equisetum laevigatum*).** Lindsay E. Koby\*, Rachel J. Zuger, Ian C. Burke, Drew J. Lyon; Washington State University, Pullman, WA (096)

Smooth scouringrush (*Equisetum laevigatum* A. Braun) has become increasingly problematic in the dryland wheat production systems of the inland Pacific Northwest. Investigative greenhouse trials were conducted with multiple herbicide modes of action (ALS, Synthetic auxins, PSII) surfactants and adjuvants (silicon based and petroleum-based oil) to identify herbicides with activity on smooth scouringrush. Only ALS inhibitors exhibited activity; necrosis was observed when metsulfuron-methyl and chlorsulfuron were applied. Necrosis was greatest when metsulfuron-methyl or chlorsulfuron were applied with a petrol-based adjuvant (Basal Bark Blue) compared to nonionic surfactant. Absorption and translocation experiments were conducted with <sup>14</sup>C metsulfuron-methyl. Metsulfuron-methyl was applied with non-ionic surfactant to the approximate center of the primary stem. Plants were harvested at 2, 8, 24 hours after treatment, followed by harvests at 50 % and 100% observable injury. At respective hourly intervals, 1.9%, 5.3%, 4.6% <sup>14</sup>C metsulfuron-methyl was absorbed, increasing over time. Translocation out of the treated zone increased over time with 1.16%, 1.19%, 2.7% of applied <sup>14</sup>C translocated, respectively. Only a small amount of <sup>14</sup>C was translocated to the rhizome, 0.33% of applied 24 hours after treatment. Limited absorption appears to be the mechanism smooth scouringrush is not controlled metsulfuron-methyl.

**Herbicide Resistant Weed Research Portfolio at Colorado State University.** Phil Westra\*, Todd Gaines, Eric Patterson, Franck E. Dayan; Colorado State University, Fort Collins, CO (097)

Abstract not available

## DISCUSSION SESSIONS

### Project 1 Discussion Session: Weeds of Range, Forest, and Natural Areas

Moderator: Derek Sebastian, Bayer, Fort Collins, CO

Topic: *Implementing a Collaborative Approach to Restoring Sites Dominated by Invasive Annual Grasses*

#### Discussion

- This is an issue we all deal with
- Fire frequency interval promotes annual grasses
  - o Do we focus on completely degraded sites or sites with desirable vegetation?
  - o Try to protect what is not already severely degraded or invaded
  - o EDRR approach can be utilized for most land managers with specific management objectives
- Cheatgrass is newly listed in some areas/counties so they are just able to use their budget to manage it
- How much above-ground/cover of natives should be present for re-establishment? What's the threshold?
  - o There should be some effort to reclaim those infested lands
  - o More research is needed in the cost of revegetation of a site as compared to being proactive
  - o Has anyone come up with a test for how much natives/desirables is left at a site?
  - o The history of the site can tell you a lot
  - o States like California have very little native species left and dominated primarily by annuals
  - o Need to set priorities on properties (like sage grouse habitat areas)
  - o Native plants are very expensive for reveg
- Frustrations/difficulties in the management process?
  - o Tools are available but some agencies like BLM are under a lot of political pressure and cannot utilize them
  - o BLM offices seem to be excited but are very limited on restrictions and personnel
  - o We need to create pressure on these agencies with the work we are doing (increasing diversity, wildlife habitat, etc.)
  - o We are always in the evolving state, so establishing native species might not be the most practical. New normal?
  - o How do we convey this message to agencies?
    - CSU field tours in partnership with counties/industry to demonstrate what tools are available
    - Counties have been very proficient but federal agencies are lagging behind
  - o Successes?
    - After fire, some are treating and re-seeding
    - Need to show these are long-term outcomes



- What are the tools that are effective besides herbicides?
  - IPM
  - Strategies alone don't work
  - Also a management issue- how we are using the land after treatment
  - Long-term management is critical
  - Seeing the value of long-term projects for funding
  - Protecting the uninvaded areas is critical
  - Cleaning up vectors (roads, waterways, etc)
  - The trigger to act...
    - Fire
    - Seems to be a disconnect between fire and re-vegetation
    - Need for fire research
  - Could we identify areas that are very pollinator sensitive?
  - People are more receptive to saving wildlife habitat
  - We can't forget education
  - Preventing spread when it first shows up (EDRR)
  - Training people to identify new invaders (ventenata, medusahead)

**Nominations of a new Chair-Elect:**

Harry Quicke is the new Chair-Elect for the Range, Forest, and Natural Areas Project of WSWS.

Chair 2018:

Shawna Bautista, US Forest Service, PNW Region, 1220 SW 3rd Avenue, Portland, OR 97204  
sbautista@fs.fed.us

Chair-Elect 2019:

Derek Sebastian, Bayer, 2114 18<sup>th</sup> Street Road, Greeley, CO 80631  
derek.sebastian@bayer.com

Chair-Elect 2020:

Harry Quicke, Bayer, 1140 Shore Drive, Windsor, CO 80550  
harry.quicke@bayer.com

Attendees:

<b>Name</b>	<b>Affiliation</b>	<b>Email address</b>
Bill Cobb	Cobb Consulting Service	wycobb42@gmail.com
Bob Finley	Freemont County Weed & Pest	bfinley@dteworld.com
Caleb Dalley	North Dakota State University	caleb.dalley@ndsu.edu
Corey Ransom	Utah State University	corey.ransom@usu.edu
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Mike Wille	Freemont County Weed & Pest	mwille@wyoming.com
Rachel Seedorf	Colorado State University	rseedorf@yahoo.com
Shannon Clark	Colorado State University	Shannon.clark@colostate.edu
Tim Harrington	U. S. Forest Service	tharrington@fs.fed.us
Tom Getts	University of CA Coop. Ext	tjgetts@ndsu.edu
Travis Bean	University of California, Riverside	bean@ucr.edu

## **Project 2 Discussion Section: Weeds of Horticultural Crops**

Moderator: Andrew Robinson, North Dakota State University, Fargo, ND

Topic: *Environmental Factors and Herbicide Performance*

Attendants initiated the conversation by sharing concerns about the 2018 winter season, a year composed of erratic rainfall in the Pacific Northwest Region. A question was raised about what to expect when it comes to the performance of preemergence herbicides later in the season. The consensus among attendants was that efficacy would be compromised and longevity of control reduced. Researchers shared experiences from other regions like California, indicating that lack of rainfall can severely limit the incorporation of pesticides into the soil profile. Comments of reduced efficacy of postemergence herbicides as a result of erratic rainfall were also made, the failure was surmised to reduce uptake of foliar applied herbicides.

The following discussion point was related to impacts of drought in crop-tolerance. Specific examples of potato crops becoming more sensitive to dicamba applications under drought conditions were given, the researchers suggested that a reduction in herbicide breakdown rate by the plant was the cause of the greater injury. Dry droplets of dicamba present on the crop leaf surface can rehydrate and be absorbed by the plant.

Reports made from California indicate that the impact of drought on pre-emergence herbicides can affect herbicides differently. For instance, rimsulfuron duration of preemergence control was indicated to be very dependent on climatic conditions with performance compromised in dry years. Questions were made whether the poor performance could be solely attributed to drought or to air temperatures as well as drought and heat are often coupled. Industry representatives explained how sales of pre-emergence herbicides, and other pesticides for that matter, are driven by rainfall pattern. Dry years tend to reduce pesticide sales.

Application in spring-time during the monsoon season need to have considered as excessive rain can move pre-emergence herbicides deeper into the soil profile leading to crop damage. Question about cautionary language in the label for crop safety was made, with specific reference to the indaziflam statement of 48 hours without rainfall following application. Most participants did not think there is a need for that type of statement on all labels.

Research shared findings of ongoing research on the impacts of irrigation water quality (saline) water with pre-emergence. Salt seems to affect the herbicide partitioning in the soil. Tree crop safety can be jeopardized as salt water may move more herbicides into the root zone. Results were dependent on soil type.

The discussion pivoted into the efficacy of deposition adjuvants in preemergence herbicide application. Adjuvant manufactures claim that these adjuvants improve efficacy and/or extend the longevity of preemergence herbicides. Most participants did not have any practical experience on the topic. The exception was the comments about trials performed in Wisconsin and North Dakota in which no differences were reported. The consensus was that certain claim seems to be unsubstantiated. Surfactants may increase injury and are not regulated. Adjuvants can have pesticides attributes without adjuvants. A question raised during the discussion was “what is the role of the non-pesticide fraction of the spray mixes?”. Adjuvants are not regulated

in most states thus no rigorous test in adjuvant formulations or the claims made by manufacturers are conducted.

Finally, the session discussed how climate change impacts on pest biology and performance of pesticides. The classification of winter versus summer-annual weeds is becoming not accurate or obsolete.

A business meeting was conducted at the end of the discussion session, and Jesse Richardson was selected as the chair-elected for the 2019 meeting in Colorado, and becoming the Horticulture chair in 2020 meeting in Hawaii. Andy Robinson is stepped down as session chair as Marcelo Moretti is the new chair.

Chair 2018:

Andrew Robinson, North Dakota State University, PO Box 6050, Loftsgard Hall 166, Fargo, ND 58108.

andrew.p.robinson@ndsu.edu

Chair-Elect 2019:

Marcelo Moretti, Oregon State University, 4017 AG Life Sciences Bldg, Corvallis, OR 97331  
marcelo.moretti@oregonstate.edu

Chair-Elect 2020:

Jesse Richardson, Corteva, 9846 Lincoln Ave, Hesperia, CA 92345.  
jmrichardson@dow.com

Attendees:

<b>Name</b>	<b>Affiliation</b>	<b>Email address</b>
Alan Helm	Gowan	ahelm@gowanco.com
Andrew Robinson	North Dakota State University	andrew.p.robinson@ndsu.edu
Bradley D. Hanson	University of California	bhanson@ucdavis.edu
Dave Johnson	Corteva	david.h.johnson@dupont.com
Drew Palrang	Bayer Crop Sciences	dre1bes@gmail.com
Fernando Baesso	Bayer Crop Sciences	fernando.baesso@bayer.com
Jesse Richardson	Corteva	jmrichardson@dow.com
Joel Felix	Oregon State University	joel.felix@oregonstate.edu
Kai Umeda	University of Arizona	kumeda@cars.arizona.edu
Pamela Hutchinson	University of Idaho	phutch@uidaho.edu
Ronald Edward Peachy	Oregon State University	peacheye@hort.oregonstate.edu
Tara Burke	Washington State University	tara.leigh.burke@gmail.com

### **Project 3 Discussion Section: Weeds of Agronomic Crops**

Moderator: Rand Merchant, BASF, Colorado Springs, CO

Topic: *State of Weed Resistance in the West.*

Discussion echoed much of what was brought up on Wednesday at the symposium regarding weed resistance; to wit, the acceptance that weed chemical resistance may ultimately be inevitable given the current state of the ag chemical industry. Concerns were raised that given the current patent laws of the US companies were encouraged to promote the overuse of chemistries to recoup investments in a brief period. The consensus was that while lessons have indeed been learned by all sides regarding the stewardship of available chemistries, achieving 100% compliance is near impossible.

Regarding possible steps moving forward the idea was brought forward to create a liaison between the WSWS and state and local weed management groups. The idea being to promote the inclusion of herbicide-resistant weeds of concern on noxious weed lists throughout the west. Not to encourage punitive measures for the lack of control of said weeds, but to open state and local funding for the control of certain herbicide-resistant weeds that also reside in non-crop areas.

Don Morishita nominated Misha Manuchehri as chair-elect for the 2019 annual meeting. With no other nominees, we proceeded to a vote. Misha was unanimously elected as chair elect.

#### Chair 2018:

Rand Merchant, BASF, 2140 Fern Ave., Greeley, CO 80631  
rand.merchant@basf.com

#### Chair-elect 2019:

Vipan Kumar, Kansas State University, 1232 240 Ave, KSU Ag Research Ctr, Hays, KS 67601  
vkumar@ksu.edu

#### Chair-elect 2020:

Misha Manuchehri, Oklahoma State Univeristy, 371 Agricultural Hall, Stillwater, OK 74078  
misha.manuchehri@okstate.edu

List of Attendees not available

## **Project 4 Discussion Section: Teaching and Technology Transfer**

Moderator: Dan Tekiela, University of Wyoming, Laramie, WY

Topic: *Who Ya Gonna Call? Extension?*

### **Discussion notes:**

Discussion began with questions about the role and state of extension. For example, who do people reach out to, is extension trusted as experts, who knows extension exists? This also brought up the topic of the declining numbers of extension agents.

It was a common theme from many land grant universities that they have gone from a county based to regional based extension educator/agent. When asked whom felt extension positions were on the decline in their region, most individuals raised their hands. As an extreme example, the Australian system was mentioned in which the extension services was replaced with crop advisers. In these cases, a “train the trainer” approach was implemented. This approach is much like many of the Western region states have unintentionally moved towards due to reductions in staffing. This was not perceived as inherently negative by the group. Some felt this system may actually be better overall; however, the outcome of less public visibility in this system will likely lead to less support for extension.

It was proposed that part of the reason these reductions exist is due to how costly extension programs can be for a university, especially as state governments are generally reducing support for land grant universities. In times of tight financial budgeting, positions such as weed scientists may be unfilled while more “contemporary” positions that have a greater likelihood of large federal grant success will be hired. This is because extension-focused positions are not competitive in pursuing large federal grants and are not intended to.

Thus the conversation led to how it can be shown to the university system that extension does, in fact, have value. One proposed issue to why this is more difficult than in the past is because the population of ranchers/farmers has declined, meaning our direct clientele are a smaller portion of the general population. Although there was discussion on ensuring we meet the needs of this group, the majority proposed that reaching out beyond this group is critical to show the importance of extension. Multiple times the topic of reaching out to gradeschool programs to foster interest in food production systems was mentioned. Alarming, in some cases gradeschool teachers did not even know the basic agricultural practices happening within their own county, so how could they be expected to excite children about agriculture? Wyoming currently has a program called “Ag in the Classroom” that has the goal of bringing agricultural experts into the classroom; however, not many other participants knew of similar programs in their states.

Branding was discussed in relation to public engagement. For example, the aquatic invasive field has been very successful with their “drain, clean, dry” campaign and have carefully targeted recreationalists of aquatic systems (e.g., fisherman/woman). In fact, they even sponsor a professional fisherman whom works on media with them. How can weed science as a whole learn from this?

Alternatively, instead of convincing the general public to the importance of agriculture and weed science, it was proposed that reaching out to politicians may be a more fruitful exercise. One objective would be to convince the federal government to increase block grant (formula funds) allocations for extension activities and thus show the university the increased support for extension. The critical point needed to convince legislatures is easy summary numbers; however, these numbers are often difficult to estimate. Overall, it was concluded that neither method was incorrect and that a combination of these ideas would likely have a better overall result.

**Overall Conclusion:**

It is critical for extension services to show their value by identifying the proper channels and types of communication. Specifically, showing the quantifiable economic benefits weed science extension activities offer and identifying topics that are meaningful to the general public (e.g., GMO crops) can increase the visibility and perceived value of extension.

**Chair-elect:**

Kirk Howatt will be next years section chair and Scott Nissen nominated Thomas Getts (tjgetts@ucanr.edu) from California for chair elect and he was elected.

Chair 2018:

Dan Tekiela, University of Wyoming, 1000 E. University Ave, Dept 3354, Laramie, WY 82071  
dtekiela@uwyo.edu

Chair-elect 2019:

Kirk Howatt, North Dakota State Univeristy, PO BOX 7670, Fargo, ND 58108  
kirk.howatt@ndsu.edu

Chair-elect 2020:

Thomas Getts, UCCE, 707 Nevada Street, Susanville, CA 96130  
tjgetts@ucanr.edu

Attendees:

<b>Name:</b>	<b>Affiliation</b>	<b>Email Address:</b>
Andrew Fillmore	West Central Distribution	Afillmore@wcdst.com
Andrew Kniss	University of Wyoming	Akniss@uwyo.edu
Bob Finely	Fremont County Weed and Pest	rfinely@dteworld.com
Chad Cummings	Dow AgorSciences	dccummings@dow.com
Chelsea Arnott	University of Hawaii	carnott@hawaii.edu
Corey Ransom	Utah State University	Corey.ransom@usu.edu
Dan Tekiela	University of Wyoming	dtekiela@uwyo.edu
Derek Sebastian	Bayer Crop ScienceBayer	Derek.sebastian@bayer.com
Fernando Beesso	BayerBayer Crop Science	Fernando.beeso@bayer.com

George Beck	Alligare, LLC	George.beck@alligare.com
Gino Graziano	University of Alaska	Gagraziano@alaska.edu
Jacob Jarret	Park County WY Weed & Pest	Jake@parkcountyweeds.org
Joe Armstrong	Dow AgroSciences	Jqarmstrong@dow.com
Kai Umeda	Univeristy of Arizona	kumeda@arizona.edu
Kirk Howatt	North Dakota State Univeristy	Kirk.howat@ndsu.edu
Lee VanWychen	WSSA-Director of Science Policy	Lee.vanwychen@wssa.net
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Mike Wille	Fremont county Weed and Pest	mwille@wyoming.com
Paulo Johnson	South Dakota State University	Paulo.johnson@sdstate.edu
Rachel Seedorf	Colorado State University	rseedorf@yahoo.com
Scott Nissen	Colorado State Univeristy	Scott.nissen@colostate.edu
Shannon Clark	Colorado State Univeristy	Shannon.clark@colostate.edu
Steve Beresta	AgraServ, Inc	steve@agraserv.com
Tara Burke	Washington State University	Tara.Leigh.Burke@gmail.com
Tom Getts	UCCE	tjgetts@ucanr.edu
Travis Bean	University of California-Riverside	bean@ncr.edu



## **Project 5 Discussion Session: Basic Biology and Ecology**

Moderator: Nevin Lawrence, University of Nebraska-Lincoln, Scottsbluff, NE

Topic: *How will Climate Instability Impact Crop Competition, Weed Communities, and Weed Biology in the Short Term?*

Climate change is an important topic of discussion in agriculture, primarily with respect to changing crop performance under stressful environmental conditions. Less frequently discussed is the effect of climate change on weeds. Several review articles (for example, see: Peters et al. (2014) Impact of climate change on weeds in agriculture: a review. *Agron. Sustain. Dev.* 707-721); although climate change is expected to affect weeds via range, niche, and trait shifts, only the first have been extensively explored. The Basic Biology and Ecology discussion section did not focus on the information currently available, rather, attendees emphasized future research needs, how to document climate change effects with respect to weeds, and how to collaborate on a regional scale (as is often required for federal support) while sufficiently addressing local agricultural concerns.

Although climate change is commonly associated with rising temperatures, the phenomenon is significantly more complicated and future weed science-related studies must be designed accordingly. Participants described observing increased variability in weed species emergence and development in their respective regions/model systems; consequently, research must be conducted to look at the extremes in weed responses to factors such as temperature, CO<sub>2</sub> concentration, water availability, and salinity. While the effects of variable weather and related factors have the potential to shift weed populations and communities, it is important to note that local production practices (such as irrigation) may mask or delay changes.

Moving forward, common garden studies across the western region could be a useful tool to better describe the range potential of troublesome weeds; efforts should also be made to identify and evaluate “sleeper” species in addition to the already known concerns. While herbicide resistance is and is likely to remain a significant problem, research efforts should not focus, solely, on resistant species. Research to describe the effects of climate change on weed shifts may require studies conducted over multiple years and regions; this could affect the potential for funding if the immediate (with respect to both time and location) impacts are not apparent to both grant providers and growers.

### Chair 2018:

Nevin Lawrence, University of Nebraska-Lincoln, 4502 Avenue I, Scottsbluff, NE 69361  
nlawrence2@unl.edu

### Chair-elect 2019:

Lynn Sosnoskie, University of California Cooperative Extension, Merced, CA 95341  
lmsosnoskie@ucdavis.edu

### Chair-elect 2020:

To Be Determined

Attendees:

<b>Name:</b>	<b>Affiliation</b>	<b>Email Address:</b>
Oli Bachie	University of California Coop Ext	obachie@ucanr.edu
Fernando Baesso	Bayer Crop Sciences	fernando.baesso@bayer.com
Brad Hanson	University of Californai-Davis	bhanson@ucdavis.edu
Corby Jensen	Monsanto	corby.jensen@monsanto.com
Andrew Kniss	University of Wyoming	akniss@uwyo.edu
Nevin Lawrence	University of Nebraska-Lincoln	nlawrence2@unl.edu
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Marcelo Moretti	Oregon State University	marcelo.moretti@oregonstate.edu
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Drew Palrang	Bayer Crop Sciences	dre1bes@gmail.com
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Lynn Sosnoskie	University of California Coop Ext	lmsosnoskie@ucdavis.edu
Siyuan Tan	BASF	siyuan.tan@basf.com
Kai Umeda	University of Arizona	kumeda@cals.arizona.edu
Ramawatar Yadav	Montana State University	ramawatar.yadav@montana.edu

## WESTERN SOCIETY OF WEED SCIENCE NET WORTH REPORT

April 1, 2017 through March 31, 2018

### ASSETS

#### Cash and Bank Accounts

American Heritage Checking	\$62,984.92
American Heritage Money Market	\$101,378.35
CD#3	\$25,100.00
CD#4	\$25,175.00
CD#5	\$25,237.50
CD#6	\$25,300.00
CD#7	\$25,362.50

<b>TOTAL Cash and Bank Accounts</b>	<b>\$290,538.27</b>
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#### Investments

RBC Dain Rauscher Account	\$193,526.49
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<b>TOTAL Investments</b>	<b>\$193,526.49</b>
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<b>TOTAL ASSETS</b>	<b>\$484,064.76</b>
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## WSWS CASH FLOW REPORT

April 1, 2017 through March 31, 2018

### INFLOWS (\$)

Annual Meeting Income	69,140.00
California Weeds Book	170.00
Capital Gains	547.76
DVD Weed ID	200.00
Interest Income	2,428.25
Dividend Income	5,247.69
Invasive Plants Book	45.00
Miscellaneous Income	1.00
Membership Dues	300.00
Rita Beard Endowment	250.00
Royalty For Proceedings Or RPR	180.00
Security Value Change	-5,737.80
Student Travel Account	1,939.00
Sustaining Member Dues	9,500.00
Weed Control In Natural Areas	393.00
Weeds Of The West	23,198.00
<b>TOTAL INFLOWS</b>	<b>107,801.90</b>

### OUTFLOWS (\$)

Annual Meeting App	2,750.00
Annual Meeting Expense	3,791.23
Bank Charge	12.77
Books	232.00
CAST Annual Dues	1,500.00
Director Of Science Policy	5,306.00
Fee Charged	1,860.73
Insurance	500.00
Management Fees	21,930.51
Merchant Account	4,397.39
Miscellaneous	2,576.06
Mobile Deposit Fee	4.50
Postage	1,940.24
Rita Beard Transfer	260.00
Rita Beard Endowment Set Up	1,987.28
Summer Meeting	2,360.42
Student Awards	3,775.00
Supplies	418.55
Taxes	588.33
Travel To Summer Meeting	3,567.58
Travel To WSWS Meeting	1,325.26
Web Site Hosting	4,400.00
<b>TOTAL OUTFLOWS</b>	<b>65,483.85</b>
<b>OVERALL TOTAL</b>	<b>\$42,318.05</b>

## WSWS 2018 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.

### **Phillip Munger**



Philip (Phil) Munger received his BS degree in Agronomy in 1981 from the Ohio State University, his MS degree in 1983 at Texas Tech University in Agronomy and Weed Science and his PhD in Plant Physiology and Weed Science at Texas A&M University, in 1986. He began his career as a Field Biologist in South Texas for the BASF Corporation in 1986 and continued his career with BASF for over 30 years retiring in 2016 as a Field Biology Manager. He is currently an Independent Field Agricultural Research specialist with Bravin Kataela Agricultural Research, Inc. He has served the WSWS on the Finance Committee and was elected as a Member at Large-Private Sector.



### **Kai Umeda**

Kai Umeda received his BS degree in Pest Management from the University of California, Berkeley and his MS degree at Southern Illinois University. He began his weed science work with American Cyanamid in 1981, moving to the University of Arizona in 1994 as a Vegetable Area Extension Agent and since 2003 as an Area Extension Agent, Turfgrass Science. He has been a member of the WSWS since 1985, serving on Student Paper, Public Relations, and Nominations committees, as well as the Board of Directors as the Constitution and Operating Procedures representative. He was also elected as Education and Regulatory chair and served as WSWS president in 2013. In his extension duties, he has planned and conducted scores of field days, workshops, seminars, and schools for growers, commercial and municipal landscapers, golf course superintendents, and crop consultants. As an agricultural /horticultural professional, Kai has authored/co-authored more than 50 abstracts and conference proceedings in a host of meetings. Thirty of these have

been for WSWS meetings, reflecting his 32 years of service to the society. He has also presented at regional and national entomology, horticulture, and agronomy meetings, displaying his ability to work collaboratively with scientists from many different disciplines. In addition, Kai has written over 100 WSWS Research Progress Reports, indicative of his dedication to the Society, and to weed science.

**WSWS 2018 HONORARY MEMBER**

This award was not conferred in 2018

## WSWS 2018 OUTSTANDING WEED SCIENTIST AWARDS

**Brian Schutte**



The Outstanding Weed Scientist, Early Career was awarded to Brian Schutte, Assistant Professor at Mexico State University.

**Rick Boydston**



The Outstanding Weed Scientist, Public Sector was awarded to Rick Boydston, (USDA-ARS) Prosser, Washington.



## **WSWS 2018 WEED MANAGER AWARD**

This award was not conferred in 2018

**WSWS 2018 PROFESSIONAL STAFF AWARD**

This award was not conferred in 2018

## WSWS 2018 PRESIDENTIAL AWARD OF MERIT

**Roger Gast**



Roger Gast received the WSWS Presidential Award of Merit from Monte Anderson at the 2018 annual meeting in Garden Grove, California.

## WSWS 2018 ELENA SANCHEZ MEMORIAL STUDENT SCHOLARSHIP RECIPIENTS



The awards committee received a record 12 applications for the Elena Sanchez Memorial WSWS Scholarship. Three of the applicants were undergraduates, so we dedicated one award for that category. All three winners this year were outstanding and were supported by impressive research papers presented at the Garden Grove meeting. The recipients of the Elena Sanchez Memorial Scholarship were Clint Beiermann (grad student, UN-Lincoln), Charlemagne Lim (grad student, MSU-Bozeman) and Grace Ogden (undergrad, OSU-Stillwater). A big thanks to their advisors for bringing along such great promising talent for the future of weed science.

## WSWS 2018 RITA BEARD ENDOWMENT STUDENT SCHOLARSHIP RECIPIENTS

The Rita Beard Endowment Foundation Board of Trustees have announced the two travel scholarship recipients for 2018. They are Shannon Clark, a Ph.D. candidate at Colorado State University and Clay Wood, an M.S. graduate student at the University of Wyoming. The Rita Beard Endowment Foundation is a 501 (c) (3) non-profit that was created from a generous donation from Rita Beard's family and friends to support students and early career invasive species managers with educational opportunities 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. Both of this year's winners will be attending the Western Society of Weed Science annual meeting in March. To read more about the Foundation, learn how to apply for the 2019 scholarships, or make a donation go to: <http://www.wsweedscience.org/rita-beard-endowment-foundation/>.

### Shannon Clark



My interest in invasive species management in natural areas started when I was hired to manage the weeds on a non-profit, educational ranch in a conservation easement from Rocky Mountain National Park. Faced with 1,000's of acres of downy brome to manage, I quickly realized the challenge faced by land managers. This led to my interest in doing a PhD focused on downy brome research. The emphasis of my PhD research consists of invasive winter annual grass (IWAG) control and restoration of desirable species on natural areas properties. More in-depth, my research looks at a new potential herbicide for IWAG control in natural areas and the release of desirable species after treatment, tolerance of native species to herbicides used in natural areas, and the impact of IWAG thatch layer to herbicide effectiveness and reinvasion of weeds. With over 50 million acres in the US infested with downy brome (*Bromus tectorum*) alone, I believe my research in management options for IWAG will contribute valuable information to natural areas managers. My ideal career and future contributions to weed science would involve continued invasive species research with a strong emphasis in communication to these managers.

### Clay Wood



Upon graduation with a master's degree I would like to pursue a career in cooperative extension, weed and pest, or a similar organization to assist landowners and producers in solving problems and developing management techniques that are practical and achievable at any scale. My research is a landscape scale cheatgrass project and intended to develop strategic management strategies that will aid land managers in making better informed cheatgrass management decisions. In the scientific literature for rangeland systems there are multiple discussions about the concept of ecological thresholds, but, there are very few applied examples and established thresholds. Cropping systems use thresholds as a decision tool for weed management and my intent is to apply these principles to cheatgrass invaded rangelands to determine infestation levels where effects of cheatgrass control are positive for desirable vegetation.

## WSWS 2018 STUDENT PAPER AND POSTER AWARDS

The 2018 WSWS Student Paper and Poster contest included 10 graduate and 2 undergraduate poster presentations and 16 oral presentations. To all students who participated in the contest, congratulations on your excellent presentations this year. In this year's contest, according to the rules established in the WSWS operating guide, the number of winning places in different sections varied depending on the number of students who participated in each section.

The Undergraduate Poster Contest was made up of two students with only 1<sup>st</sup> place awarded. The 1<sup>st</sup> place winner was Abigail Friesen from Kansas State University. The winning poster title was "Confirmation of ALS-Inhibitor Resistance in Wild Buckwheat (*Polygonum convolvulus* L. Polco) from Kansas".

The Graduate Poster Contest was made up of 10 students, with 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> places awarded. The 1<sup>st</sup> place winner was Nami Wada from Oregon State University. The winning poster title was "Comparison of Solarization and Biosolarization for Weed Control in a Tree Seedling Nursery in Western Oregon". The 2<sup>nd</sup> place winner was Lucas Bobadilla from Oregon State University. The winning poster title was "Effects of Synthetic Auxin Herbicides on Seed Production and Seed Viability of Herbicide Resistant Populations of Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) in Western Oregon". The 3<sup>rd</sup> place winner was Ramawater Yadav from Montana State University. The winning poster title was "Management of Glyphosate and Dicamba - Resistant Kochia (*Kochia scoparia*) in Roundup Ready® Xtend Soybean".



### Poster Winners



**Ramawater Yadav**, Montana State University, **Abigail Friesen**, Kansas State University, **Nami Wada**, Oregon State University, and **Lucas Bobadilla**, Oregon State University



Students in the oral contest were divided into two sections. The first section had 7 papers all in the Basic Biology and Ecology section with 1<sup>st</sup> and 2<sup>nd</sup> places awarded. The 1<sup>st</sup> place winner was Albert Adjesiwor from the University of Wyoming. The winning paper title was “Shade Avoidance in Sugarbeet: Tragedy of the Commons?”. The 2<sup>nd</sup> place winner was Hudson Takano from Colorado State University. The winning paper title was “Why is Inhibition of Glutamine Synthetase Toxic to Plants?”. The second section had 9 papers across the Agronomy, Horticulture and Range sections with 1<sup>st</sup> and 2<sup>nd</sup> places awarded. The 1<sup>st</sup> place winner was Gabriel Flick from Oregon State University. The winning paper title was “Brassicaceae Seed Persistence Under Different Tillage Regimes in The Willamette Valley”. The 2<sup>nd</sup> place winner was Clint Beierman from the University of Nebraska. The winning paper title was “Integrating Crop Rotation and Herbicide Programs to Improve Control of Problematic Weed Species in Sugarbeet?”.

Basic Biology and Ecology of Weeds	Weeds of Agronomy, Horticulture and Range
	
1 <sup>st</sup> - <b>Albert Adjesiwor</b> , University of Wyoming 2 <sup>nd</sup> - <b>Hudson Takano</b> , Colorado State University	2 <sup>nd</sup> - <b>Clint Beierman</b> , Univeristy of Nebraska 1 <sup>st</sup> - <b>Gabriel Flick</b> , Oregon State University

Finally, a huge thank you to all the judges who contributed their time and energy for this year’s contests.

## WSWS 2018 ANNUAL MEETING NECROLOGY REPORT

At the Thursday breakfast business meeting, the biographies of WSWS members who passed away this year were read and a moment of silence was observed. Those members were:

### **Ron Crockett**

Ron Crockett passed away April 26, 2017. Ron was a long-time member of WSWS and served on numerous committees (Awards, Herbicide Resistant Plants, Publications, Program, among others) and served as WSWS President in 2008. Ron was employed by Monsanto before his retirement in 2010.

### **Art Lange**

Art Lange passed away June 27, 2017. Art retired from UC in 1986 after a productive career as a weed science specialist and began a second career as a stone fruit farmer. He spent the majority of his UCCE career in the Central Valley where he collaborated with and influenced many of his weed science colleagues around the state. Art was named an Honorary Member of the California Weed Science Society in 1986 and Fellow of the Western Society of Weed Science in 1977. Art is remembered for a deep enthusiasm for weed management research that he shared with his colleagues and encouraged them to expand upon in their own research and extension programs. Art Lange was impactful both as a scientist and as a mentor to his colleagues and had a large impact on weed science in California during his UCCE career.

### **Gustavo Sbatella**

Gustavo Sbatella passed away August 2, 2017. He received his bachelor's degree in agronomy from the Universidad de Nacional de Buenos Aires, Argentina in 1990. He came to the University of Wyoming in 2002 where he earned his master's degree in 2004, and his doctorate degree in 2006. Following his education, he worked as a Post-Doctoral Research Associate for the University of Nebraska and an Assistant Professor at Oregon State University. He returned to Wyoming in 2014 to become an Assistant Professor for the College of Agriculture where he specialized in irrigated crop and weed management. In this position, he taught courses and mentored graduate students, as well as conducted research and managed a valued extension program. He is survived by his two children, Ángel Alex Sbatella and Mailen Sbatella, their mother, Maria Rosa Bravo, his two grandchildren, Adrian and Azariel, and his brother Ricardo.

### **Steve Orloff**

Steve Orloff passed away October 3, 2017. Steve spent his 33-year career as a UC Cooperative Extension Farm Advisor, initially in the high desert of southern California and for the past 20+ years in northern California in Siskiyou County. Steve was an important contributor to UC's weed science program and was engaged with researchers, farmers, and the agricultural industry as a forage and cereals agronomist. Steve was beloved by growers and industry representatives in California, the West, and nationwide due to his robust research program, excellent crop management knowledge, and his great ability to extend information in a fun and easy to understand style. Steve had a real impact on many of his UCCE colleagues through his scientific and interpersonal interactions. He made his mark through strong science, hard work, and commitment to agriculture but also through his sense of humor and his genuine care for friends, colleagues, and family.



## WSWS 2018 ANNUAL MEETING RETIREES REPORT

We received notice that five members of the society retired since the 2017 Annual Meeting or will retire later this year. We are grateful to these individuals for many years of service to the society and professional leadership in their respective positions. Listed chronologically by retirement date.

Jeff Tichota, Monsanto Company, retired spring 2017 (not in attendance). Jeff was named Outstanding Weed Scientist in 1997. He was the WSWS President in 2000. And he was named Fellow in 2002.

Charlotte Eberlein, University of Idaho, retired June 2017 (not in attendance). Charlotte started with the University of Idaho in 1989 at an Extension/Research Station in south Idaho and assumed duties of Extension Director in 2002. She was WSWS President in 1997 and named Fellow in 1999.

Rick Boydston, USDA-ARS, retiring April 30, 2018. Rick started with the USDA-ARS in Prosser, WA, in 1985. He served as field agronomist for Cascadian Farm from 1997-1999 and then returned to the USDA-ARS until his retirement later this year. Rick was named WSWS Fellow in 2008 and Outstanding Weed Scientist in 2018.

Curt Thompson, Kansas State University, retiring July 18, 2018. Curt worked as a technician at North Dakota State University while obtaining his MS and then accepted a position at the North Central Research Extension Center at Minot in 1982. He started as a technician at the University of Idaho in 1989, completed his PhD, and, after a few more years, began his tenure with Kansas State University at the Southwest Research Extension Center, Garden City, in 1993. Curt moved to the Manhattan campus in 2008.

Rod Lym, North Dakota State University, retiring December 31, 2018. Rod accepted a Post Doc position on the Leafy Spurge Task Force at North Dakota State University in 1979. This activity led to a permanent faculty position a couple years later and continued service at NDSU until his retirement later this year. Rod received the WSWS Presidential Award of Merit in 1994, served as President in 1999, was named Fellow in 2000, and named Outstanding Weed Scientist in 2007.

Congratulations and best wishes to all in their future endeavors.

Submitted by Kirk Howatt, Immediate Past-President

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## WSWS 2018 ANNUAL MEETING – AUTHOR INDEX

Index of authors and their abstract numbers.

Adams, Jason W.	80, 81
Adjewor, Albert T.	90
Al-Khatib, Kassim	20
Anderson, Monte D.	61
Angeles, Jorge	138
Armstrong, Joe	28
Arnott, Chelsea	121
Ashigh, Jamshid	78
Barrett, Michael	49
Barroso, Judit	22, 88, 116
Beck, Leslie	12
Beiermann, Clint W.	39, 115
Berry, Pete A.	14, 109, 111, 128
Beutler, Brent	130
Boydston, Rick A.	136
Boyer, Grant	43, 114
Brunharo, Caio Augusto	94
Burke, Ian C.	7, 11, 13, 24, 25, 37, 52, 55, 82, 95, 96, 107, 125, 132
Burke, Tara L.	25, 55, 107
Burnett, Kimberly	65
Campbell, Joan	23
Carter, Arron	55, 95
Clark, Shannon L.	3, 73, 99

Claypool, David A.	57, 92
Clayton, Megan	5, 71
Cobb, William T.	69
Cole, Kail	32, 34, 35
Cox, Linda	121
Cox, Ryan	138
Creech, Cody	39, 86
Creech, Earl	41
Croese, Jodie	32, 34, 35
Cummings, D.	34
Currie, Randy	43, 49, 123
Curtis, Dan W.	36, 83, 84, 111, 118
Dahl, Greg	79
Dalley, Caleb	42
Daniel, Jim	2, 47, 54
Davy, Josh S.	103
Dayan, Franck E.	93, 97
Degenhardt, Rory	50, 78, 106
Dille, Anita	49
Edwards, Ryan	79
Endres, Gregory J.	38, 108, 112
Engel, Ryan	43
Flick, Gabriel D.	117
Fowers, Beth	59, 98, 100, 119
Friesen, Abigail	58
Gaines, Todd	33, 50, 85, 89, 97, 105, 123

Galla, Mariano F.	20
Gast, Roger E.	26, 28, 50, 77, 106
Geary, Nelson	129
Gednalske, Joe V.	79
Getts, Tom	8
Giles, Ken	127
Gillilan, Jo A.	79
Giumaraes Abe, Daniel	42
Graziano, Gino	72
Haidar, Mustapha A.	18
Haley, Scott	85
Hanselka, Wayne	5, 71
Hanson, Brad	17, 20, 94, 124
Hanson, Bryan	29
Hare, Don	106
Harrington, Timothy B.	68
Hart, Charles	102
Hatterman-Valenti, Harlene	38, 129
Hauvermale, Amber L.	24, 25, 37, 55, 82, 95, 107
Hayden, Thomas A.	79
Hildebrandt, Curtis M.	85
Hixson, Adam	35
Howatt, Kirk A.	30, 104, 112
Hulting, Andy G.	36, 83, 84, 109, 111, 118, 136
Hutchinson, Pam	130, 131
Idowu, O. John	12

Ishaq Pelligrini, Sue	110
Israelsen, Clark	41
J, Anjani	40, 46
Jackson, James	102
James, Jeremy J.	103
Jenkins, Daniel	127
Jenks, Brian	29, 38
Jennings, Lydia	63
Jha, Prashant	40, 44, 46, 56, 57, 91, 92, 123
Jhala, Amit J.	39
Johnson, Paul	47
Jones, Lisa C.	67
Jugulam, Mithila	49, 58
Juras, Len T.	78, 106
Klein, Robert	123
Knezevic, Stevan Z.	39, 123
Kniss, Andrew	46, 56, 57, 60, 90, 91, 92, 123
Koby, Lindsay E.	7, 82, 95, 96, 107
Kopecky Bobadilla, Lucas	14, 36, 109, 128
Kumar, Vipin	40, 43, 44, 114
Kyser, Guy B.	6, 103
Larocca de Souza, Larissa	15, 16, 19
Lawrence, Nevin C.	39, 46, 56, 57, 91, 92, 115, 123
Leary, James	65, 121, 127
Lehnhoff, Erik A.	4, 10
Leland, Shane	44, 46

LeQuia, Kathrin	113
Libbin, James	12
Lim, Charlemagne Alexander A.	40, 46, 56
Lindenmayer, Brad	34
Long, Dan	22, 88
Lym, Rod	70
Lyon, Drew J.	31, 96, 116
Lyons, Robert	5, 71
MacRae, Andrew	78
Madsen, John D.	1, 6, 66
Mahnken, Brooke V.	65
Mallory-Smith, Carol	14, 36, 83, 84, 109, 111, 117, 118, 128
Mangold, Jane	10
Mann, Richard K.	133
Manuchehri, Misha	32, 34, 35
Marley, David	64
Martin, Christy	121
Martin, Katie	17
Mashiri, Fadzayi E.	103
McCloskey, William B.	45, 133
McDonald, Sandra K.	123
McGinty, Allan	5, 71
Mealor, Brian A.	59, 74, 98, 100, 101, 119
Medlin, Case R.	5, 71
Menalled, Fabian	110
Mettler, Joseph E.	30, 104

Miller, Timothy W.	76, 131, 135
Miskella, John	1, 6
Moechnig, Mike	77
Moretti, Marcelo L.	15, 16, 19
Morishita, Don W.	40, 113, 125
Morran, Sarah	94
Mosqueda, Elizabeth G.	46, 57, 92
Msheik, Ali M.	18
Murray, Leeland	4
Newberry, George	130
Nissen, Scott J.	33, 73, 99
Norsworthy, Jason K.	33
Norton, Randy	45
Ogden, Grace	35
Olsen, Heather E.	9, 51
Ostlie, Mike H.	29, 38, 108, 112
Pace, Mike	41
Parke, Jennifer	14, 128
Parrish, Scott	54
Patterson, Eric	89, 97
Peachey, Ed	15, 21
Peterson, Dallas	48, 49, 58, 87, 123
Peterson, Vanelle F.	103
Pettinga, Dean	105
Pierson-Metier, Emily	10
Pigati, Ray L.	79

Prasifka, Patti	26, 77
Prather, Tim	7, 67
Purba, Wiharti O.	135
Quicke, Harold	2, 3, 8, 73
Ransom, Corey V.	9, 41, 51
Rauch, Traci	23
Redmond, Christopher	48
Rew, Lisa J.	10
Richardson, Jesse M.	133
Rinella, Matthew J.	10, 103
Robinson, Andrew	38, 129
Rodriguez, Jeanette A.	24, 82, 95, 107
Rodriguez, Roberto	127
Roerig, Kyle C.	83, 84, 118
Rupp, Robert	34
Russell, Morgan	102
Saleh, Osama S.	27, 53
San Martín, Carolina	22, 88, 116
Sanchez, Adriana	12
Sander, Luke	100
Sandlin, M Randa	121
Sauer, Steve	2, 3
Sbatella, Gustavo M.	46, 56, 57, 91, 92
Schlegel, Alan J.	87
Schroeder, Jill	49
Schutte, Brian J.	4, 12, 122, 126, 137

Sebastian, Derek J.	2, 3, 73, 99
Sebastian, Jim	2, 3
Secor, Gary	129
Seefeldt, Steven S.	72, 131, 135
Seipel, Tim	110
Shelton, Chad	85
Shrestha, Anil	138
Simao, Luana	86
Skovgard, Jordan L.	59
Sleugh, Byron B.	28
Smith, Laura	78
Soni, Neeta	33, 89
Sosnoskie, Lynn M.	11, 13, 52, 120, 132
Spandl, Eric	79
Squires, Caleb C.	55, 95, 107
Stahlman, Phil	43, 49, 114, 123
Stella, Felipe Augusto	36, 109
Strickland, Gary	32
Takano, Hudson K.	93
Tekiela, Dan R.	75
Thompson, Asunta	129
Thompson, Curtis R.	48, 49, 87
Thompson, Jeremy R.	52
Thompson, William	5, 71
Thorne, Mark E.	116
To, Mala	138



Todd, Olivia E.	105
Tomco, Patrick	72
Umeda, Kai	134
Van Wychen, Lee	49, 62
Wada, Chris	65
Wada, Nami	14, 128
Walsh, Michael	33
Ward, Sarah M.	123
Waters, Tim	107
Westra, Eric	47, 54, 85, 105
Westra, Phil	33, 47, 50, 54, 85, 93, 97, 105, 123
Wetzel, Henry C.	25, 31, 82
Whitesides, Ralph E.	51
Wilson, Robert	8, 136
Wirth, Devin A.	80
Wood, Clay W.	74, 101, 119
Yadav, Ramawatar	40, 44, 56, 91
Yenish, Joe	26, 77, 106
Zhang, Mingchu	72
Zollinger, Rich	38, 80, 81, 129
Zuger, Rachel J.	24, 25, 37, 82, 95, 96, 107

## WSWS 2018 ANNUAL MEETING – KEYWORD INDEX

Index of keywords and the numbers of the abstracts where they appear.

2,4-D	49, 70
acetochlor	29
Acetochlor	39
Adjuvants	79, 80
<i>Aegilops cylindrica</i>	85
<i>Allium cepa</i>	107
<i>Amaranthus palmeri</i>	115
<i>Amaranthus powellii</i>	136
<i>Amaranthus retroflexus</i>	14, 128, 136
Aminocyclopyrachlor	5, 71
Aminopyralid	72
Aminopyralid	70
<i>Anthemis cotula</i>	31
Apple	13, 132
Application, fall	9
Application, methods	70
Application, spring	9
Aquatic environment	1, 66, 76
Areas, natural	9, 59, 66, 67, 73, 74, 98, 100, 101, 119
Atrazine	21, 49
Barley	29, 104
Basal bark	72
Bean, dry	38, 108, 113

Bentazon	113
bicyclopyrone	31
Bioassay	72
Bioassay	93
Biological control	4
Bispyribac-sodium	20
Blueberry	52
Bromoxynil	31
<i>Bromus japonicus</i>	9, 67
<i>Bromus rubens</i>	73
<i>Bromus tectorum</i>	9, 23, 59, 67, 73, 74, 85, 99, 101, 119
Brush	5, 71
California annual grasslands	103
Capric acid	13
Caprylic acid	13
<i>Chenopodium album</i>	40, 131, 132
<i>Chloris truncata</i>	49
<i>Cirsium arvense</i>	70
Clopyralid	31, 39
Clover	21
Competition	59
conservation agriculture	18
conspecifics	90
<i>Convolvulus arvensis</i>	52
<i>Conyza canadensis</i>	49
Corn	21, 40

Cover crop	14, 21, 56
Crops, minor	118
Cultivation	21
<i>Cytisus scoparius</i>	68
Desmedipham	39
Dicamba	38, 49, 104, 112, 129
<i>Digitaria sanguinalis</i>	13
Dimethenamid-P	29, 113
Ditches, ditchbanks	76
Dose-response	40
Drift control	79
Drift, spray	20, 38, 112
Ecology, weed	66, 100
Education	49, 119, 120, 123
<i>Eichhornia crassipes</i>	1, 66
EPTC	113
<i>Erigeron canadensis</i>	49
Ethalfuralin	113, 130
<i>Euphorbia esula</i>	67, 70
Extension	120
Extension	49, 119
Fir, Douglas	68
Flucarbazone	23, 29
flumioxazin	29
Fluroxypyr	31, 77, 104, 106
Forage production	103

Forest	68
Germination	14, 56, 68
Glufosinate	93
Glyphosate	9, 38, 40, 52, 80, 94, 98, 99, 123, 129
Growth stage influence	68
Habitats, disturbed	4, 18, 68
Habitats, natural	9
Herbicide mode of action	93
Herbicide resistance	31, 49, 56, 106, 123, 125
heterospecifics	90
Imazamox	113
Imazapic	9, 74, 99, 101
Imazapyr	4
Indaziflam	9, 73, 98, 99, 132
Interactions, herbicide	98
Internet Outreach	120
Invasive species	9, 67, 68, 99, 100
kin recognition	90
<i>Kochia scoparia</i>	49, 50, 56, 106, 115, 136
<i>Lactuca serriola</i>	132
Light quality	68
light quality	90
Long-term control	9
<i>Lysimachia vulgaris</i>	76
<i>Malva neglecta</i>	132
<i>Mentha spp.</i>	136

Mesosulfuron-methyl	23
Metribuzin	131
Mint	136
Modeling	56, 67
Monitoring	67
Mowing	4
Mulch	14
no-till	18
Non-crop	9, 49
Noxious weed	9
Onion	107
organic herbicides	52
<i>Orobanche ramosa</i>	18
Oryzalin	132
Outreach	120
Oxyfluorfen	132
Paraquat	49
Pea, dry	38
Pelargonic acid	13
Pendimethalin	29, 132
Penoxsulam	132
<i>Phaseolus vulgaris</i>	113
Phenmedipham	39
Physiological	93
Phytohormones	52
Picloram	70

<i>Poa annua</i>	14, 94, 128
<i>Poa bulbosa</i>	59
Polygonum pensilvanicum	128
Polygonum pensylvanicum	14
<i>Portulaca oleracea</i>	14, 128
Potato	18, 129, 131
Propoxycarbazone	9
<i>Prosopis glandulosa</i> var. <i>glandulosa</i>	71
Prunus padus	72
<i>Pseudotsuga menzesii</i>	68
Pulse Width Modulation	70
pyrasulfotole	31
Pyridate	136
Pyroxasulfone	29
Pyroxsulam	77
Quinclorac	70
Quizalofop	85
Rangeland	5, 59, 67, 70, 71, 73, 74, 98, 99, 100, 101, 119
Rangeland	103
Residues, herbicide	38, 112
Resistance management	125
Restoration	59, 98, 99, 119
Right-of-way	70
Rimsulfuron	9, 132
Riparian areas	4, 76
Rye	108

s-metolachlor	29
Safety	31
Saflufenacil	136
<i>Secale cereale</i>	85, 99
<i>Setaria viridis</i>	29
shade avoidance	90
Simazine	132
smartweed, Pennsylvania	14, 128
<i>Solanum tuberosum</i>	129, 130, 131
Solarization	14, 128
Soybean	112
Sugar beet	40
<i>Taeniatherum asperum</i>	103
<i>Taeniatherum caput-medusae</i>	9, 73, 100
<i>Tamarix ramosissima</i>	4
Tankmixtures	80, 131
Teaching	118
Tembotrione	21
thiencarbazone	23
Thresholds	101
Tillage	21
Tolpyralate	21
Topramezone	21
Triclopyr	5, 71
<i>Trifolium repens</i>	13, 132
<i>Triticum aestivum</i>	31



<i>Triticum aestivum</i>	23, 55, 77
Variety tolerance	130
<i>Ventenata dubia</i>	73, 100
<i>Vulpia myuros</i>	23
Weed biology	52
Weed control	13
Weed establishment	52
Weed management	9, 49, 67, 99, 125, 136
Weed suppression	52
Wheat	23, 55, 85, 104, 106
wheatgrass, crested	9
wheatgrass, western	9
Winter annual grass	103
Yield loss	136

**WSWS 2018 ANNUAL MEETING – ABSTRACT NUMBER, PAGE NUMBER INDEX**

001, 2	027, 19	054, 34
002, 2	028, 20	055, 34
003, 3	029, 20	056, 34
004, 4	030, 21	057, 35
005, 5	031, 21	058, 1
006, 6	032, 22	059, 1
007, 6	033, 22	060, 37
008, 7	034, 23	061, 37
009, 8	035, 23	062, 37
010, 9	037, 24	063, 41
011, 10	038, 25	064, 41
012, 11	039, 25	065, 41
013, 12	040, 26	066, 42
014, 12	041, 26	067, 42
015, 13	042, 27	068, 43
016, 13	043, 27	069, 44
017, 14	044, 28	070, 44
018, 14	045, 29	071, 45
019, 15	046, 29	072, 46
020, 15	047, 30	073, 46
021, 16	048, 30	074, 47
022, 16	049, 31	075, 48
023, 17	050, 32	076, 48
024, 17	051, 32	077, 58
025, 18	052, 33	078, 58
026, 18	053, 33	079, 59

080, 59	098, 49	116, 70
081, 60	099, 49	117, 71
082, 61	100, 50	118, 72
083, 61	101, 50	119, 72
084, 62	102, 51	121, 73
085, 62	103, 51	127, 52
086, 63	104, 64	128, 52
087, 63	105, 65	129, 52
088, 71	106, 65	130, 53
089, 73	107, 65	131, 53
090, 74	108, 66	132, 54
091, 74	109, 66	133, 55
092, 75	110, 67	134, 56
093, 75	111, 68	135, 56
094, 76	112, 68	136, 57
095, 76	113, 68	137, 57
096, 77	114, 69	138, 30
097, 77	115, 70	

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### **Poster** - *President-Elect*

Jared Unverzagt (2018)  
Alan Helm, Chair (2019)  
Misha Manuchehri (2020)

### **Public Relations**

*Education & Regulatory Section Chair*

Lynn Sosnoskie (2018)  
Travis Bean (2018)  
Kai Umeda, Chair (2019)  
Pat Clay, Co-Chair (2019)  
Richard Zollinger (2020)  
Joe Armstrong (2020)

### **Site Selection** - *President*

Joseph Yenish (2018)  
Steve Eskelsen, Chair (2019)  
Pete Forester (2020)

### **Sustaining Membership** - *Past President*

Craig Alford (2018)  
Ryan Rector, Chair (2019)  
Charlie Hicks (2020)

## **2018 WSWS Sustaining Members**

Alligare LLC

AMVAC Chemical Corporation

Arysta LifeScience

BASF Corporation

Bayer CropScience

Campbell Scientific

Dow AgroSciences

DuPont Crop Science

FMC

Gowan Company

Gylling Data Management

Helena Chemical Company

Monsanto Company

Syngenta

United Phosphorus, Inc.

Valent

Wilbur-Ellis Company

Winfield Solutions LLC