Canadian Weed Science Society
Société canadienne de malherbologie

73rd Annual Meeting
November 18th to 21st 2019

Réunion annuelle
18 au 21 novembre 2019

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Weed Science in Canada

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Jonathan Rosset	Grad student presentations

CWSS-SCM 2019 Annual Meeting Agenda

Note that the abstracts for the individual presentations are listed by number in the Abstract section.

Monday, November 18, 2019		
Time	**Topic/Event**	**Room**
8:00-9:00 am	CWSS-SCM Board Meeting Breakfast	Cassiar/Cascade
9:00 am - 5:00 pm	Registration	Hotel Conference Lower Foyer
9:00 am – 4:00 pm	CWSS-SCM Board Meeting	Selkirk
1:00-5:00 pm	Optional Tours	Hotel Conference Lower Foyer
11:00 am - 6:00 pm	Commercial exhibits and poster set up	Grand Foyer
5:00 - 6:00 pm	Graduate Student Meet and Greet with Board Members	Mt. Boucherie
6:00 - 10:00 pm	Industry Reception	Grand Foyer

Tuesday, November 19, 2019			
#	**Time**	**Topic/Event**	**Room**
	7:00 am - 5:00 pm	Registration	Grand Foyer
	7:00 - 7:30 am	Graduate student setup	Shuswap/Pennask/Skeena
	7:00 - 8:00 am	Continental Breakfast	Shuswap Foyer
		Graduate Student Presentations	**Shuswap/Pennask/Skeena (Breanne Tidemann)**
	8:00 - 8:10 am	Opening remarks – President and LAC Announcements	Rory Degenhardt/Ken Sapsford
1	8:10-8:25 am	Competing signals: The role of ROS production in plant interactions	Nicole Berardi* S. Amirsadeghi Clarence Swanton
2	8:25-8:40 am	Mechanisms of weed seed predation and its potential role in weed biocontrol	Khauldoun Ali* Christian Willenborg
3	8:40-8:55 am	Control of multiple-herbicide-resistant waterhemp (*Amaranthus tuberculatus*) in corn with single- and two-pass weed control programs	Christian Willemse* Peter Sikkema David Hooker Darren Robinson Amit Jhala

4	8:55-9:10 am	Is there a preconditioning effect of ALS herbicide inhibitors and glyphosate on the herbicide sensitivity of resistant and sensitive biotypes of Alopecurus myosuroides and Lolium rigidum	Abakah Shaif* Regina Belz
5	9:10-9:25 am	Evaluation of acetolactate synthase inhibitors in *Chenopodium album* L. populations in Ontario	Clement Mo* Francois Tardif Istvan Rajcan Mike Cowbrough
6	9:25-9:40 am	Development of management strategies for spreading dogbane (*Apocynum androsaemifolium* L.) in lowbush blueberry fields	Hugh Lyu* Scott White Nancy McLean Andrew McKenzie-Gopsill
	9:40-10:30 am	AM Break	Shuswap Foyer
7	10:30-10:45 am	Influence of adjuvants on the control of glyphosate-resistant Canada fleabane (*Conyza canadensis* L. Cronq.) and waterhemp (*Amaranthus tuberculatus*) in corn with tolpyralate	Nicole Langdon* Alan J. Raeder Darren E. Robinson David C. Hooker Peter H. Sikkema
8	10:45-11:00 am	Multiple modes of selection prove successful in managing Canada fleabane	Ted Vanhie* Clarence Swanton Mike Cowbrough François Tardif
9	11:00-11:15 am	Weed seed biocontrol by carabids in pulse crops	Stefanie De Heij* Christian Willenborg
10	11:15-11:30 am	Glyphosate-resistant Canada fleabane (*Conyza canadensis* (L.) Cronq.) and giant ragweed (*Ambrosia trifida* L.) control in winter wheat with halauxifen-methyl applied POST	Jessica Quinn* Jamshid Ashigh Darren E. Robinso David C. Hooker Peter H. Sikkema
11	11:30-11:45 am	Molecular and biochemical investigation on vacuolar sequestration of glyphosate in glyphosate resistant Canada fleabane (*Conyza canadensis* (L.) Cronq.)	Emily Priester* Clarence Swanton Eric Page François Tardif
	11:45 am -12:00 pm	Welcome from the Mayor of Kelowna	Mayor Colin Basran

	12:00-1:00 pm	Lunch	**Shuswap** Foyer
	1:00 - 2:15 pm	Poster Viewing (Authors Present)	**Shuswap** Foyer
		Corn, Soybean and Edible Bean	**Chilcotin (Adam Pfeffer)**
12	2:15-2:30 pm	Spray drift of dicamba from a commercial sprayer onto non-XTend traited soybeans – a comparison of drift amount, plant symptoms, and yield	Tom Wolf* Brian Caldwell Chris Willenborg Eric Johnson Said Darras Adam Pfeffer Hubert Landry
13	2:30-2:45 pm	Presence of neighbouring weeds alters the mode of action of thiamethoxam in maize (*Z. mays*)	M. House S. Amirsadeghi Clarence J. Swanton* L. Lukens
14	2:45-3:00 pm	Problem weed control using Acuron	Karrie Boucher
15	3:00-3:15 pm	Safened Rimsulfuron (Sortan ISTM) tank mix combinations applied pre-emerge and post-emerge for the control of problematic western Canadian weeds in corn	Laura Smith* Rory Degenhardt Len Juras Jamshid Ashigh Kevin Falk Swaroop Kher
		Weed Biology, Ecology and Invasive Species	**Shuswap/Pennask/Skeena (David Clements)**
16	2:15-2:30 pm	Determining light requirements for Bohemian knotweed (*Reynoutria* x *bohemica*) seed germination	Vanessa Jones* David R. Clements
17	2:30-2:45 pm	Determining shade responses of Bohemian knotweed (*Reynoutria* x *bohemica*) seedlings	Virginia Oeggerli* David R. Clements
18	2:45-3:00 pm	Effects of red/far-red light ratio on hybrid knotweed (*Reynoutria* x *bohemica*) seed germination and seedling growth	Delia Anderson* Ryan Critchley Jichul Bae David R. Clements
19	3:00-3:15 pm	The effect of water disturbance on floatation, germination and survival of hybrid knotweed (*Reynoutria* x *bohemica*)	Maria Goncharova* David R. Clements
	3:15-3:30 pm	PM Break	**Shuswap** Foyer
		Weed Biology, Ecology and Invasive Species (continued)	**Shuswap/Pennask/Skeena (David Clements)**
20	3:30-3:45 pm	The twisted tale of the invasive vine,	Andrew McKenzie-Gopsill

		Celastrus orbiculatus, in Prince Edward Island	
21	3:45-4:00 pm	Assessing benthic barriers versus aggressive cutting as effective yellow flag iris (*Iris pseudacorus* L.) control mechanisms	Catherine Tarasoff* K. Streichert W. Gardner B. Heise J. Church T.G. Pypker
22	4:00-4:15 pm	Too much of a good thing – Using water to control the aquatic invasive yellow flag iris	Catherine Tarasoff
23	4:15-4:30 pm	Photoperiodism and glyphosate resistance in common ragweed (*Ambrosia artemisiifolia L.*).	Eric Page* Jichul Bae Martin Laforest Robert Nurse
24	4:30-4:45 pm	A sexual hybrid and autopolyploids in crosses between *Neslia paniculata* and *Camelina sativa* (Brassicacae)	Sara Martin* Tracey James Connie A. Sauder
25	4:45-5:00 pm	Sexual and asexual reproduction in a range-expanding weed: apomixis on trial in Palmer amaranth	Sarah Yakimowski* Hayley Brackridge Nikita Konstantinov
26	5:00-5:15 pm	Revisiting cropping systems studies with an ecological perspective on weed management	Dilshan Benaragama* Steven J. Shirtliffe Christian J. Willenborg
		Horticulture and special crops	**Chilcotin (Jichul Bae)**
27	3:30-3:45 pm	Evaluation of a prototype precision sprayer for Florida plasticulture production	Shaun Sharpe* Nathan Boyd Arnold Schuman
28	3:45-4:00 pm	Weed survey of Nova Scotia wild blueberry fields	Hugh Lyu Scott White* Nancy McLean Andrew McKenzie-Gopsill
29	4:00-4:15 pm	Management of cow wheat (*Melampyrum lineare*) in wild blueberry	Gavin Graham
30	4:15-4:30 pm	Herbicide options for weed management in onions, leeks and carrots grown on high organic soils	Clarence Swanton* Peter Smith Shawn Janse
31	4:30-4:45 pm	Tracking and managing triazine resistant *Chenopodium album* in Atlantic Canadian potato production	Andrew McKenzie-Gopsill* Gavin Graham Martin Laforest

			Sebastian Ibarra Sheldon Hann Cameron Wagg
32	4:45-5:00 pm	Genetic resistance testing unveils single and multiple resistance in horticultural crops	Marie-Josée Simard* Martin Laforest Robert Nurse Eric Page Kristen Obeid David Miville
	6:30 pm	President's Dinner	Off Site
	6:30 pm	Optional Dine Arounds	Meeting in Hotel Conference Lower Foyer

Wednesday, November 20, 2019			
#	**Time**	**Topic/Event**	**Room**
	7:00 – 8:00 am	Local Arrangements Breakfast	Cassiar/Cascade
	7:00 am - 5:00 pm	Registration	**Shuswap** Foyer
	7:00 - 8:00 am	Continental Breakfast	**Shuswap** Foyer
		Plenary Session "New Ways of Thinking about Weed Management"	**Shuswap/Pennask/Skeena**
	8:00-8:10 am	First Nations Welcome	Carol Derickson, Westbank First Nations
	8:10-8:15 am	President's Welcome and LAC Announcements	Rory Degehhardt/David Clements
	8:15-8:20 am	Plenary Introduction	Jichul Bae (chair)
33	8:20-9:00 am	Embracing relational science: What an indigenous worldview offers complicated issues in invasive species management	Jennifer Grenz
34	9:00-9:40 am	The forgotten science of aquatic weed management	James Littley
35	9:40-10:20 am	A deeper look at weeds with deep learning	Dr. Mohsen Mesgaran
	10:20-10:40 am	AM Break	Shuswap Foyer
36	10:40-11:20 am	Keeping biocontrol in the weed management tool box	Dr. Robert Bourchier
37	11:20 am -12:00 pm	Biocontrol Resistance in St. John's Wort – Challenges of invasive	Dr. Catherine Tarasoff* T.G. Pypker

		species management in rangeland ecosystems	K. Donkor Z.C. Guo G. Whitworth
	12:00-1:00 pm	Lunch	**Shuswap** Foyer
		Plenary Session "New Ways of Thinking about Weed Management" continued	**Shuswap/Pennask/Skeena**
38	1:00-1:40 pm	The effect of glyphosate on soil microbial communities: fake news vs. facts	Dr. Timothy Paulitz
39	1:40-2:20 pm	The politics of pesticides	Dennis Prouse
40	2:20-3:00 pm	Connecting, engaging, translating: How to bridge the gap between modern agriculture and consumers	Adrienne Ivey
	3:00-3:15 pm	PM break	**Shuswap** Foyer
		Glyphosate Workshop	**Shuswap/Pennask/Skeena (Charles Geddes)**
	3:15-3:20 pm	Introduction	Charles Geddes
41	3:20-3:40 pm	Options for a life without glyphosate: costs or benefits and efficacy	Eric Johnson* Tom Wolf
42	3:40-4:00 pm	Under pressure: Pre-harvest glyphosate and its impacts on crop yield and quality.	Chris Willenborg* E.N. Johnson T. Zhang N. Ames
43	4:00-4:20 pm	Glyphosate/AMPA residues in field soils and their potential impact on crop productivity	Charles Geddes* Louis Molnar Yantai Gan Cynthia Grant Neil Harker Eric Johnson Ramona Mohr John O'Donovan Greg Semach Robert Blackshaw
44	4:20-4:40 pm	Risk of glyphosate to aquatic and terrestrial ecosystems in Canada	Ryan Prosser
	4:40-5:00 pm	Discussion	
	6:30-7:00 pm	Cocktail Reception	Shuswap Foyer
	7:00-10:00 pm	**CWSS-SCM Awards Banquet**	**Shuswap/Pennask/Skeena**

Thursday, November 21, 2019			
#	**Time**	**Topic/Event**	**Room**
	7:00 – 8:45 am	Breakfast and CWSS-SCM Annual General Meeting	Shuswap/Pennask/Skeena
	8:45 - 9:10 am	Presentation by Brian Beres, editor-in-chief, Canadian Journal of Plant Science	Shuswap/Pennask/Skeena
		Cereals, Oilseeds and Pulses	**Chilcotin (Charles Geddes)**
45	9:15-9:30 am	Progress in forming a wild oat action committee	Eric Johnson Breanne Tidemann Charles Geddes
46	9:30-9:45 am	Update from the North American Kochia Work Group	Charles Geddes* Phil Westra Kelly Bennett Cody Creech Rory Degenhardt Mithila Jugulam Rand Merchant Sarah Morran Olivia Todd Todd Gaines
47	9:45-10:00 am	Glyphosate residue impacts on crop productivity for southern Alberta low-disturbance no-till soils: Farmer directed research	Rob Dunn
48	10:00-10:15 am	Re-cropping of faba bean after residual herbicides	Sid Darras* Eric Johnson Christian Willenborg
49	10:15-10:30 am	Control of perennial and hard-to-kill annual weeds in Canadian cereal crops with a new preformulated mixture of Arylex™ active/Fluroxypyr/Clopyralid	Kevin Falk* Len Juras Rory Degenhardt Laura Smith
50	10:30-10:45 am	A novel herbicide mixture to Safen early applications of 2,4-D to spring cereals	Jamshid Ashigh* Rory Degenhardt Len Juras Laura Smith
51	10:45-11:00 am	Using early maturing crops in rotation to increase the proportion of wild oat available for harvest weed seed control	Breanne Tidemann* Larry Michielsen Patty Reid Elizabeth Sroka

			Jennifer Zuidhof Hiroshi Kubota Rob Gulden Neil Harker Alick Mulenga Greg Semach
52	11:00-11:15 am	Effect of different manure fertilizers on the weed community	Farnaz Kordbacheh* Rob Gulden
		Rangeland, Forestry and Industrial Weed Management	**Cassiar/Cascade (Cameron Carlyle & Lisa Jarrett)**
53	9:15-9:30 am	Effect of non-native plants on rangeland ecosystem goods and services	Cameron Carlyle
54	9:30-9:45 am	Invasive species management in the Thompson Nicola Regional District (TNRD).	Sheryl Wurtz
55	9:45-10:00 am	Is the long-term ecological impact of seeding after wildfire with domestic species justified?	Eleanor Basset* Brian M. Wallace Reg F. Newman
56	10:00-10:15 am	Forage recovery following wildfire in the northern dry mixedgrass prairie.	Brendan Bischoff* Cameron N. Carlyle Eric Lamb Edward W. Bork
57	10:15-10:30 am	Efficacy of four herbicides on wild licorice applied at two growth stages in mixedgrass prairie	Lisa Raatz* Edward Bork
58	10:30-10:45 am	Aerial helicopter application to control hoary alyssum (*Berteroa incana*).	Robson Rogan
59	10:45-11:00 am	Recovery of legumes in northern temperature pastures following the application of broadleaf herbicides	Amanda Miller* Edward W. Bork Linda M. Hall
		Provincial Reports and Regulatory Updates	**Selkirk**
60	9:15-9:30 am	Canadian Food Inspection Agency update: pest plants-when risk becomes reality	Wendy Aspil* Kristina Pauk Bruno Gallant Erin LeClair Christine Villegas
61	9:30-9:45 am	PMRA update	Michael Downs
62	9:45-10:00 am	Nova Scotia update	Angela Gourd
63	10:00-10:15 am	Atlantic Weed Tour 2019	Gavin Graham

64	10:15-10:30 am	Manitoba update	Tammy Jones
	11:00 am-12:00 pm	Commercial Exhibits Takedown	
	12:00-5:30 pm	**CWSS-SCM Board Lunch & Meeting**	**Monashee**

Poster Session

#	Title	Author(s)
65	Artificial Neural Network based sprayer system for site-specific application of agrochemicals	Nazar Hussain Aitazaz Farooque Hassan Afzaal Andrew McKenzie-Gopsill*
66	Build up of glyphosate/AMPA residues in western Canadian field soils	Charles Geddes Louis Molnar* Yantai Gan Cynthia Grant Neil Harker Eric Johnson Ramona Mohr John O'Donovan Greg Semach Robert Blackshaw
67	Can a Sunn hemp (*Crotalaria juncea*) living mulch reduce herbicide usage in sweet corn?	Robert Nurse* Jichul Bae Kerry Bosveld Marie-Josee Simard
68	Carbon stock and plant communities across an elevation gradient of a semiarid grassland: A 58-year follow up.	Alexander Kramer* Maja Krzic Brian Wallace
69	Characterization of dicamba- and fluroxypyr-resistant kochia [*Bassia scoparia* (L.) A.J.Scott] in Alberta	Charles Geddes Mallory Owen* Elise Martin Linda Hall Scott Shirriff Julia Leeson Hugh Beckie
70	Control of annual ryegrass with spring-applied herbicides prior to seeding corn	Nader Soltani* Christy Shropshire Peter H. Sikkema
71	Farmer-directed research on crop productivity impacts of glyphosate residues in southern Alberta low-disturbance no-till soils	Rob Dunn
72	Impact of tillage timing and intensity on weeds under organic management in the Brown Soil Zone.	Julia Leeson* Myriam R. Fernandez Brian McConkey

73	Integration of a blade system into a cage mill for weed seed devitalization	Breanne Tidemann* Hiroshi Kubota Patty Reid Jennifer Zuidhof
74	Large-scale evaluation of off-target movement of Dicamba in North America	Nader Soltani* Maxwel C. Oliveira Guiherme S. Alves Rodrigo Werle Greg Kruger Jason K. Norsworthy Christy Sprague Bryan G. Young Dan Reynolds Peter Sikkema
75	Rapid spread of glyphosate-resistant kochia [*Bassia scoparia* (L.) A.J.Scott] in Manitoba	Charles Geddes Teandra Ostendorf* Robert Gulden Tammy Jones Julia Leeson Shaun Sharpe Scott Shirrif Hugh Beckie
76	Shedding light on the power of plant competition	Nicole Berardi* Clarence Swanton
77	Soil moisture and nutrient impacts on biocontrol of spotted knapweed by seed-feeding weevils *Larinus* spp.	Kayleigh G. Nielson* Rosemarie De Clerck-Floate Jason Pither
78	Update on herbicide resistance genetic testing	Kristen Obeid* Marie-Josée Simard Martin Laforest Robert Nurse Eric Page David Miville

Abstracts

1	**Competing signals: The role of ROS in plant interactions.** Berardi, N., Amirsadeghi S., Swanton C.J. Department of Plant Agriculture, University of Guelph, Guelph, ON N1G 2W1 Changes in light quality induced by the presence of neighbouring weeds is an important mechanism of plant competition. Alteration of the light environment is recognized via changes in the red to far-red light ratio (R/FR), in which a reduction in R/FR is induced by light that is reflected horizontally off neighbouring vegetation. Recognition of a reduced R/FR elicits physiological stress responses within the plant characterized by increased reactive oxygen species (ROS) production and subsequent modification of antioxidant capacity to regulate ROS levels. Previous research suggests that as ROS levels rise, they will elicit a signalling event within the plant causing a distinct set of genes to be up- or down- regulated which is specific to each individual ROS. To further explore the mechanisms surrounding plant competition and ROS signalling, *Arabidopsis thaliana* was studied under two light environments: a high R/FR (weed-free) environment and a low R/FR (weedy) environment. Results indicate that antioxidant status and ROS levels are altered in response to far-red enriched light. The results also suggest that key ROS are involved in the physiological stress response to low R/FR and that signalling events of various ROS may be competing. Further identification of these responses would not only provide important insights into the molecular basis of plant competition, but may also provide support for theories that suggest the competitive nature of ROS signalling.
2	**Mechanisms of weed seed predation and its potential role in weed biocontrol.** Ali, K. Willenborg C., University of Saskatchewan, Saskatoon, SK. Predation is one of the fates that weed seeds could succumb to while on the mother plant, or after they disperse and land on or into the soil. Many field studies have documented that invertebrate seed predators could remove 65-90% of the seed crops produced by weed species each year. Despite these attractive findings, clear answers regarding why and how weed seeds are being eaten remain wanting. To fill in this gap, we adopted a reductionist approach to study weed seed predation ecology at deep and detailed levels. For this purpose, laboratory studies were carried out using different carabid predatory species and three species of brassicaceous weeds as an experimental model system. So far, we were able to produce clear evidence that olfactory receptors drive seed predation interactions in the model system under study. More interestingly, roles of other sensory modalities like taste and vision were found to be minor. We were also able to isolate and identify the exact nature of the chemical cues that drive the interactions. In this regard, chemical information is encoded into an alphabet of fatty acid derivatives (i.e. alkanes, esters, alcohols, ketones, etc.). The three weed species analyzed showed species-specific profiles of volatile chemicals with both qualitative and

	quantitative differences. In essence, long chain alkanes and esters account for the majority of species-specific differences. In other words, the chemical signature that define each weed species is written in a language of alkanes and esters, and those encode the information carabid beetles need to recognize the seed and assess its quality as a food item. This also indicates that seeds are an irreplaceable source of lipids in the carabid diet. Despite the fundamental role of chemistry, mass relationships between the predators and seeds were found to be more decisive with regards to seed choice decisions.
3	**Control of multiple-herbicide-resistant waterhemp (*Amaranthus tuberculatus*) in corn with single- and two-pass weed control programs.** Willemse C.[1], Hooker D.[1], Jhala A.[2], Robinson D.[1], and Sikkema P.[1] [1]Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON; [2]Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE. Multiple-herbicide-resistant (MR) waterhemp is becoming increasingly difficult to control due to the evolution of resistance to herbicide Groups 2, 5, 9 and 14. Field studies were conducted in Ontario in 2018 and 2019 to determine if MR waterhemp can be effectively controlled with 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides applied postemergence (POST), and if two-pass herbicide programs provide greater and more consistent control of MR waterhemp than single-pass programs in corn. The control of MR waterhemp with the HPPD-inhibiting herbicides isoxaflutole, mesotrione, topramezone, tembotrione and tolpyralate with and without the addition of atrazine was evaluated. At 4 WAA, the addition of atrazine to isoxaflutole, mesotrione, topramezone and tembotrione improved MR waterhemp control by 15, 11, 7 and 7%, respectively. Tolpyralate + atrazine applied PRE provided 98% control of MR waterhemp and was not increased by a POST application of glufosinate. Single- and two-pass programs for MR waterhemp control were evaluated in one study by applying isoxaflutole + atrazine, s-metolachlor/mesotrione/bicyclopyrone/atrazine and tolpyralate + atrazine preemergence (PRE), with and without a POST application of glufosinate. A second study by applying s-metolachlor + atrazine, saflufenacil/dimethanamid-p and dicamba/atrazine PRE, with and without mesotrione + atrazine POST. At 4 WAA, isoxaflutole + atrazine and tolpyralate + atrazine, followed by POST applications of glufosinate, increased MR waterhemp control from 90 to 97 and 84 to 96%, respectively. At 8 WAA, s-metolachlor/atrazine and dicamba/atrazine, followed by POST applications of mesotrione + atrazine, increased MR waterhemp control from 95 to 99 and 88 to 99%, respectively. Saflufenacil/dimethanamid-P PRE provided 98% MR waterhemp control and was not increased by a POST application of mesotrione + atrazine. This research identifies effective and consistent single- and two-pass herbicide programs for MR waterhemp in corn in Ontario.
4	**Is there a preconditioning effect of ALS inhibitors and glyphosate on the sensitivity of resistant and sensitive biotypes of *Alopecurus myosuroides* and *Lolium rigidum*?**

	Abakah, S., Belz R. Agroecology Unit, Hohenheim University, Germany. Weeds continue to pose a serious threat to crop yield as they continuously become resistant to herbicides. With *Alopecurus myosuroides* (ALOMY) having already developed resistance to ALS inhibitors and *Lolium rigidum* (LOLRI) to glyphosate, there is a chance that they are preconditioned by sublethal doses in split applications to become more tolerant to a second application. The objective of this study was to investigate the occurrence of preconditioning by ALS inhibitors and glyphosate on the sensitivity of resistant and sensitive biotypes of ALOMY and LOLRI to a second exposure within a quick test. Seeds were pregerminated and cultivated in a greenhouse. Sublethal doses of glyphosate, mesosulfuron+iodosulfuron or pyrosulfuron+florasulam were applied to pre-treat plants prior to a quick test for sensitivity against the same or a different herbicide. Plant root length was measured as the end point and used to model dose-response curves. The quick test was able to detect a preconditioning effect for all herbicides. For example, sensitive LOLRI as preconditioned with 21.73 g a.i/ha of glyphosate showed a decreased sensitivity in the quick test. In contrast, resistant LOLRI biotypes showed an increased sensitivity when preconditioned with either 58.9 g a.i/ha or 451.5 g/ha of glyphosate. Preconditioning of resistant ALOMY with 90 % of the recommended rate of the ALS inhibitors revealed a more complex response. For example, preconditioning with 100 or 5000 g a.i/ha of mesosulfuron+iodosulfuron both increased the sensitivity of the plants in the quick test. This suggests that there is a measurable effect of preconditioning in the quick test, but its outcome seems to be very complex and may depend on several factors like herbicide concentration, time after treatment, and the type of preconditioning herbicide.
5	**Evaluation of acetolactate synthase inhibitors in *Chenopodium album* L. populations in Ontario.** Mo, C.[1], F. Tardif [1], I. Rajcan[1], M. Cowbrough[2] *Department of Plant Agriculture[1], University of Guelph, Guelph, ON, Canada, N1G 2W1* *Government of Ontario, Ontario Ministry of Agriculture, Food and Rural Affairs[2], Guelph, ON, Canada, N1G 4Y2* Common lamb's-quarters (*Chenopodium album* L.) is an annual dicot plant that is highly adaptable and competitive with major global crops. Left uncontrolled, common lamb's-quarters can cause large yield losses in Ontario corn and soybeans. Long seed dormancy and high fecundity make this species persistent and hard to manage. Historical uses of acetolactate synthase (ALS) inhibitors, a group of herbicides that inhibit branched-chain amino acid production, were efficacious in common lamb's-quarters control. However, common lamb's-quarters is documented to be resistant to the sulfonylurea (SU) subclass of ALS inhibitors in Canada. Differential response to the ALS herbicide subgroups were examined in this study. Four different post-emergent ALS inhibitor classes were evaluated against two susceptible and two suspected resistant biotypes of common lamb's-quarters at different biologically active rates. Above ground biomass was collected and dry weight data was analyzed to determine resistance factors. Visual

	injury and survival ratings were collected to determine visual efficacy. Resistant biotypes displayed anywhere from two to 17 fold resistance to the ALS inhibitors used, suggesting cross-resistance between four of the five subclasses of this herbicide group, three more than previously documented. Dose response experiments confirmed resistance to Pinnacle SG (thifensulfuron-methyl) and Pursuit (imazethapyr) in two suspected populations. Thiencarbazone-methyl; a newer molecule, was more effective at controlling common lamb's-quarters populations than historically used ALS inhibitors. Staple LX (pyrithiobac-sodium), currently not registered in Eastern Canada, also displayed control at doses much lower than field rate. Staple LX was the most efficacious herbicide on the suspected resistant biotypes if applied by the two to three pair of true leaf stage of common lamb's-quarters.
6	**Development of management strategies for spreading dogbane (*Apocynum androsaemifolium* L.) in lowbush blueberry fields.** Lyu, H.[1], White, S.[1], McLean. N.[1], McKenzie-Gopsill A.[2]. [1]Department of Plant, Food, and Environmental Sciences, Dalhousie University Faculty of Agriculture, Truro, NS. [2]Charlottetown Research and Development Centre, Agriculture and Agri-Food Canada, Charlottetown, PEI. Lowbush blueberry is an important crop in Nova Scotia and weed management is an ongoing challenge in commercial lowbush blueberry fields. Spreading dogbane is an increasingly common creeping herbaceous perennial weeds in lowbush blueberry fields. Spreading dogbane is problematic in lowbush blueberry as it spreads rapidly and reduces blueberry yield and profits. Field trials were established in 2017 and 2018 to develop management strategies for spreading dogbane in lowbush blueberries. Broadcast application of foramsulfuron and flazasulfuron caused damage and density reduction (47%) in the application year, as well as the year after application (37%). Dicamba was the most effective spot treatment and consistently reduced spreading dogbane shoot density in both the application year and in the year following application. Spot applications of dicamba in tank mixture with foramsulfuron, flazasulfuron or nicosulfuron+ rimsulfuron caused greater stem density reductions in the application year than dicamba applications alone and reduced spreading dogbane stem density by 77-100, 83-90 and 71%, respectively, in the year of application. Stem density reductions were also appeared in the year after application, with dicamba + foramsulfuron and dicamba+ nicosulfuron + rimsulfuron reducing density by 70 and 65%, respectively. Utilizing dicamba as a model symplastic herbicide, applications at the floral bud initiation and flowering stages reduced spreading dogbane shoot density by 77 and 93%, respectively, in the year after application, and were more effective than applications made during vegetative growth or after seed production. Growers should therefore utilize dicamba spot applications at the flowering growth stage for optimum spreading dogbane control in lowbush blueberries.
7	**Influence of adjuvants on the control of glyphosate-resistant Canada fleabane (*Conyza canadensis* L. Cronq.) and waterhemp (*Amaranthus tuberculatus*) in corn with tolpyralate**

	Nicole Langdon[1], Alan J. Raeder[2], Darren E. Robinson[3], David C. Hooker[3], and Peter H. Sikkema[4] [1] Graduate Student, Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada, [2] Herbicide Field Development and Technical Service Representative, ISK Biosciences Inc., Concord, OH, USA, [3] Associate Professors, Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada and [4] Professor, Department of Plant Agriculture, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada Tolpyralate is a new benzoylpyrazole, 4-hydroxyphenyl-pyruvate dioxygenase inhibitor, registered for use in corn, with recommended adjuvants methylated seed oil (MSO) concentrate plus an ammonium nitrogen fertilizer such as UAN. Since 97% of the corn acreage in Eastern Canada is seeded to Roundup Ready® hybrids, the common use pattern for tolpyralate + atrazine will be tankmixed with glyphosate. Two field studies were completed on two problem weeds in Ontario: glyphosate-resistant (GR) Canada fleabane (*Conyza canadensis* L. Cronq.) and waterhemp (*Amaranthus tuberculatus*). The objective of both studies was to determine if an additional adjuvant is required when tolpyralate plus atrazine is tank-mixed with glyphosate. Each study consisted of six field experiments conducted over a two-year period (2018-19) on farms in southwestern Ontario with confirmed multiple-herbicide-resistant populations. At 8 WAA, tolpyralate + atrazine controlled GR Canada fleabane 84% and GR waterhemp 80%; the addition of MSO to tolpyralate + atrazine increased GR Canada fleabane and waterhemp to 96% and 94%, respectively. The addition of glyphosate (900 g ai h^{-1}) improved control of both species 0-5% depending on adjuvant used. This study concludes that maximum control of GR Canada fleabane and waterhemp is achieved when MSO is added to glyphosate + tolpyralate + atrazine.
8	**Multiple modes of selection prove successful in managing Canada fleabane (*Conyza canadensis* (L.) Cronq.).** Ted Vanhie[1], Clarence Swanton[1], Mike Cowbrough[2], François Tardif[1] Department of Plant Agriculture[1], University of Guelph, Guelph, ON, N1G 2W1 Ontario Minister of Agriculture, Food and Rural Affairs[2], Guelph, ON, N1G 4Y2 Developing strategies to control glyphosate-resistant Canada fleabane (*Conyza canadensis* (L.) Cronq.) requires an integrated approach that utilizes multiple modes of selection that exceed the sole use of chemical control methods. Managing herbicide-resistant Canada fleabane is proving difficult as farmers have a limited selection of management strategies available to control this weed. This is especially true for soybean growers, to whom Canada fleabane poses the greatest threat. In fields where this weed is left uncontrolled soybean yields can be decreased over 90%. Research trials were conducted in Delhi, Ontario replicated over the 2018 and 2019 growing seasons to evaluate the efficacy of three modes of selection. These include rye (*Secale cereale* L.) cover crops, shallow tillage and herbicides, in controlling

	Canada fleabane. The results displayed that the rye cover crop as a sole treatment managed to reduce the number of weeds that emerged by 30% and 40% in 2018 and 2019, respectively. Furthermore, rye decreased the biomass of the fleabane's population by 80% and 98% compared to the untreated check, between the two seasons. Shallow tillage managed to decrease the biomass of fleabane by 95% in the first season and 65% the second season. Herbicide treatments showed that only Banvel II in 2018 and Eragon and 2,4-D in 2019 provided over 90% visual control. When the cereal was paired with one other management tactic, either herbicides or tillage, visual control of Canada fleabane exceeded 95% in several cases. The results of this trial are promising, they show new management strategies in which multiple modes of selection work in symphony to improve the efficacy and consistency of control of Canada fleabane. Lastly, this research gives farmers choices in terms of management solutions that best fit their operation and helps diversify the methods used to control this weed to prevent further resistance.
9	**Weed seed biocontrol by Carabids in pulse crops.** Stefanie E. de Heij, Christian J. Willenborg, Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK. Carabid beetles (Coleoptera; Carabidae) are increasingly being labeled as beneficial weed seed consumers in agricultural fields. Certain species have been found to consume large amounts of weed seeds and they are associated with changing weed communities. However, little is known about their usefulness as biocontrol agents in pulse crops, and what factors drive their abundance and feeding habits in the intensive agricultural fields of Saskatchewan. We performed a two year (2017 & 2018) field survey that quantified the seed feeding invertebrates and seed consumption in pulse crops. The survey was conducted in a total of 24 large commercial fields of four different crop types: lentil, pea, soy, and faba. These four crops were chosen for their similar place in cropping rotations but differences in crop architecture. Differences in crop architecture can create variable canopy micro habitats, which can in turn affect ground crawling insect communities and carabid feeding behavior. Surprisingly we found large differences in the carabid beetle abundance, community structure, and weed seed consumption in different fields, even when planted with the same crop. While we found clear correlations between weed seed consumption and carabid abundance in some fields, no such relationships existed in other fields. Interestingly, overall pea fields supported the highest carabid abundance while seed consumption was highest in lentil fields. We will address how crop type, cropping history, and soil type seems to influence carabid abundance, community, and seed consumption. Furthermore, we will conclude by addressing the potential role of the larger community of animals in crop fields and agronomic practices on the biocontrol potential of carabid beetles.
10	**Glyphosate-resistant Canada fleabane (*Conyza canadensis* (L.) Cronq.) and giant ragweed (*Ambrosia trifida* L.) control in winter wheat with halauxifen-methyl applied POST.** Quinn J[1], Ashigh J[2], Hooker D.C.[1], Robinson D.E.[1], Sikkema P.H.[1] [1]Department of

	Plant Agriculture, University of Guelph, Ridgetown, ON; [2]Corteva Agriscience, London, ON Canada fleabane is a competitive summer or winter annual weed that produces up to 230,000 small seeds per plant that are capable of travelling more than 500 km via wind. Giant ragweed is a tall, highly competitive summer annual weed. Populations of glyphosate-resistant (GR) Canada fleabane and GR giant ragweed can be found in the United States and southwestern Ontario, Canada, posing significant challenges for wheat producers. Halauxifen-methyl is a new, selective, broadleaf, postemergence herbicide for use as a in cereal crops; there is limited information on its efficacy on GR Canada fleabane and GR giant ragweed. Two studies, each consisting of 6 field experiments, completed over a two-year period (2018, 2019) were conducted to determine the efficacy of halauxifen-methyl applied postemergence (POST), alone and in a tank-mix, for the control of GR Canada fleabane and GR giant ragweed in wheat across southwestern Ontario at sites with confirmed GR Canada fleabane and GR giant ragweed populations. At 8 weeks after application (WAA), halauxifen-methyl, fluroxypyr/halauxifen, fluroxypyr/halauxifen + MCPA EHE, fluroxypyr + MCPA ester, 2,4-D ester, clopyralid, and pyrasulfotole/bromoxynil + AMS controlled GR Canada fleabane 95, 97, 97, 95, 97, 97 and 98%, respectively. Fluroxypyr and MCPA provided only 86 and 37% control GR Canada fleabane, respectively. At 8 WAA, fluroxypyr, fluroxypyr/halauxifen, fluroxypyr/halauxifen + MCPA EHE, fluroxypyr + MCPA ester, fluroxypyr/halauxifen + MCPA EHE + pyroxsulam, 2,4-D ester, clopyralid, and thifensulfuron/tribenuron + fluroxypyr + MCPA ester controlled GR giant ragweed 87, 88, 90, 94, 96, 96, 98 and 93%, respectively. Halauxifen-methyl and pyroxsulam provided only 45and 28% control of GR giant ragweed, respectively. This study concludes that halauxifen-methyl, applied POST in the spring controls GR Canada fleabane but not GR giant ragweed in winter wheat.
11	**Molecular and biochemical investigation on vacuolar sequestration of glyphosate in glyphosate resistant Canada fleabane (*Conyza canadensis* (L.) Cronq.).** Priester E.[1], Tardif F.[1], Swanton C.[1], Page E.[2] [1]Department of Plant Agriculture, University of Guelph, ON; [2]Agriculture and Agri-Food Canada, Harrow, ON. The last two decades have been marked by a rise in glyphosate-resistant weeds worldwide. One troublesome weed, Canada fleabane, can cause great declines in crop yields and is very difficult to manage when resistant to glyphosate. This resistance has occurred through target site and non-target site resistance (NTSR) mechanisms. While it is generally accepted that resistance in this weed is due to NTSR, other mechanisms are possible. In Ontario, many populations have been documented with a target site EPSPS mutation. There are, however, three copies of EPSPS in Canada fleabane and it is possible that having only one resistant gene out of the three may not be enough to confer resistance. It has been proposed that the main mechanism of resistance would remain vacuolar sequestration in these plants. Glycine is an analog of glyphosate that

	has been shown to act as a competitive inhibitor of glyphosate sequestration. This provides an opportunity to decipher the relative importance of the two resistance mechanisms in Canada fleabane using glycine. The objective of this research was to better understand the resistance mechanisms within Canada fleabane. To do this, a hydroponic system was developed to allow for easy uptake of glycine and glyphosate into plants. The hypothesis was that high levels of shikimate would be found in susceptible Canada fleabane with and without glycine. The resistant Canada fleabane should have higher levels of shikimate in treatments with glycine than without glycine. This would be due to glycine in the vacuole possibly interfering with glyphosate sequestration. Therefore, allowing glyphosate to reach the target site, cause an increase in shikimate accumulation and eventually kill the plant. After completing the hydroponic experiments, the susceptible fleabane had higher levels of shikimate accumulation. However, the resistant plants had lower levels of shikimate accumulation when treated with a glycine/glyphosate solution compared to the plants treated with just glyphosate. These results allow for a better insight into what is happening within the plant at the cellular level and to better understand the biology of Canada fleabane.
12	**Spray drift of XTendiMax dicamba from a commercial sprayer onto non-XTend traited soybeans - a comparison of drift amount, plant symptoms, and yield.** Tom Wolf*[1], Brian Caldwell[1], Chris Willenborg[2], Eric Johnson[2], Said Darras[2], Adam Pfeffer[3], Hubert Landry[4]; [1]Agrimetrix Research & Training, Saskatoon, SK, [2]University of Saskatchewan, Saskatoon, SK, [3]Bayer CropScience, Guelph, ON, [4]PAMI, Humboldt, SK. Spray drift and dose-response studies were conducted to compare the off-target movement of dicamba (XtendiMax). On July 4, 2019, a single spray pass of dicamba (XtendiMax with VaporGrip Technology) was applied to a field of non-dicamba-tolerant soybeans (V3-V4 Stage) at 600 g ae/ha using a John Deere R4045 sprayer emitting an ASABE Medium spray and travelling 27 km/h at a boom height of 50 cm above target. Wind speed averaged 9 km/h, 31 degrees from perpendicular to travel direction. The spray mixture contained 0.25% v/v Rhodamine WT dye so that spray movement could be quantified using fluorimetry. On-swath and downwind deposits were captured using 150 mm diameter petri plates. Spray deposit amounts, soybean symptoms, and grain yields were measured 1, 2, 5, 10, 20, 40, 80, and 160 m downwind. Dose response studies non-dicamba-tolerant soybeans were conducted separately. Eight doses were applied, 1X to 0.000061X, where 1X was 600 g ae/ha. Crop tolerance ratings and seed yields were taken in 2018 and 2019. The log of spray drift deposit amounts varied linearly with the log of distance, as in previous studies. Soybeans exhibited dicamba exposure symptoms at all drift distances. A 20% effect rating was calculated to occur at 80 m downwind, where a rate of approximately 0.0005X was deposited. In the 2018 dose response studies, 20% effects were observed at 0.0003X, whereas yield reductions of >20% occurred at doses of >0.0005X.
13	**Presence of neighbouring weeds alters the response of maize to thiamethoxam.** M.A. House, S. Amirsadeghi, C.J. Swanton, L. Lukens. Department of Plant Agriculture,

	University of Guelph Thiamethoxam (TMX), a neonicotinoid insecticide, in addition to protecting germinating seedlings from herbivorous insects, has non-specific effects on plant growth including increased seedling vigour. Recent studies indicate that environmental stress factors, such as drought and neighbouring weeds, can also alter plant responses to TMX. The molecular mechanisms behind both stable and condition-specific responses to TMX likely involve jasmonic acid, JA, and salicylic acid, SA, biosynthesis and response pathways. We investigated the effect of a TMX seed treatment on global gene expression in maize coleoptiles both under normal conditions and under low red to far-red (R/FR) light stress induced by the presence of neighbouring weeds. In the absence of weeds, TMX does not affect SA biosynthesis but represses SA response genes involved in (a)biotic stress such as fungal and bacterial diseases. In addition, TMX represses genes encoding enzymes involved in the non-jasmonic acid forming pathway as well as the jasmonic acid response pathway, thereby compromising resistance to herbivores. In contrast, the presence of weeds reversed these effects. This weed-mediated alteration in the response of maize to TMX may regulate the balance between the JA- and SA-response pathways. These responses appear to be species-specific and conditional with the type and severity of stress. These findings have significant implications for assessing the non-specific effects of seed treatments in major crop plants that may compromise plant resistance to non-target herbivores and pathogens.
14	**Problem weed control using Acuron.** Boucher, K. Product Development, Syngenta Canada Inc., Plattsville, Ontario. The efficacy of Acuron on problem weeds was assessed in eighteen field trials across Ontario and Quebec in 2018 and 2019. Of these eighteen trials, five were conducted on yellow nutsedge (*Cyperus esculentus*, L.), seven were conducted on glyphosate-tolerant Canada fleabane (*Conyza canadensis*, L), and three trials were conducted on both hairy galinsoga (*Galinsoga quadriradiata*, Cav.) and on glyphosate-tolerant giant ragweed (*Ambrosia trifida*, L.). In each trial, treatments were applied to 3 m by 6 m plots and were replicated four times in a randomized complete block design. Treatments of Acuron were applied post emergence at 1631 g ai/ha and 2026 g ai/ha (in mixture with glyphosate) targeting 8-15 cm yellow nutsedge, 5-20 cm Canada fleabane and 5-10 cm giant ragweed. Without glyphosate, Acuron at the same rates was applied in the hairy galinsoga trials pre-emergence, and at the high rate on 5-10 cm hairy galinsoga post-emergence. Results across trials showed that Acuron at the 2026 g ai/ha rate, controlled 8-15 cm yellow nutsedge at a rate of 88%, 5-10 cm Canada fleabane at over 99% and 10-20 cm Canada fleabane at 97%. Acuron at the rate of 2026 g ai/ha controlled hairy galinsoga at 97% when applied pre-emergence and over 99% when applied post-emergence on 5-10 cm hairy galinsoga. Acuron at 2026 g ai/ha provided 93% control of 5-10 cm giant ragweed. These eighteen trials show that Acuron applied

	pre- and post emergence at the high and low rates control glyphosate-tolerant and problem weeds in various soil and environmental conditions.
15	**Safened Rimsulfuron (Sortan IS™) Combined with Clopyralid (Lontrel™ XC) applied Post-emerge for the Control of Problematic Western Canadian Weeds in Corn.** Smith, L.R, Degenhardt, R.F., Kher, S., Ashigh, J., Falk, K. and Juras, L.T. Corteva Agriscience™, Calgary, AB. Sortan IS, a group 2 herbicide containing the active ingredient rimsulfuron (20% w/w) and the safener isoxadifen-ethyl, provides superior crop tolerance, allowing for application from pre-emergence up to the 5-leaf stage of corn. Small plot research studies were conducted in Manitoba, Saskatchewan and Alberta in 2018 and 2019 to evaluate weed efficacy and crop tolerance of Sortan IS at 7.5 g ai/ha combined with Lontrel XC (Clopyralid 600 g ae/L, Group 4 herbicide) at 100-150 g ae/ha applied on glyphosate-tolerant corn from the 1-3 leaf stage. Sortan IS plus Lontrel XC was applied in combination with either Agral 90 at 0.25% v/v or glyphosate at 900 g ae/ha. Results from these trials determined that applying Sortan IS plus Lontrel XC with either Agral 90 or glyphosate provided control of redroot pigweed (*Amaranthus retroflexus*), glyphosate resistant canola (*Brassica napus*), common lamb's quarter (*Chenopodium album*), wild buckwheat (*Polygonum convolvulus*) and common hempnettle (*Galeopsis tetrahit*) that was commercially acceptable, and either equivalent or superior to levels conferred by the components applied separately. The tank-mix of Sortan IS plus Lontrel XC is a broad- spectrum herbicide combination that, when combined with glyphosate, will provide 3 distinct modes of action for superior control of annual and perennial weeds that are hard to kill in corn with glyphosate alone. ™ Trademark of Dow AgroSciences, DuPont or Pioneer, or their affiliated companies or their respective owners.
16	**Determining light requirements for Bohemian knotweed (*Reynoutria* × *bohemica*) seed germination.** Jones V.L., Clements, D.R. Department of Biology, Trinity Western University, Langley, BC. *Reynoutria × bohemica,* Bohemian knotweed, is a highly invasive plant throughout North America, and is of particular concern along the Pacific Northwest Coast, including on the Lower Mainland of BC. This species is a hybrid of two other invaders of North America and Europe: Japanese knotweed (*Reynoutria japonica*) and Giant knotweed (*Reynoutria sachalanensis*). The resultant hybrid is thought to be able to reproduce both through rhizomes as well as by seed dispersal, meaning that it has retained both means of reproduction from its parent species. Although it has been shown to reproduce through rhizome growth locally, it is not known to what degree the seeds are important in dispersal of Bohemian knotweed. Therefore, the purpose of this study was to determine whether there is a light requirement of Bohemian knotweed seeds for germination, as well as determine the optimal germination conditions. This was

	accomplished by subjecting Bohemian knotweed seeds collected from a site in Abbotsford, BC to 12 different regimens of light and temperature. The results demonstrated that Bohemian knotweed seeds do not have a light requirement, based on >10% germination in full darkness in all four temperature settings. The ideal germination settings for Bohemian knotweed were 14 hours light, 10 hours dark at 24h 20°C, resulting in 96% germination. However, when comparing germination rates across multiple knotweed stands from Surrey, Abbotsford, and Mission, BC, there was significant variance in germination rates among populations, ranging from 5-97%. This makes it difficult to make a generalization about the light requirements of the species as a whole. Future studies could investigate reasons for this difference, such as genetic makeup, physical location of the site, and previous chemical treatments.
17	**Determining shade responses of Bohemian knotweed (*Reynoutria* ×*bohemica*) seedlings** Oeggerli V.V., Clements, D.R. Department of Biology, Trinity Western University, Langley, BC. Restoring disturbed environments requires an understanding of the mechanisms of invasive plants and how they respond to environmental stressors. The mode of distribution along with germination and growth are essential information when determining management strategies. It is unknown if the seedlings of Bohemian knotweed (*Reynoutria* ×*bohemica*) can survive and grow under their parent canopy. Unlike the prominent North American strain of one of its parental species, Japanese knotweed (*R. japonica*), the hybrid species Bohemian knotweed produces many viable seeds. The effect of shade from a large parent canopy of Bohemian knotweed on the survival and growth of its seedlings was determined through measuring plant architecture. Shade responses of Bohemian knotweed seedlings were measured under four varying light intensities: full light, 400 lux, 200 lux and complete darkness. Seedlings within the shaded condition exhibited the greatest vertical growth, attaining an average height of approximately 7.5 cm compared to 5.8 cm in full light. The number of leaves produced varied between trials with the seedlings in full light having six to seven leaves whereas all the shaded seedlings had three to four leaves. Only the seedlings with exposure to full light had substantial leaf growth whereas the seedlings grown under shaded conditions and darkness showed limited leaf growth. Shade clearly has a substantial impact on plant architecture of Bohemian knotweed seedlings suggesting that the shade cast by the parent patch may affect growth and mortality, but seedlings can generally continue to grow through altering their architecture. These results indicate that seedlings are somewhat resilient to adverse conditions such as growing under heavy shade cast by their parent canopy. Thus, it is possible for sexual reproduction to occur within a Bohemian knotweed patch, increasing genetic diversity leading to increasingly resilient patches.
18	**Effects of red/far-red light ratio on hybrid knotweed (*Reynoutria* x *bohemica*) seed germination and seedling growth.** Anderson D.D.[1], Critchley R.[2], Bae J.[2], Clements D.R.[1]

	[1]Department of Biology, Trinity Western University, Langley, BC. [2]Agriculture and Agri-Food Canada, Agassiz, BC. Bohemian knotweed (*Reynoutria x bohemica*) is an invasive hybrid species resulting from the crossing of Japanese (*Reynoutria japonica*) and giant knotweed (*Reynoutria sachalanensis*). The hybridization of the two species allows for increased genetic diversity in *R. bohemica*, making it an aggressive invader. Despite the presence of viable seeds in wild specimens, seedling emergence and establishment of Bohemian knotweed are rarely observed. It was hypothesized that environmental conditions may influence seed germination and seedling growth. In this experiment, red to far-red light ratios (R:FR) of 0.3, 0.6, and 1.0 were utilized to investigate germination and seedling growth under different light quality, ranging from deep shade (R:FR of 0.3) to full sunlight (R:FR of 1.0). Seeds from multiple collection sites throughout the Lower Mainland, British Columbia were used. Germination rates differed among sites ($p < 0.01$). The 0.3 R:FR had lower germination rates than both higher ratios ($p < 0.01$). The 0.6 and 1.0 R:FR produced mean germination of 61.33% and 60.83% respectively, while the 0.3 ratio resulted in 50% germination success. As a seedling vigor parameter, chlorophyll contents measured by a SPAD meter were not different among sites. However, chlorophyll levels were lower at the 0.3 ratio ($p = 0.0327$) than the higher ratios. No significant difference in biomass was found between sites or ratios. Leaf number was lower in the 0.3 R:FR than the 1.0 ratio ($p = 0.0447$). Seedling height was not reduced by lower R:FR ratios; however, significant difference was found between sites ($p = 0.0002$). This study suggests that the presence of a canopy may reduce the number of successful germinants of *R. bohemica* but would not inhibit seedling emergence. This data could help explain the lack of seedlings found in proximity to established stands of Bohemian knotweed.
19	**The effect of water disturbance on floatation, germination and survival of hybrid knotweed (*Reynoutria ×bohemica*).** Goncharova M., Clements D.R. Department of Biology, Trinity Western University, Langley, BC. *Reynoutria ×bohemica,* Bohemian knotweed, is among the most economically and environmentally damaging invasive species in British Columbia. It is a hybrid product of *R. japonica* and *R. sachalinensis*. *R. japonica* is listed among the top 100 of the world's worst invasive species by the International Union for the Conservation of Nature (IUCN). Bohemian knotweed is frequently observed near riverbanks which suggests that knotweed can disperse through water. We studied the influence of water disturbance on Bohemian knotweed seed germination and seedling growth. Bohemian knotweed seeds from 5 different sites in the Fraser Valley were subjected to no, low and high-water disturbance conditions and their germination rates, growth and survival were analyzed. The low and high levels of water disturbance were created by immersing the seeds in water dishes placed on a standard laboratory rocker set at low and high speeds. Results demonstrated no relationship of germination rate to water disturbance

	($P > 0.05$). Although % germination varied greatly by site, knotweed seeds germinated readily when immersed in water, with germination rates exceeding 80% at the highest average viability site. Seedlings growing under higher water disturbance conditions tended to become more elongated ($P < 0.05$) but devoted less energy to leaf growth. The average seedling life span was reduced with greater disturbance, ranging from 42 days for high disturbance to 52 days for still water ($P < 0.05$). It is apparent that increasing levels of water disturbance induces stress on the developing plants, which decreases survival.
20	**The twisted tale of the invasive vine, *Celastrus orbiculatus*, in Prince Edward Island** McKenzie-Gopsill A.G.[1]. [1]Agriculture and Agri-Food Canada, Charlottetown, PE Oriental bittersweet (*Celastrus orbiculatus* Thunb.) is an aggressive invasive vine native to eastern Asia that twines itself around surrounding vegetation. Oriental bittersweet is highly plastic and found across diverse ecosystems from pasture and field margins to forests and sand dunes. Rapidly forming dense monocultures, oriental bittersweet can smother, girdle and kill native vegetation. Prior to 2017, it was believed oriental bittersweet had a limited distribution in Prince Edward Island (PEI) and was concentrated in the Three Rivers area of eastern PEI. In addition, limited studies have investigated possible management options for this species. Therefore, a study was initiated in 2018 to survey the distribution of oriental bittersweet in PEI, and develop management options suitable for use across the diverse habitats oriental bittersweet invades. Survey results indicated oriental bittersweet has a much greater distribution than anticipated and can be found across PEI. Field experiments established in 2018 and repeated in 2019 at four locations in eastern PEI evaluated control options and herbicide application timing. Treatments included weekly mowing, mowing + tarping, and spot applications of glyphosate (0.67%), glyphosate (1.34%) or triclopyr (3%) applied in mid-July or in mid-October. Results to date indicate, all treatments except glyphosate (0.67% or 1.34%) applied in July provided excellent control of oriental bittersweet 1 year after application. Further evaluation in 2020 will help in determining effective control options for this highly aggressive invasive vine in PEI.
21	**Assessing benthic barriers versus aggressive cutting as effective yellow flag iris (*Iris pseudacorus* L.) control mechanisms.** Tarasoff C.S.[1], Streichert K.[2], Gardner W.[2], Heise B.[2], Church J.[2], Pypker T.G.[2] [1]Agrowest Consulting Scientists, Kamloops, BC; [2]Thompson Rivers University, Kamloops, BC A comparison of mortality of the invasive aquatic emergent plant, yellow flag iris (*Iris pseudacorus* L.) using rubber benthic barriers versus aggressive cutting was studied. Treatments were compared against a control at two locations, Dutch Lake and Vaseux Lake (n=4 and n=5, respectively) within British Columbia, Canada. Yellow flag iris response was significantly different between the two sites, but biologically the results were identical: the benthic barrier killed yellow flag iris rhizomes within 70 days of treatment. Over the extent of the research, at Vaseux Lake the effect of aggressive

	cutting was no different from the control, while aggressive cutting was statistically no different than the benthic barrier at Dutch Lake. Approximately 200 days after the benthic barriers were removed, treatments were assessed for vegetation regrowth and no regrowth was recorded for areas treated with benthic barriers. These results indicate that rubber benthic barriers may be an effective treatment for yellow flag iris and maybe suitable for other, similar species.
22	**Too much of a good thing - Using water to control the aquatic invasive yellow flag iris (*Iris pseudacorus* L.).** Tarasoff C.S.[1] [1]Agrowest Consulting Scientists, Kamloops, BC A comparison of mortality of the invasive aquatic emergent plant, yellow flag iris (*Iris pseudacorus* L.) using various level of water was studied. September, 2017 at Cheam Lake Wetlands (Chilliwack, BC) water levels were lowered by 40 cm by adjusting an outflow box. Once water levels were dropped, yellow flag iris populations (n=41) where the rhizome base was permanently below water were cut to ground level. Following treatment, the outflow box was closed and Cheam Lake refilled to previous levels. Water levels at treatment locations ranged from 5 cm to 100 cm above the cut stems. May, 2018 all sites were visited and assessed for regrowth of cut stems. Results were 54% of the treated populations had zero regrowth; 78% of the sites had less than 30% regrowth, and 4% of the sites had greater than 60% regrowth. There was no relationship between water depth and plant regrowth. A greenhouse experiment was initiated to accurately control water depth and timing of treatment. Water depth treatments were 5, 10, 15, 20, and 25 cm versus a control (no water). Rhizomes were assessed for mortality 30, 70, 110 and 200 days after treatment. While there was a significant relationship between days after treatment and rhizome mortality, there was no relationship between water depth and mortality. As little as 5 cm of water above the cut stem base was enough to prevent regrowth of yellow flag iris. At 200 days after treatment, rhizome mortality was approximately 80%, versus 10% for the control plants. These results indicate that water barriers can be used as an effective yellow flag iris control technique where water levels are stable and remain at least 5 cm above rhizome populations.
23	**Photoperiodism and glyphosate resistance in common ragweed (*Ambrosia artemisiifolia L.*).** Page, E.R.[1], Nurse, R.E.[1], Laforest, M.[2], Bae, J.[3] [1] Agriculture and Agri-Food Canada (AAFC), Harrow, [2] AAFC St. Jean, QC, [3]AAFC Agassiz, BC. The photoperiodic sensitivity of common ragweed is well known. In 1945, Allard reported on the acceleration of flowering in common ragweed as day length declined during autumn conditions. Glyphosate resistant common ragweed was first documented in Canada in 2012 and it was observed that the resistant biotype has displayed a phenotype that could be characterized as short statured and accelerated flowering. The objective of this research was to test whether this phenotype was associated or linked to the glyphosate resistance. Near isogenic lines were created by backcrossing the parental resistant biotype with a known susceptible such that four

	resistant generation were created (i.e., F1, R_{BC1}, R_{BC2}, R_{BC3}). Seedlings of these four generation and their parental biotypes were grown in two contrasting light environments to test their photoperiodic response: i) 12hrs, and ii) 12+2hrs, where the photoperiod was extended with deep red LEDs. Results of this study confirmed that the parental resistant biotype displays reduced photoperiodic control of flowering and that this phenotype is conferred to the progeny but is reduced with each successive backcross generation. Similarly, the short statured phenotype associated with the parental resistant was apparent in early backcross generations but by the R_{BC3} generation, progeny were of similar stature to the parental susceptible. These results indicate that the short-statured, accelerated flowering phenotype is associated with the parental resistant biotype but it is not linked to the glyphosate resistant trait. It is hypothesized that the phenotype presented by the background genetics of the parental resistant individual(s) may play an important role in selection, thereby directly influencing the probability that the resistance trait is carried forward in future generations.
24	**A sexual hybrid and autopolyploids in crosses between *Neslia paniculata* and *Camelina sativa* (Brassicaceae)**. Sara Martin, Tracey James, Connie A. Sauder It is important to understand the probability of hybridization and potential for introgression of transgenic crop alleles into wild populations as part of pre-release risk assessment. Here we completed bidirectional crosses between the emerging crop, camelina (*Camelina sativa*) and its weedy relative ball mustard (*Neslia paniculata*). Ball mustard is a self-compatible annual that produces hard ball-like seeds similar to canola seed in size and shape. A total of 1,593 crosses were completed and collected with camelina as the maternal parent, while 3,253 crosses were successfully collected in the reverse direction. Putatively hybrid seedlings were screened with flow cytometry and a species specific ITS markers. Three plants had DNA contents close to expectations for hybrids, but only one of these, formed on camelina, had the expected ITS makers. This hybrid exhibited low fertility and neither self-pollination nor backcrossing produced viable progeny. The other two plants, formed on ball mustard, had high pollen and seed fertility and were identified as ball mustard neoautotetraploids. Therefore, the hybridization rate between camelina and ball mustard is relatively low at 1 in 20,000 ovules pollinated when camelina is the maternal parent. However, autotetraploids may form frequently in ball mustard and tetraploid populations may exist.
25	**Sexual and asexual reproduction in a range-expanding weed: apomixis on trial in Palmer Amaranth (*Amaranthus palmeri*).** [1]Sarah Yakimowski, [1, 2]Hayley Brackenridge and [1,2]Nikita Konstantinov**.** [1]Queen's University, [2]University of Guelph Many plants combine sexual and asexual reproduction: sexual reproduction creates novel genetic combinations, whereas asexual reproduction 'locks in' genetic combinations. The range-expanding, multi-herbicide resistant crop weed Palmer Amaranth (*Amaranthus palmeri*) reproduces sexually with separate female and male

	plants (dioecy). It has also been proposed to be capable of reproducing asexually, via the production of autogamous apomictic seed. If this weed combines sexual and asexual reproduction it raises the question – *is asexual reproduction playing a role in the rapid spread of this herbicide-resistant weed*? To address this we investigated: (1) How variable is autogamous apomixis across populations in eastern North America? (2) Is there evidence of higher propensity for apomixis in more northern populations? We studied 23 populations of Palmer Amaranth from Georgia, North Carolina and Illinois. We conducted an isolation experiment under greenhouse conditions to determine whether females (*n*=333 bags, mean= 2.03 bags/female) are capable of seed set when isolated, by greenhouse and bagging, from males. Overall, seed production per inflorescence in isolation ranged from zero to 233 (mean=16.4). Seed production in isolation was observed in 20-71% of individuals from each population. However, 47% of these individuals produced ≤3 seeds. Moreover, latitude did not have a significant effect on whether inflorescences produced seed (*t*=-0.4, *P*=0.7), total seed production (*t*=0.3, *P*=0.7) or seed production/cm inflorescence (*t*=0.007, *P*=1). This study has given rise to flow cytometric investigation of putative 'spontaneous' seeds produced, to verify whether seeds are of sexual origin, and whether populations contain variation in ploidy, which usually plays a role in the occurrence of apomixis. Overall, this isolation experiment casts doubt on the hypotheses that Palmer Amaranth plants, known to produce 100s-of-thousands of seeds per plant, commonly produce a substantial number of seed through autogamous apomixis, and that apomixis has played a role in the species' rapid range expansion.
26	**Revisiting cropping systems studies with an ecological perspective on weed management** Benaragama, D., Shirtliffe, S.J., and Willenborg, C.J. Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK. Cropping systems experiments are considered vital to devise sustainable strategies to overcome many challenges in weed management. A plethora of cropping systems studies have been carried out to develop weed management solutions for a specified weed problem, or for general weed management. Even though these studies were indispensable to develop weed management strategies, they have common limitations. Our talk will review common approaches in cropping systems studies and identify their drawbacks and formulate a common strategy to conduct cropping systems experiments with an ecological framework. Inability to produce generalized conclusions, lack of procedures to understand the mechanisms of weed suppression due to diverse cropping systems, lack of use of proper statistical procedures to understand the weed dynamics and inability to predict weed dynamics are the key limitations. We propose an ecological framework to design and understand cropping systems experiments for weed management perspective which will enable to mitigate limitations identified. We propose a framework that focuses on 1. defining cropping systems ecologically rather than agronomically, 2. using a dynamic approach for data analysis to capture ecological

	attributes and 3. understanding the effect of cropping systems on weed functional traits. In short, our approach defines cropping systems using resource gradients and disturbance gradients in order to better understand the diversity of cropping systems and to design effective cropping systems. Furthermore, we advocate for a statistical approach to understand the temporal dynamics to realize both stochastic and deterministic processes of weed community assembly. Finally, we believe the use of weed functional traits and its diversity over weed density and species diversity will allow us to better understand and predict weed dynamics. Such a shift in the design and analysis of cropping systems studies will improve our understanding of how cropping systems produce better weed management.
27	**Evaluation of a prototype precision sprayer for Florida plasticulture production.** Sharpe, S.M.[1], Boyd, N.S.[2], Schumann, A.W.[3] [1]Saskatchewan Research and Development Centre, Agriculture and Agri-Food Canada, Saskatoon, SK, [2]Gulf Coast Research and Education Center, University of Florida, Balm, FL, [3]Citrus Research and Education Center, University of Florida, Lake Alfred, FL. Carolina geranium (*Geranium carolinianum*) is a troublesome weed in Florida strawberry plasticulture. It emerges from the planting holes to compete with the crop and reduce harvest efficiency. Clopyralid is a viable herbicide for suppressing Carolina geranium but adoption is limited due to producer concerns of crop tolerance. Reduced applications to nontarget vegetation may ease producer concerns, increase adoption, and provide suppression of Carolina geranium. A prototype sprayer for applying herbicides atop the bed in plasticulture production has been developed. The sprayer's machine vision component consists of a digital camera and a convolutional neural network hosted on an onboard computer. The convolutional neural network was Single Shot Multibox Detector. The experimental design was a randomized complete block with three treatments: untreated, clopyralid application using precision technology, and clopyralid application using conventional technology. The timing for herbicide application was according to industry practices, approximately mid-January. For the prototype precision sprayer, the precision was 0.37, the recall was 0.78, and the Fscore was 0.50. Plots were heavily infested with purple nutsedge (*Cyperus rotundus* L.), which was notably absent in the neural network training dataset and led to a high number of false positives. The precision sprayer did reduce the volume of herbicide applied by 50% (±8% SE) compared to a conventional application. By 30 days after treatment, damage induced by conventional application was 65% while the precision spray only induced 18% damage. This was likely a consequence of missed plants, crop shielding, application timing, and plant growth stage. Direction for future development includes network desensitization or expansion for other weeds in strawberry production and applying clopyralid earlier in the growing season, when both the weed and crop are smaller.
28	**Weed survey of Nova Scotia wild blueberry (*Vaccinium angustifolium* Ait) fields.** Lyu, H.[1], White, S.N.[1], McLean, N.[1], and McKenzie-Gopsill, A.[2] [1]Department of Plant, Food, and Environmental Sciences, Dalhousie University Faculty of Agriculture, Truro, NS;

	[2]Agriculture and Agri-Food Canada (AAFC), Charlottetown, PEI. Weed surveys provide the basis for weed management research in wild blueberry, but have not been conducted in this crop since 2001. Since then there have been documented declines in herbicide efficacy, loss and/or acquisition of herbicide active ingredients, confirmation of herbicide-resistant biotypes of important weed species, and documented vectoring of weed seeds by machinery. A weed survey was therefore initiated in 2017 to assess potential changes in the weed flora of wild blueberry fields in Nova Scotia. A total of 165 bearing year (fruiting) wild blueberry fields were surveyed from 2017 to 2019, within which approximately 211 weed species were identified. Most weed species were herbaceous perennial forbs (89 species) and woody perennials (50 species), followed by annual broadleaf (24 species) and perennial grass weeds (20 species). The remaining flora consisted of a range of ferns, biennials, sedges and rushes, and orchids. The most common weed species were red sorrel (*Rumex acetosella* L.), poverty oatgrass (*Danthonia spicata* L.), haircap moss (*Polytrichum commune* Hedw.), hair fescue (*Festuca filiformis* Pourr.), narrow-leaved goldenrod (*Euthamia graminifolia* (L) Nutt.), tickle grass (*Agrostis hyemalis* (Walter) BSP.), wooly panicum (*Dichanthelium acuminatum* Ell.), cow wheat (*Melampyrum lineare* Desr.), bunchberry (*Cornus canadensis* L.), and yellow hawkweed (*Hieracium caespitosum* Dumort). When compared to previous weed surveys, increased occurrence of these weed species is likely the result of documented or observed reductions in hexazinone and terbacil efficacy, confirmation of triazine-resistant biotypes, and common occurrence of seeds of these weed species on machinery. Low crop prices have also caused reduced pronamide use, contributing to increased occurrence of hair fescue. Results are guiding future research priorities for weed management in wild blueberry.
29	**Management of cow wheat (*Melampyrum lineare*) in wild blueberry.** Graham, G.L. New Brunswick Department of Agriculture, Aquaculture and Fisheries (NBDAAF), Fredericton, NB Cow wheat (*Melampyrum lineare*) is a small, branching annual weed in wild blueberry production. Plants grow within the blueberry canopy and can be directly competitive with the wild blueberry crop, cause harvesting issues and act as a hemiparasite of wild blueberry. In the spring of 2018, a trial was established near Drisdelle, New Brunswick in a wild blueberry field entering the vegetative (sprout) phase of production. The trial evaluated applications of mesotrione and foramsulfuron over different application timings (early sprout year, late sprout year and crop year) and multiple herbicides to control cow wheat. Sprout year applications of mesotrione provided a high level of cow wheat control in the season of application. The level of control declined in the following crop year as new cow wheat seedlings germinated. Similarly, foramsulfuron suppressed cow wheat in the sprout year with a similar decline in control for the crop year. Cow wheat germination in the crop year was variable but significant for all sprout year only herbicide treatments. There was no increase in weed control following tank mixes or

	repeated applications within the sprout year and no improvement in control for the following crop year. Mesotrione applied before blueberry bloom provided excellent crop year control. To control cow wheat for the full crop cycle, growers would require herbicide application in the both the sprout and crop year.
30	**Herbicide options for weed management in onions, leeks and carrots grown on high organic soils**. C.J. Swanton, P. Smith, S. Janse, University of Guelph, Guelph, ON. Commercially acceptable weed management in onions, leeks and carrots grown on high organic soils is challenged by: a limited number of registered herbicides, evolution of herbicide resistant weed species, the seasonal emergence pattern of the extant weed community and the need for herbicide selectivity at the early stages of crop seedling development. As a result of these challenges, field studies were conducted in 2018 and 2019 to explore the potential for new herbicides and alternative use patterns. The biologically effective rates of oxyfluorfen, acifluorfen and pyroxasulfone applied POST for control of linuron resistant pigweed were found to be selective on carrots at the cotyledon stage of crop development. Pyridate at 450 and 900 g ai ha-1was safe on carrots when applied POST at the 6 to 7 leaf stage. Pyroxasulfone applied POST at rates of 149 to 298 g ai ha-1 was selective on both onions and leeks. In addition, a formulation of pyroxasulfone + flumioxazin applied POST at rates of 80, 160 and 266 g ai ha-1 resulted in excellent crop selectivity and weed control in onions. These herbicides can be used to develop an effective weed management strategy for specific vegetables grown on high organic soils.
31	**Tracking and managing triazine resistant *Chenopodium album* in Atlantic Canadian potato production.** McKenzie-Gopsill A[1]*, Graham G[2], Laforest M[3], Ibarra S[4], Hann S[5], Wagg C[5]**.** [1]Agriculture and Agri-Food Canada (AAFC), Charlottetown PE; [2]New Brunswick Department of Agriculture, Aquaculture and Fisheries, Fredericton NB; [3]AAFC, Saint-Jean-sur-Richelieu, QC; [4]Prince Edward Island Department of Agriculture and Land; [5]AAFC, Fredericton, NB Management of herbicide resistant weeds is one of the largest challenges facing agriculture today. The potato rotation in Prince Edward Island (PEI) and New Brunswick (NB) depends heavily on a single herbicide mode of action, metribuzin, a group 5 triazine herbicide. Despite resistance documented since the 1970s, only recently producers across PEI have begun to report reduced efficacy of metribuzin on lamb's quarters (*Chenopodium album* L.). To evaluate the current situation across PEI and NB, lamb's quarters populations were collected from across the potato producing regions of each province and subjected to resistance testing. Molecular markers and dose response bioassays confirmed metribuzin resistance in 46% of populations surveyed. In 2018, a field experiment was established in PEI and NB to evaluate herbicide options in potato from diverse modes of action. A variety of treatments provided > 90% reduction in biomass of *C. album* and other weeds. Potato marketable yield was significantly higher in all treatments evaluated compared to the weedy check. Additional studies on

	cultural, biological and mechanical weed management options for potato producers are ongoing. To date, these results suggest potato producers have several viable options for management of triazine resistant weed species in the Atlantic Canadian potato rotation.
32	**Genetic resistance testing unveils single and multiple resistance in horticultural crops.** Marie-Josée Simard[1], Martin Laforest[1], Robert Nurse[1], Eric Page[1], Kristen Obeid[2], David Miville[3]. [1]Agriculture and Agri-Food Canada [2]OMAFRA [3]MAPAQ Herbicide resistant populations must be detected and managed rapidly in high value crops such as carrots, grapes, onions and tomatoes where fewer herbicide options are available. Diagnostic tests based on molecular makers offer rapid results compared to conventional greenhouse evaluations. To develop and trial these tests, herbicide resistant weed biotypes were surveyed in horticultural crops in Québec and Ontario. Since 2016 a total of 76 potential cases of herbicide resistance have been reported in these crops and a total of 16 genetic tests have been successfully developed so far (five additional tests are in progress). Surveys revealed the presence of biotypes with non-target site linuron resistance in common ragweed (*Ambrosia artemisiifolia*) and target gene duplication in large crabgrass (*Digitaria sanguinalis*) resistant to ACCase-inhibitor herbicides. In 2019, the genetic tests detected multiple resistant biotypes (ALS + Photosystem II inhibitors) in three tomato fields. As agronomists and growers get used to sending leaf samples, species identification, false negatives and sample size issues (since single plant testing is possible) are more common than with conventional dose response diagnostics. To alleviate these risks, genetic tests for species identification (two now available) have been used. Genetic tests for metabolic resistances will also be developed but the genetic complexity of their mechanisms requires more in-depth studies.
33	**Embracing relational science: What an indigenous worldview offers complicated issues in invasive species management.** Jennifer Grenz. University of British Columbia, Vancouver, BC. Indigenous perspectives on invasive species are largely unknown. Informed by Western science, the specific impacts of invasive species are often generalized and not well understood. Common approaches to ecological restoration are rooted is the native versus non-native dichotomy which equates native species with evolutionary fitness. Food insecurity is one of the most significant challenges facing Indigenous communities. Traditional foods are nutritionally superior making their availability important. Integration of Indigenous ecological knowledge in land management while increasingly popular, may not provide the full benefit that the application of the Indigenous world view can. Integration may provide snippets of valuable information but is often context specific and does not acknowledge the depth of relationship between Indigenous peoples and their land. The goal of this study is to answer the question, "What does the application an Indigenous worldview to ecological restoration tell us about the

	impacts of invasive species on Indigenous food security and food sovereignty in the context of our changing climate?" Working with Cowichan Tribes on the restoration of their ancient village site, Ye'yumnuts, as well as other traditional knowledge holders, we gathered oral histories, stories, and perspectives pertaining to invasive species and our role in managing the natural environment. The application of Indigenous research methodology to this complicated field of study revealed new insights into species assessment and ecological restoration. The acknowledgement of values and relationality played a vital role in developing a framework to guide land management decisions that reflects an Indigenous worldview, cultural values and allowed us to redefine and reclaim practices that protect food security and sovereignty for generations to come.
34	**The forgotten science of aquatic weed management.** James Littley, Okanagan Basin Water Board, Kelowna, BC. Since 1970, the Okanagan Basin Water Board has been controlling invasive Eurasian water milfoil in Okanagan Lakes. Current control techniques use mechanical removal of root systems in the winter by rototilling the lake bottom while the plant is dormant in water temperatures below 10 degrees C. In the summer, the top 5 feet of the plants are cut and moved to shore by aquatic harvester as a purely aesthetic control technique for the benefit of beach and water users. Harvested plants are transported to local orchards and gardens for use as compost, rich in aquatic nutrients like Nitrogen and Phosphorus. The Okanagan Milfoil Control Program was originally developed by the B.C. Ministry of Environment through experimenting with physical, biological and chemical means over 17 years. The experiments included the use of aquatic herbicides such as 2, 4-D and Diquat, physical bottom barriers, and the breeding and release of native milfoil weevils. In the United States, many areas use newly developed selective herbicides to control milfoil, while banning the use of mechanical removal. In Canada, the release of deleterious substances into water bodies is tightly regulated and aquatic herbicide use has no social licence in the Okanagan. While some of the early experimental milfoil control methods were not feasible, at least one promising technique, ultrasonic irradiation, was never fully developed. This presentation will provide an overview of different aquatic weed control methods, their strengths and limitations, as well as discussing operational aspects of weed management in the Okanagan. It will challenge researchers to explore new opportunities to control a costly and environmentally damaging aquatic weed.
35	**A deeper look at weeds with deep learning.** Mohsen Mesgaran. University of California, Davis. Recent advances in machine vision and sensing technology coupled with the power of high-performance computers have enabled us to both generate and analyze massive amount of data. Data analytic tool such as machine learning has been revolutionary in this rapidly evolving area and particularly holds promise in precision (digital)

	agriculture. Deep learning, a subfield of machine learning, has shown human-level or even outperformed human's eyes in detecting objects and patterns in various image-based problems. In weed research and management deep learning offers a new set of valuable implications from accurate discrimination of weeds from the crop and automated weed identification to examining the seed viability or seed classification. In this presentation, I will provide an overview of deep learning technique and its uses in studying weeds.
36	**Keeping biocontrol in the weed management tool box.** Robert Bourchier. Agriculture and Agri-Food Canada, Lethbridge Research and Development Centre, Lethbridge, AB. Canada has a long history of successful public-good research targeting the suppression of introduced invasive plants with arthropods as biological control agents. Over 80 insect species have been released for the suppression of more than 30 introduced invasive plant species since 1952, including recent notable successes with leafy spurge, diffuse knapweed, purple loosestrife, houndstongue and Dalmatian toadflax. The release and establishment of a biocontrol agent in Canada is the culmination of 10 to 15 years of cooperative work with international consortia that follows a seven-step process to: identify promising agents, conduct host-range testing for safety and impact, release and establish agents, and monitor spread and long-term impact. *Hypena opulenta* is a multivoltine, moth originating in Eastern Europe that was first released in Canada in 2013 for biocontrol of invasive swallow-wort, (also known as dog strangling vine). The insect is now established at early release sites on *Vincetoxicum rossicum* in Ontario and has spread at least 2 km from release locations. This insect will be used as an example to illustrate the seven-step process and the experiments required for establishment of biocontrol agents in Canada. We will also review the current list of invasive plants that are being targeted for biological control in Canada, and the potential new biocontrol agents that are under study.
37	**Biocontrol Resistance in St. John's Wort: Challenges of invasive species management in rangeland ecosystems.** CS Tarasoff[1], TG Pypker[2], K Donkor[2], ZC Guo[2], G Whitworth[2] [1]Agrowest Consulting Scientists [2]Thompson Rivers University Evidence of biocontrol resistance in British Columbia complicates an already challenging management regime. Within British Columbia, range tenures cover 34 million hectares (roughly 1/3 of BC). Because of the vast area, and diversity of ecosystem types, land managers must utilize all tools of integrated pest management in an extensive rather than intensive invasive species management program. Biocontrol is considered an effective management tool for a number of invasive species, including St. John's wort. However, in 2018, biocontrol resistance was discovered at an historical release location (Marsh Creek, release - 1952). Evidence of biocontrol resistance included both biochemical and physical differences between susceptible and resistant plants.

	Resistant plants have significantly higher levels of hyperforin reflected by a drastic reduction in defoliation. Resistant plants are taller, have greater leaf gland density, and larger leaves than their susceptible counterparts within the population. Evidence of emerging biocontrol resistance within British Columbia emphasizes the need for increased funding and resources towards the development of new biocontrol agents.
38	**The effect of glyphosate on soil microbial communities: fake news vs. facts.** Timothy Paulitz. United States Department of Agriculture, Pullman, Washington Glyphosate (Roundup) is a key component of no-till systems throughout the world, especially for wheat in the Pacific Northwest (PNW). It is relatively safe, tightly bound to soil particles, is broken down by microbes, and does not have a long residual in the soil. However, there are concerns about non-target effects, especially on beneficial bacteria and fungi in the soil. With high-throughput sequencing, we can generate tens of thousands of DNA sequences from a single soil sample and identify all the microbes that could never be cultured. To answer the question: how does glyphosate affect soil microbes, we sampled the fields of four long-time no-tillers across the precipitation zones of WA and ID, over two years. At each farm, we sampled wheat fields with a long history of glyphosate use, and adjacent CRP land with no history of use. We planted the soil with wheat in greenhouse experiments. One half of the pots were terminated after one month with glyphosate at field rates, and in the other half, plants were mechanically clipped. We sampled the soil and rhizosphere and extracted DNA. We continued this for 4 cycles of planting, killing and replanting. DNA was sequenced with Illumina MiSeq and bacterial and fungal sequences were identified and communities were analyzed. For bacteria, the location of the field and the cropping system were the primary drivers of community composition. Glyphosate had a very minor role, often only explaining 1-2% of the variation. Only a small percentage of the bacteria showed a differential response to glyphosate (<1%). More were stimulated by glyphosate use than were reduced. This is due to a greenbridge effect, selecting for communities favored by dying roots. Glyphosate has two greater risks than effects on microbes- the greenbridge effect and the risk of developing resistant weeds with widespread glyphosate use.
39	**The politics of pesticides.** Dennis Prouse, CropLife Canada Over the last number of years, the subject of pesticide use in all developed nations has become highly emotional, and thus very political. These controversies are fanned even more by the collapse of traditional media and the rise of social media. This in turn has worked to facilitate the growth of junk science, fanning public fears and making debate around sound science even more difficult. Through this environment, CropLife Canada, the national association for Canada's plant science sector, has been on the front lines working to secure public policy based on sound science, and communicating the industry's message. Dennis Prouse, Vice President Government Affairs of CropLife Canada, will discuss how the politics of pesticides have evolved, what the current hot issues are facing the industry and its stakeholders, and how CropLife Canada is working

	to find success in advocating for its members in a difficult, rapidly changing political climate.
40	**Connecting, engaging, translating: How to bridge the gap between modern agriculture and consumers.** Adrienne Ivey, View From the Ranch Porch. In a highly polarized world, the gap between modern food production and the people making food purchasing decisions is ever widening. From glyphosate to GMOs to beef's environmental footprint – misinformation travels far faster than the less glamorous truth. Fear sells and marketers have no shame in selling a false narrative. Consumers don't know who to trust when it comes to the food they put into their bodies. It is up to agriculture to step forward and create change in how these food conversations are happening. Both farmers and agricultural professionals tend to think and communicate very differently than the general public. While we focus on science, numbers and data – the rest of the world is making decisions based on emotions, gut feelings, and the fear of the unknown. Information is abundant in the web-based world, so how do we fight through the clutter? How do we gain the attention of the public and hold onto their trust? How do we take Agriculture's powerful message and translate it into a story that will change minds and create change? Adrienne Ivey will share her successes as well as her failures in sharing the story of agriculture with the world.
41	**Options for a life without glyphosate: costs or benefits and efficacy.** Johnson, E. N[1]., and Wolf, T. M.[2]. [1]Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK; [2]Agrimetrix Research and Training, Saskatoon, SK. Glyphosate has undergone intense public scrutiny, particularly in the last decade. The International Agency for Research on Cancer (IARC) classified glyphosate as "probably carcinogenic" on humans, despite numerous regulatory agencies refuting this claim. Numerous lawsuits have been initiated in the United States in which plaintiffs claim that glyphosate exposure contributed to their contraction of non-Hodgkin's lymphoma. Although there is no immediate regulatory risk of glyphosate being banned in North America, many grain buyers are prohibiting the use of pre-harvest glyphosate in their contracts (eg. Grain Millers Canada Corporation). Additionally, the number of glyphosate resistant weeds continues to increase world-wide which threatens the sustainability of glyphosate use. Glyphosate can be applied pre-seed, post-emergence, pre-harvest, or post-harvest. The application timing most vulnerable to being eliminated is pre-harvest as it contributes to the highest levels of residues remaining in the harvested product. There are a number of better harvest aids available for crop drydown; however, there are few, if any, practical alternatives for controlling perennial weeds pre-harvest. Post-harvest control of perennial weeds can be effective provided there is sufficient time and environmental conditions are suitable. Post-harvest application is not a consistent option in the more northern areas of the Canadian Prairies. There are a few non-selective (glufosinate, diquat) herbicides that could be used as a pre-seed burnoff treatment; however, they are generally more expensive and

	don't provide the same spectrum of weed control as glyphosate. Other strategies that could be considered are tillage, optical spot spraying, steaming, and glyphosate application during swathing. The potential benefits and limitations of these practices will be discussed. Glyphosate is a powerful tool in Canadian agricultural production with few alternatives existing that are as cost-effective or efficacious. Judicious use of glyphosate is required; however, some sacrifices in use patterns may be required to retain its utility.
42	**Under pressure: Pre-harvest glyphosate and its impacts on crop yield and quality.** Willenborg, C.J., Johnson, E.N., Zhang. T., University of Saskatchewan, Saskatoon, SK; Ames, N., Agriculture and Agri-Food Canada, Winnipeg, MB Applying harvest aid herbicides, such as glyphosate, can dry down crops evenly and quickly, and can help control late-emerging weeds. However, improper application timing may reduce yield and quality, and leave unacceptable herbicide residues in seed, which can cause commercial issues when marketing these crops. Furthermore, increasing public scrutiny towards products such as glyphosate can have impacts on consumer markets. Little published evidence exists regarding pre-harvest glyphosate applications in several crops, yet this information is critical to the industry and to consumer confidence. We have conducted over the past five years studies with pre-harvest glyphosate in both cereal and broadleaf crops across Saskatchewan. These trials examined the timing of glyphosate application, and the impact of agronomic management practices on lentil and oat crop yield, quality, and glyphosate seed residues. Our data indicate that application of glyphosate at seed moisture contents below 30% results in no reductions in crop yield or quality, and significantly limits seed residue content. Almost no reduction in backing and milling quality was observed at the moisture content in oat. In fact, various quality and yield parameters were actually improved by pre-harvest application of glyphosate compared with a swathing treatment. Applications at seed moisture contents in excess of 30% seed moisture can result in undesirable residues, as well as substantial reductions in crop yield. Based on our findings in these two crops, there appears to be limited potential for glyphosate seed residues to exceed North American MRLs for if applications are made at the 30% seed moisture content recommended by the label. However, zero is a very small number and if the consumer demands seed residues not exceed 0 or 0.1, it will be impossible to meet this requirement with a pre-harvest application of glyphosate.
43	**Glyphosate/AMPA residues in field soils and their potential impact on crop productivity.** Geddes, C.M.[1], Molnar, L.J.[1], Gan, Y.[2], Grant, C.A.[3], Harker, K.N.[4], Johnson, E.N.[5,7], Mohr, R.M.[3], O'Donovan, J.T.[4], Semach, G.[6], and Blackshaw, R.E.[1]. [1]Lethbridge Research and Development Centre (RDC), Agriculture and Agri-Food Canada (AAFC), Lethbridge, AB; [2]Swift Current RDC, AAFC, Swift Current, SK; [3]Brandon RDC, AAFC, Brandon, MB; [4]Lacombe RDC, AAFC, Lacombe, AB; [5]Scott Research Farm, AAFC, Scott, SK; [6]Beaverlodge Research Farm, AAFC, Beaverlodge, AB; [7]Present address: Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK.

	Many growers rely on the herbicide glyphosate for pre-emergence weed control in zero- or minimum-tillage production systems, while usage windows exist also post-emergence (glyphosate-resistant crops), pre-harvest, and post-harvest. In the past decade, glyphosate use tripled in the Canadian prairies, raising concerns over the potential accumulation of glyphosate and its main metabolite aminomethylphosphonic acid (AMPA) in field soils and the concomitant impacts on agroecosystem function. Field and greenhouse studies were conducted to determine the impact of glyphosate and AMPA soil residues on crop productivity. Glyphosate soil concentrations required to decrease shoot and root biomass by 20% ranged from 80 to 190, 90 to 350, and 120 to 320 mg kg^{-1} for field pea, canola, and wheat, respectively, while AMPA concentrations required for the same result ranged from 40 to 70, 20 to 30, and 80 to 120 mg kg^{-1}, respectively. These doses convert to estimated glyphosate application rates ranging from 17.6 to 77 kg a.e. ha^{-1}, which are well above current recommendations. Equivalent doses reduced crop biomass to a greater extent in a loamy sand compared with a sandy loam soil. Glyphosate applied pre-plant and post-harvest to the same field plots at rates of 0, 1, 2, 4, and 8 kg a.e. ha^{-1} did not reduce yield of canola, field pea or wheat at five locations across the Canadian prairies after four years; even though glyphosate and AMPA concentrations in field soils had a positive linear response to increased glyphosate application rate. Overall, greater glyphosate and AMPA concentrations in soils as a result of increased glyphosate use are unlikely to impact crop productivity in the Canadian prairies. If a decline in productivity were observed it would likely be caused by elevated AMPA soil residues as a result of very high rates of glyphosate applied to sandy soils multiple times per year.
44	**Risk of glyphosate to aquatic and terrestrial ecosystems in Canada.** R.S. Prosser, University of Guelph, Guelph, ON Glyphosate is the most widely used herbicide in Canada. Glyphosate can be transported via various pathways into natural aquatic and terrestrial ecosystems. Consequently, glyphosate could pose a risk to biota inhabiting these ecosystems, and by extension the ecosystems themselves. This presentation will 1) outline the data that has been used to assess the risk of glyphosate to aquatic and terrestrial ecosystems in Canada, and 2) identify data gaps, that if filled, would allow us to better characterize the risk of glyphosate to Canadian ecosystems.
45	**Progress in forming a wild oat action committee.** Johnson, E. N[1]., Tidemann, B. D.[2], and Geddes, C. M.[3] [1]Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK; [2]Agriculture and Agri-Food Canada, Lacombe, AB. [3]Agriculture and Agri-Food Canada, Lethbridge, AB. The inaugural Wild Oat Action Committee (WOAC) was formed in 1973 as result of concerns with the marketing of grain due to wild oat dockage. The United Grain Growers, a grain handling company, took action in 1972 and donated money towards

	wild oat research. With the cooperation of Agriculture Canada, a seminar was organized and the Wild Oat Action Committee was formed which included Research and Information Sub-committees. Research on seed dormancy, biology, and cultural and chemical control was initiated. Each province formed its own Wild Oat Action Committee, which was responsible for disseminating research information. A logo was developed which depicted wild oat as "The Great Grain Robber" using "Wild Oat Bill" as a mascot. An excellent workbook on wild oat biology and management was developed by the University of Saskatchewan's Extension Division. The committee carried on for about ten years, until the need for it declined due to the introduction of a number of effective herbicides. At the 2017 CWSS-SCM Annual Meeting in Saskatoon, a request was made to the BOD to form a new Wild Oat Action Committee to address the issues that have evolved primarily due to herbicide resistance in wild oat. The request came from Alberta, led by Ken Eshpeter, a producer from Daysland, AB and Dr. Neil Harker from Lacombe, AB. Eric Johnson agreed to spearhead the initiative. An initial meeting was organized in Forestburg, AB on Feb. 7, 2019 by Ken Eshpeter in which 13 people attended, most of which were growers. Eric Johnson and Charles Geddes attended on behalf of CWSS-SCM. A follow-up conference call was held in August which included Ken Eshpeter, Eric Johnson, Charles Geddes, Breanne Tidemann, and Janette McDonald from Edmonton, AB. The results of these meetings and a suggested workplan for the upcoming year will be presented.
46	**Update from the North American Kochia Work Group.** Geddes, C.M.[1], Westra, P.[2], Bennett, K.[3], Creech, C.[4], Degenhardt, R.[3], Jugulam, M.[5], Merchant, R.[6], Morran, S.[2], Todd, O.[2], and Gaines, T.A.[2]. [1]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB; [2]Bioagricultural Sciences & Pest Management, Colorado State University, Fort Collins, CO; [3]Corteva AgriScience; [4]Department of Agronomy and Horticulture, University of Nebraska Lincoln, Scottsbluff, NE; [5]Department of Agronomy, Kansas State University, Manhattan, KS; [6]BASF. Kochia [*Bassia scoparia* (L.) A.J.Scott] is a problematic weed in cropped and non-cropped areas throughout western Canada and the United States. Prolific seed production, a short-lived seedbank, high genetic variability, pollen- and seed-mediated gene flow, phenotypic plasticity, and tolerance to drought, salinity, and cold temperatures make this weed an ideal candidate for the evolution of herbicide resistance. Separate kochia populations have been confirmed resistant to photosystem II inhibitors (Kansas, Idaho and Iowa in 1976; not present in Canada), acetolactate synthase inhibitors (Kansas in 1987; 1988 in Canada), synthetic auxins (Montana in 1994; 2015 in Canada), and glyphosate (Kansas in 2007; 2011 in Canada). Multiple resistance in kochia is present in Canada (three-way resistance) and the United States (four-way resistance), and reports of herbicide resistance in kochia are increasing rapidly. Growers have expressed concern regarding lack of kochia control and the lack of other management tools which are effective for kochia management. The North American Kochia Work Group was established following the initial meetings of the

	Kochia Action Committee at the 2017 Global Herbicide Resistance Challenge Meeting in Denver, CO and the 2018 Western Society of Weed Science Meeting in Garden Grove, CA. The North American Kochia Work Group Executive Committee planned the first in-person meeting of the Kochia Work Group hosted in Denver, CO on October 16-17, 2019. Over forty academic and government researchers, industry representatives, and local farmers attended the meeting, which included forward-thinking presentations and discussion on kochia knowledge-gaps and research priorities. The research priorities were ranked by attendees and targeted research teams were established. The North American Kochia Work Group aims to develop a coordinated research strategy to improve knowledge of kochia biology, ecology and management, awareness of herbicide resistance, and adoption of beneficial management practices of farms in North America.
47	**Glyphosate residue impacts on crop productivity for southern Alberta low-disturbance no-till soils: Farmer directed research.** Dunn, R., FarmWise Inc., Lethbridge, Alberta. Hildebrand, B., Palliser Agricultural Management Society. This three-year study evaluated glyphosate soil residue impacts on crop productivity for low-disturbance no-till soils in southern Alberta. Sites had a long no-till history (>20 years) with low disturbance disk-type planting systems with two in the Dark Brown Soil Zone (Lethbridge, Claresholm) and one in the Brown Soil Zone (Foremost). Glyphosate was applied pre-plant and post-harvest over a 3-year period (2014 to 2016) at 0, 1, 2, 4 and 8 kg ai ha^{-1} in a RCBD with the farmers using their normal cropping systems. Glufosinate + clethodim (.5 + .05 kg ai ha^{-1}) was applied to the “0” control and there was also an untreated control with no pre-plant or post-harvest herbicide (hand weeded). Increasing glyphosate rate reduced crop density and yield at all sites but there were differences by crop type and site-year. Flax and winter wheat plant density and yield declined with increasing glyphosate rate (3 site-years). Spring CWRS wheat, yellow pea and hemp plant density declined with increasing glyphosate rate (2 site-years). Further study at nearby locations on the same farms (2 sites in each of 2015 and 2016) evaluated the effect of glyphosate with or without surface litter. Litter was removed prior to pre-plant glyphosate (8 kg ai ha^{-1} in 2015 and 2 and 8 kg ai ha^{-1} in 2016) in a RCBD with glufosinate + clethodim (.5 + .05 kg ai ha^{-1}) as the “0” control. Glyphosate significantly reduced flax density and yield at both sites (2015), more so when surface litter was left intact. Glyphosate had no effect on pea or lentil in 2016 although surface litter removal increased plant density (both sites) and lentil yield (one site). Further study is needed to understand the mechanism of glyphosate residue impact on crop productivity when used at high rates in low-disturbance no-till systems.
48	**Re-cropping of faba bean after residual herbicides**. Sid Darras*[1], Eric Johnson[1], Christian Willenborg[2]; [1]Research Associate at the University of Saskatchewan, Saskatoon, SK. [2]Associate Professor, Saskatoon, SK. Faba bean (*Vicia faba* L.) is an excellent rotational pulse crop because it fixes

	atmospheric nitrogen and provides for crop diversification of the agroecosystem. However, faba bean is susceptible to the soil residues of some herbicides used in the previous year. In this study, seven herbicides were tested (clopyralid, quinclorac, flucarbazone, bromoxynil + pyrasulfotole, dicamba, metsulfuron, and 2,4 D LV 700 Ester) for their potential residual activity on faba bean. The study was carried out at Kernen and Scott, SK. sites in 2017, 2018, and 2019. The residual herbicides were sprayed 7 to 10 months before planting faba bean. The results showed that most of the herbicides tested had some potential to cause minor transient herbicide injury in faba bean. This was most prevalent under the certain environmental conditions such as low soil moisture, low pH, and soil organic matter content. The residual effects of clopyralid (600 g ai ha^{-1}) caused significant seed yield reduction in faba bean in two site-years, while quinclorac applied at both the 100 and 200 g ai ha^{-1} rates also caused yield reductions in one site-year.
49	**Control of perennial and hard-to-kill annual weeds in Canadian cereal crops with a new preformulated mixture of Arylex™ active/Fluroxypyr/Clopyralid** Falk, K., Juras. L., Degenhardt, R., Smith, L. Corteva Agriscience Canada Inc., Calgary, AB. Corteva Agriscience has developed a new post-emergence wide-spectrum broadleaf weed herbicide containing Arylex™ active (halauxifen-methyl), fluroxypyr and clopyralid. Between 2018 and 2019, the preformulated mixture of Arylex/fluroxypyr/clopyralid was evaluated in small plot field research trials in Western Canada and the Northern United States for control of perennial and hard-to-kill annual weeds in cereal crops. Applications 1X and 2X of the target use rate of 5 g ae/ha Arylex plus 125 g ae/ha fluroxypyr plus 100 g ae/ha clopyralid, with or without a phenoxyacetic acid herbicide tank-mix partner, were safe to spring wheat, durum wheat and spring barley. The Arylex/fluroxypyr/clopyralid premix provided control of a wide range of hard-to-kill annual weeds including kochia (*Bassia scoparia*), false cleavers (*Galium spurium*), redroot pigweed (*Amaranthus retroflexus*), lamb's-quarters (*Chenopodium album*) and wild buckwheat (*Polygonum convolvulus*). It will also control perennial weeds such as Canada thistle (*Cirsium arvense*) and volunteer alfalfa (*Medicago sativa*), and when mixed with a phenoxy herbicide will control volunteer canola *(Brassica napus*) and winter annuals like narrow-leaved hawk's-beard (*Crepis tectorum*). Excellent compatibility was observed between the Arylex/fluroxypyr/clopyralid premix and both Group 1 and Group 2 graminicides. In summary, the Arylex/fluroxypyr/clopyralid premix will provide Western Canadian farmers with a new one-pass solution to control challenging annual, winter annual and perennial broadleaf weeds in wheat and barley crops. ®™ Trademarks of Dow AgroSciences, DuPont or Pioneer, and their affiliated companies or their respective owners.
50	**A novel herbicide mixture to Safen early applications of 2,4-D to spring cereals.** Ashigh, J., Degenhardt, R, Juras, L, Smith, L; Corteva™ Agriscience, Calgary, AB

	Application of 2,4-D in cereal crops prior to the 4 leaf stage of development can cause significant head deformity and reduce yield. Cloquintocet is a safener used primarily to reduce injury caused by Group 1 and Group 2 graminicides to cereal host crops. A three-year study from 2016 to 2018 was conducted in several locations across Western Canada to evaluate the safening effect of mixing 2,4-D with Corteva herbicides containing cloquintocet. The tank-mix of Corteva products containing cloquintocet (i.e. Simplicity™ GoDri herbicide or Rexade™ A herbicide) with either 2,4-D alone, or with a mixture of 2,4-D and fluroxypyr-meptyl (OcTTain™ XL herbicide), mitigated head deformity in spring wheat and durum wheat from early herbicide applications. Results indicate that the tank-mix of 2,4-D with Corteva products containing cloquintocet (i.e. Simplicity GoDri or Rexade A) can be safely applied to spring wheat and durum wheat at the 2-3 leaf stage of development. Results also established the minimum rate of cloquintocet required for effective safening of 2,4-D at early application timings. Our findings widen the application window of certain 2,4-D-containing herbicide mixtures, expanding their utility as effective weed management tools in spring cereals. *™ ® Trademark of Dow AgroSciences, DuPont or Pioneer, and their affiliated companies or their respective owners*.
51	**Using early maturing crops in rotation to increase the proportion of wild oat available for harvest weed seed control.** Tidemann B.D.[1], Michielsen L.[1], Reid P.[1], Sroka E.[1], Zuidhof J.[1], Kubota H.[1], Gulden, R.[2], Harker, K.N.[1], Mulenga A.[3], Semach G.[4] [1]Lacombe Research and Development Centre, Agriculture and Agri-Food Canada, Lacombe, AB. [2]Department of Plant Science, University of Manitoba, Winnipeg, MB. [3]Scott Research Farm, Agriculture and Agri-Food Canada, Scott, SK. [4]Beaverlodge Research Farm, Agriculture and Agri-Food Canada, Beaverlodge, AB. Harvest weed seed control is a novel weed management technique that has been recently adopted throughout much of Australia and there is interest in adoption of the practice in other global areas. One of the factors likely to limit harvest weed seed control adoption in western Canada is the low level of seed retention of wild oat. This study, conducted at 4 locations in the Prairies, examined whether the number of wild oat seeds collectable and targetable with harvest weed seed control can be increased through the use of early maturing crops in rotation. Treatments included 2 years of early, 'normal' and late maturing crop rotations in a factorial with swathed or straight cut treatments. In the third year of the rotation all treatments were seeded to barley to allow for evaluation of wild oat density, biomass, soil seed bank and collectable wild oats in chaff within the same crop. Half of the sites agreed with the hypothesis that wild oat population density would be lowest following harvest weed seed control in early maturing crops, followed by 'normal' maturing crops and late maturing crops. One location showed the lowest population density in the late maturing crops followed by the early and then the 'normal' maturity rotations while the final location showed no

	significant differences. Half of the locations also showed fewer wild oats using harvest weed seed control in combination with swathing, while the other locations had no significant differences. Location specific differences were also measured for wild oat biomass, seed bank and collectable wild oats in chaff. Overall, this study shows that early maturing crops may be useful to increase the proportion of wild oats targetable with harvest weed seed control, however there is still a high level of variability in efficacy of harvest weed seed control on wild oat.
52	**Effect of different manure fertilizers on the weed community.** Kordbacheh F., Gulden R. University of Manitoba, Winnipeg, MB. The response of the weed community to different types of Nitrogen (N) fertilizers is a component of integrated weed management that is not well understood. We investigated the effect of N fertilizer type (synthetic, and manure: liquid pig, solid dairy, and solid pig), and year (2008, 2009, 2011, 2012, and 2019) on the weed community composition and indices of species diversity that was collected in a rotation study initiated in 2007. The abundance, and indices of diversity (species richness, Simpsons diversity, and Simpson's evenness) of the entire weed community were measured in response to different types of fertilization and experimental years. We also divided the weed community into annual and perennial groups and measured the responses of these groups separately to the fertility type and year. Our results indicated that the weed community assembly was influenced by both fertility type and experimental year. The lowest weed abundance and diversity was observed in the synthetic fertilizer and liquid pig manure treatments, both of which had no straw or potential weed seed entry. The greatest weed abundance and species diversity were observed when solid manure fertilizers (solid dairy, solid pig, compost pig manures) were applied. Annual/biennial species declined significantly when the liquid pig and synthetic fertilizers were applied. The decline of annual/biennials was more pronounced in dryer years. Perennial species, became more abundant with the use of solid manures and with passage of time from 2008 to 2019. Our results suggest that the application of N nutrition in the form of liquid pig N could be a useful method for managing the weed community composition in both conventional and organic cropping systems.
53	**Effect of non-native plants on rangeland ecosystem goods and services.** Carlyle, C.N. Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB. Rangelands cover large areas of Western Canada, provide a variety of ecosystem goods and services and are frequently colonized by non-native, invasive plant species. Non-native plants can affect ecosystem goods and services such as the provision of forage for livestock, carbon storage and sequestration, and biodiversity. Trade-offs frequently occur between these ecosystem services, and the presence of a non-native plant may be beneficial to one and not the others. I will review recent research from the Canadian prairies demonstrating that invasion of agronomic species frequently benefits forage

	production, sometimes benefits carbon storage, but rarely benefits biodiversity. The presence of cicer milkvetch (*Astragalus cicer*) reduced plant diversity and carbon storage, while increasing forage quantity and quality. Kentucky bluegrass (*Poa pratensis*) appears to be associated with increased soil organic carbon and forage. And finally, there is a general pattern in which non-native species are found in more productive locations, but with few native species. Consequently, the management of these landscapes, and non-natives plants within them, requires consideration of the multiple uses and benefits we expect from them.
54	**Invasive species management in the Thompson Nicola Regional District (TNRD).** Wurtz, S. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development Valuable progress and learning with great success have been made to manage invasive plant species in the Thompson Nicola Regional District (TNRD) as part of a $2.2-million pilot project that began in 2016. The three-year project has helped support B.C.'s ranching industry, First Nations and rural communities in the region affected by the spread of non-native invasive plants. These species can inhibit the growth of desirable plants and have a negative impact on grazing areas and the health of grassland ecosystems. The awareness of invasive species management continues to increase. The challenge has been balancing increased need from this awareness, without losing sight of protecting the cultural and traditional plants for First Nations and important agricultural areas in BC to name only a few. In response, FLNRORD has quadrupled our invasive plant management budget in the TNRD over the past three years. In addition they have introduced a variety of innovative management techniques and delivery models, including piloting a "good neighbor" approach to protect private landowner investments where invasive plants are being controlled. The presenter will share the changes trialed and results achieved so far, including the important observation about cheatgrass invasion and the overall goal of promoting resilient and healthy ecosystems across Crown lands in BC with a changing climate and multiple landscape uses and perspectives on management. Invasive species management will always have a demand that outweighs our ability to respond, but significant progress has been made within the TNRD over the past few years to develop protocols and programs working towards a balance. This presentation will outline some of the recent changes to TNRD's invasive plant management program, promoting cross-agency collaboration and resource sharing on many of the emerging issues impacting us all.
55	**Is the long-term ecological impact of seeding after wildfire with domestic species justified?** Bassett, E.[1], Wallace, B.M.[2] and Newman, R.F.[2] [1] Range Branch, Forests, Lands and Natural Resource Operations and Rural Development, Williams Lake, BC; [2] Thompson Okanagan Region, Forests, Lands and Natural Resource Operations, Kamloops, BC. High-intensity wildfires completely consume aboveground vegetation and litter in dry

	forests, leaving the area susceptible to introduction and spread of invasive plants. A research trial was initiated following a 2003 fire near Kamloops, British Columbia to test the impact and efficacy of applying a domestic seed mix on an area with high wildfire burn severity. The seed mix contained Italian ryegrass (*Lolium multiflorum* Lam.), creeping red fescue (*Festuca rubra* L.), Canada bluegrass (*Poa compressa* L.), timothy (*Phleum pretense* L.) western wheatgrass (*Pascopyrum smithii* (Rydb.) Á.Löve) and Rambler alfalfa (*Medicago sativa* L.). was applied. The seed mix was applied by helicopter in May of 2004 at a rate of 5 kg ha^{-1} in 50 x 250 m strips, paired with a similar sized unseeded control, replicated in four blocks in a randomized design. Vascular plant and ground cover were estimated in early summer on 50 plots in each strip from 2004 through 2014, with exception of 2011. Dalmatian toadflax (*Linaria genistifolia* (L.) Mill.), Canada thistle (*Cirsium arvense* (L.) Scop.), plumeless thistle (*Carduus acanthoides* L.), and spotted knapweed (*Centaurea biebersteinii* DC) were only found in trace amounts (<1%) in any year of the experiment in both the control and seeded treatments. There was no significant difference in total plant cover between treatments (p=0.06), however the seeded treatment did have greater proportion of grasses (p=0.01) than the control. Seeded species maintained 30-50% vascular cover starting in 2005, with Rambler alfalfa and Canada bluegrass persisting and co-dominating the seeded areas. The seeded areas had significantly less (p=0.04) cover of cheatgrass (*Bromus tectorum* L.) from 2007 to 2010, and was reduced in both treatments in 2012 to 2014. The ecological impact of post-wildfire seeding needs to be investigated further to weigh the short term benefits against negative long-term impacts. Results from this study are crucial in understanding the local impact of post-wildfire broadcast seeding with domestic species.
56	**Forage recovery following wildfire in the northern dry mixedgrass prairie.** Bischoff, B.K., C.N. Carlyle, E. Lamb, E. Bork. University of Alberta, AB. A common management recommendation to ranchers following grassland wildfire is to defer grazing. Deferment allows time for forage recovery through plant regrowth and litter accumulation, but there is a debate on the required length of deferral and whether deferral contributes to the maintenance of rangeland health. Using a paired experimental design, we compared vegetative recovery of burned and adjacent non-burned areas (n=45) along the perimeter of two wildfires that occurred in October 2017 across the Alberta-Saskatchewan border within the Dry Mixedgrass Prairie. To assess recovery we evaluated forage quantity (grasses, forbs, and residual litter), forage quality (crude protein, neutral detergent fibre, and acid detergent fibre), root biomass, plant species composition, and rangeland health over two successive growing seasons. In July of the year following the fire, burned areas had only 51% (540 kg/ha) of the total current annual plant biomass found in non-burned areas. Importantly, litter was nearly absent from burned areas, which, given its importance for soil moisture retention, may be contributing to reduced annual biomass production. Unlike shoot biomass, root biomass in the top 15 cm of soil did not differ between burned and non-burned areas.

	Despite changes in the cover of individual plant species, community composition did not show significant differences with exposure to fire. We are continuing to monitor these locations to examine how private landowner management affects recovery. As the occurrence of prairie wildfire is increasing, this information will provide grazing managers with information to aid in post-fire management decisions.
57	**Efficacy of four herbicides on wild licorice applied at two growth stages in mixedgrass prairie.** Raatz, L.L, and Bork, E.W. Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta. Wild licorice, *Glycyrrhiza lepidota* Pursh., is a perennial legume forb native to Canada and adapted to mesic, sandy, disturbed prairie sites. It is considered an invasive weed in parts of the western USA and spreads prolifically via rhizomes and bur-like seed pods. Cattle generally avoid grazing wild licorice and anecdotal evidence from southern Alberta suggests that wild licorice densities have been increasing in native grassland. In 2017, a field study was conducted at two sites on the Mattheis Research Ranch in southeast Alberta to assess the efficacy of four pasture herbicides (2, 4-D ester; aminopyralid + 2, 4-D DMA salt; dicamba; and metsulfuron-methyl + aminocyclopyrachlor) applied at each of two timings (Spring: 3-4 leaf stage, or Summer: early flower) and compared to untreated controls, including a manual weed removal. Wild licorice density and biomass, as well as grass, forb, and litter biomass, were quantified in 2017, 2018 and 2019. Following spring and summer herbicide applications in 2017, wild licorice densities declined 40 to 99% relative to the untreated control, and biomass was reduced 55 to 100%. Residual herbicide activity from summer applied herbicides kept wild licorice densities 54 to 98% lower than controls through 2019, although reduced wild licorice biomass was only observed at one site in 2018, and neither location in 2019. Summer herbicide applications were more effective at reducing wild licorice density and biomass. Although differences were non-significant, most herbicide treatments tended to have elevated grass biomass relative to the control in 2017, with select treatments 5 to 12% greater in grass biomass compared to the wild licorice hand-removed control.
58	**Aerial helicopter application to control hoary alyssum (*Berteroa incana*).** Robson G. Rogan, Purity Feed Ltd., Kamloops, BC Hoary alyssum *(Berteroa incana)* is an annual to short-lived perennial weed that is designated noxious under the BC *Weed Control Act. The proliferation and rapid distribution of this invasive plant throughout* south-central and southeastern BC including the Okanagan, Cariboo, Boundary, Thompson, and Kootenay areas is of grave concern not only due to the it's competitiveness to native flora but also based on its toxic attributes to grazing livestock and wildlife. This presentation will highlight the successes and herbicide application techniques utilized through aerial application to control Hoary alyssum in the BC interior grasslands.
59	**Recovery of legumes in northern temperature pastures following the application of**

	broadleaf herbicides. Amanda J. Miller, Linda M. Hall and Edward W. Bork. University of Alberta, Edmonton, AB. Beneficial legumes such as alfalfa (*Medicago sativa* L.) and white clover (*Trifolium repens* L.) are important features of northern temperate pastures. These legumes increase pasture productivity and forage quality. Herbicide application for broad leaf weed control removes legumes from these stands. Although prompt re-establishment of legumes in sprayed pastures is a goal of many land managers, little is known about the potential for this to occur following commonly used herbicides. Field and greenhouse trials were conducted to assess the breakdown of soil residues of two broadleaf herbicide bioactives, aminopyralid and aminocyclopyrachlor, as well as associated legume (alfalfa and white clover) re-establishment and pasture sward production dynamics. Greenhouse bioassay trials indicated legume seedling germination and emergence was unaffected 15 months-after-treatment (MAT) with herbicide, while field trials showed a longer time to recovery (24 MAT). Short-term variable dose trials in the field suggest that even small amounts of these herbicides (0.06125x) reduce legume establishment during the current growing season. The two herbicide bioactives were functionally indistinguishable, and the focal legume species had similar responses to herbicide application. Total forage production was unaffected by herbicide application in the field, with net increases in biomass noted over the study. Recovery of common weedy species such as dandelion (*Taraxacum officinale* Weber) was similar to that of legumes.
60	**Canadian Food Inspection Agency update: pest plants-when risk becomes reality.** Wendy Asbil[1], Kristina Pauk[1], Bruno Gallant[1], Erin LeClair[1] and Christine Villegas.[1] [1]Canadian Food Inspection Agency The Canadian Food Inspection Agency (CFIA) is Canada's National Plant Protection Organization. It leads the protection of Canada's agriculture, forestry and natural environment from the introduction, spread and impacts of plant pests. However, invasive alien species are a shared risk and their risk mitigation is a shared responsibility. Active involvement of all levels of government, non-government organizations, stakeholders and citizens is essential to reduce the risk of introduction and spread of invasive plant pests. The CFIA focuses on prevention, early detection and response, pathways and partnerships. An important component of early detection is reporting pest finds in order to plan appropriate responses. With the increase of online trading, possible threats to Canada's plant health from pests, such as invasive plants, have also increased. This presentation will focus on the implications of e-commerce on risk of pest plant introduction, the importance of reporting pest plants, and promoting plant protection work during 2020 – International Year of Plant Health.
61	**PMRA Update.** Downs, M. P. Pest Management Regulatory Agency (PMRA), Ottawa, ON.

	This presentation will provide an overview of the various internet-based means of interacting with Health Canada's Pest Management Regulatory Agency (PMRA), and the options to address the value of a minor use registration. The PMRA has developed a number of webpages to facilitate public involvement, including the Public Engagement Portal, the Public Registry, and the Pest Management Information Service. In terms of the value assessment for minor uses, three approaches have been developed – the 'A' priority approach, the streamlined approach, and the standard approach.
62	**Nova Scotia Update.** Angela Gourd, Nova Scotia Department of Agriculture, Truro, NS.
63	**Atlantic Weed Tour 2019.** Graham, G.L. New Brunswick Department of Agriculture, Aquaculture and Fisheries (NBDAAF), Fredericton, NB The Atlantic Weed Science Network is an informal group interested in increasing knowledge transfer about weed management in Newfoundland and Labrador, Nova Scotia, Prince Edward Island and New Brunswick. The annual Atlantic Weed Tour was hosted by New Brunswick on August 1, 2019. Twenty-two individuals from provincial government, federal government, and industry joined the tour with representation from all provinces in the region. The tour began with a visit to a mixed fruit/vegetable producer, who had invested in a robotic weeder and electrostatic sprayer. The second stop highlighted herbicide screening research for sheep sorrel (*Rumex acetosella*) control in wild blueberry production. The third location outlined a new agro-tourism location and highlighted challenges with wild blueberry, raspberry, highbush blueberry and apiculture production. The next location was a new apple plantation, where the learning curve of a new entrant was discussed and how proper care and planning within establishment years is key to early fruit production. The final tour location presented a cranberry farm which has diversified to harvest peat. A trial to evaluate control of leatherleaf (*Chamaedaphne calyculata*) in cranberry was presented. The interactions between the producers and between attendees was highlighted as the biggest benefit of the tour. The balance between producers, new technology and research was appreciated. Future tours should engage processors and registrants. There is an open invitation for all members of the CWSS to attend the 2020 Atlantic Weed Tour, scheduled for Nova Scotia.
64	**Manitoba Update.** Tammy Jones, Manitoba Agriculture, Carman, MB.
65	**Artificial Neural Network based sprayer system for site-specific application of agrochemicals.** Nussain N[1], Farooque A[1], Afzaal H[1], McKenzie-Gopsill AG[2] [1]School of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown PE; [2]Agriculture and Agri-Food Canada, Charlottetown, PE Site-specific pest management seeks to monitor, detect and respond to the patchy nature of pest species distributions within agricultural fields. Real-time detection of weeds and diseases will allow for the development of smart sprayers capable of real-time application of agrochemicals in fields. Deep learning using artificial neural

	networks can be used to detect phenotypic features during image processing. The objectives of this study were to develop, design and evaluate a smart sprayer system using deep learning techniques for the real-time application of herbicides in potato fields. Images of healthy and diseased potato plants, weeds, bare soil and in various combinations were collected in potato fields of Prince Edward Island and New Brunswick and used to train and evaluate six deep learning framework convolutional neural network combinations. All frameworks evaluated provided > 90% accuracy for disease and weed detection in lab testing. Field evaluation of the smart sprayer system is currently in progress.
66	**Build up of glyphosate/AMPA residues in western Canadian field soils.** Geddes, C.M.[1], Molnar, L.J.[1], Gan, Y.[2], Grant, C.A.[3], Harker, K.N.[4], Johnson, E.N.[5,7], Mohr, R.M.[3], O'Donovan, J.T.[4], Semach, G.[6], and Blackshaw, R.E.[1]. [1]Lethbridge Research and Development Centre (RDC), Agriculture and Agri-Food Canada (AAFC), Lethbridge, AB; [2]Swift Current RDC, AAFC, Swift Current, SK; [3]Brandon RDC, AAFC, Brandon, MB; [4]Lacombe RDC, AAFC, Lacombe, AB; [5]Scott Research Farm, AAFC, Scott, SK; [6]Beaverlodge Research Farm, AAFC, Beaverlodge, AB; [7]Present address: Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK. Glyphosate use in the Canadian prairies tripled in the last decade, raising concerns about potential accumulation of glyphosate and its main metabolite aminomethylphosphonic acid (AMPA) in agroecosystems. Glyphosate is the most widely used herbicide in the world for several reasons, including: broad-spectrum and systemic activity on a wide range of plant species, low residual activity in soil, low mammalian toxicity, minimal environmental impact, and low herbicide cost. However, overuse of any tool in cropping systems can have detrimental effects on agroecosystem function. The objective of this study was to determine whether increased glyphosate use could cause accumulation of glyphosate or AMPA concentrations in western Canadian field soils. Glyphosate was applied pre-plant and post-harvest to the same plots over a four year period at rates of 0, 1, 2, 4 and 8 kg a.e. ha^{-1}. Experimental locations included Brandon, MB [clay loam (CL)], Swift Current, SK (loam/silt loam), Scott, SK (loam), Lethbridge, AB (CL/sandy CL), and Beaverlodge, AB (clay). In general, glyphosate and AMPA soil residues had a positive linear response to increased rate of glyphosate application; however, responses varied among location and year. The greatest glyphosate (5.40 mg kg^{-1}) and AMPA (3.6 mg kg^{-1}) soil residues were observed at Beaverlodge, AB, the location with the highest clay content (42% clay vs. <30% at all other sites). This suggests that glyphosate and AMPA were less available for microbial degradation due to strong adsorption to soil with high clay content. Glyphosate or AMPA soil residues did not increase consistently over the four years. Increased rates of glyphosate application can result in greater glyphosate and AMPA residues in field soils, however these residues are not expected to accumulate over time. Further research is warranted to determine the potential impact of increased glyphosate and AMPA residues on crop productivity and agroecosystem function.

67	Can a Sunn hemp (Crotalaria juncea) living mulch reduce herbicide usage in sweet corn? Nurse, R.E.1, Bae, J.2, Bosveld, K.1, and Simard, M-J3. 1Agriculture and Agri-Food Canada (AAFC), Harrow, ON; 2AAFC-Agassiz, BC; 3AAFC-St. Jean-sur-Richelieu, QC Sweet corn producers have fewer registered herbicides available in comparison to field corn producers. Therefore, it is important to develop weed management systems that address the stewardship of these products. The use of living mulches within a sweet corn crop can potentially improve weed control and reduce the over reliance on herbicides. The objective of this research was to evaluate the weed control provided by Sunn hemp in combination with full or reduced herbicide doses. The trial was conducted at three locations across Canada (Agassiz, BC., Harrow, ON., and St. Jean-sur-Richelieu, QC.) in 2018 and 2019. The trials were arranged as split plot designs with the main plot being the presence or absence of the living mulch and the sub-plot being herbicide dose. A half dose of saflufenacil/dimethenamid-P (0.368 kg ai/ha) was applied pre-emergence over the entire trial to provide initial grass and broadleaved weed control. The sub-plot treatment of mesotrione + Agral 90 was applied at 100 (0.1 kg ai ha^{-1} + 0.2% v/v), 75, 50, 25, and 0% doses. Mesotrione caused bleaching (up to 62%) in the Sunn hemp that persisted for more than 42 days after application, and reduced biomass (up to 80%) in comparison to the untreated control. The most effective weed biomass reductions were obtained when Sunn hemp was present; however, there was no significant effect of herbicide dose. Sweet corn height, stand, and time to 50% tassel was not affected by the presence of the living mulch or dose of the herbicide. Similarly, sweet corn yield was not affected by either factor in comparison to the weed-free control. Results demonstrated that herbicide dose could be reduced when paired with Sunn hemp in a sweet corn crop.
68	**Carbon stock and plant communities across an elevation gradient of a semiarid grassland: A 58-year Follow up.** Alex Kramer[1], Maja Krzic[1], Brian Wallace[2] 1. Faculty of Land and Food Systems, The University of British Columbia, Vancouver, British Columbia; 2. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Kamloops, British Columbia. In 1961, soil and plant communities were examined at twenty-eight sites across an elevation gradient from 350 to 950 m in elevation in a grassland steppe ecosystem in British Columbia. Three distinct zones were classified based on the correlated changes in vegetation communities and soil great group. This was tied to the 6-fold increase in soil organic carbon (1.3 to 8.1 %C), which was observed as elevation increased. At this time, sheep were grazing in a seasonally deferred manor. It had been recently overgrazed and non-native and rangeland increasers species had taken hold. Since this time, moderate seasonally deferred grazing by cattle has become the dominant range management practice. This study has three main goals: 1) Re-sample the grassland and assess the effect of time and improved grazing management on soil and plant properties; 2) to increase understanding of the carbon stock in the grassland and its ability to be a carbon sink; and 3) to apply modern GIS techniques with LiDAR to

	improve our understanding of the topographic control on soil and plant properties. Detailed soil physical and chemical properties have been measured with a record of plant species cover and frequency determined using Daubenmire transects. Soil total, organic, inorganic and active carbon pools were measured. Measurements were taken at specific topographic positions every 25-m gain in elevation. The 58-year period between data collection will provide valuable insight into the carbon storage potential and recovery of native vegetation in this unique ecosystem.
69	**Characterization of dicamba- and fluroxypyr-resistant kochia [*Bassia scoparia* (L.) A.J.Scott] in Alberta.** Geddes, C.M.[1], Owen, M.L.[1], Martin, E.[2], Hall, L.M.[2], Shirriff, S.W.[3], Leeson, J.Y.[3], and Beckie, H.J.[3,4]. [1]Lethbridge Research and Development Centre (RDC), Agriculture and Agri-Food Canada (AAFC), Lethbridge, AB; [2]Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB; [3]Saskatoon RDC, AAFC, Saskatoon, SK; [4]Present address: Australian Herbicide Resistance Initiative, School of Agriculture and Environment, University of Western Australia, Crawley, WA. A recent 2017 survey confirmed dicamba resistance in 18% of kochia populations in Alberta, while 10% were triple-resistant to tribenuron/thifensulfuron, glyphosate and dicamba. This followed the first confirmation of auxinic herbicide-resistant kochia in western Canada found in a spring wheat field in Saskatchewan (in 2015). While the initial auxin-resistant kochia population exhibited resistance to both dicamba and fluroxypyr, the Alberta populations were tested with dicamba only. Auxinic herbicide cross resistance in kochia populations would leave growers with limited herbicide options, especially in small-grain cereal crops. The objective of this study was to characterize resistance to the synthetic auxin herbicides dicamba and fluroxypyr in Alberta kochia populations. Dicamba and fluroxypyr dose-response experiments were used to study 17 kochia populations, including one dicamba- plus fluroxypyr-resistant control and four susceptible controls. The herbicide dose required to reduce fresh weight biomass by 50% relative to the untreated control (GR50) ranged among kochia populations from 36 to 314 g ai ha^{-1} for dicamba, and 3 to 916 g ai ha^{-1} for fluroxypyr. Excluding controls, ten of the twelve kochia populations were confirmed dicamba-resistant; three with high-level resistance [resistant to susceptible ratio (R/S) of 4.0 to 5.3], and seven with low-level resistance (R/S of 2.0 to 2.8). Seven populations were fluroxypyr-resistant; five with high-level resistance (R/S of 13.2 to 29.8) and two with low-level resistance (R/S of 3.8 to 4.0). Six populations were cross-resistant to dicamba and fluroxypyr, four were resistant to dicamba only, and one was resistant to fluroxypyr only. However, resistance confirmations were dependent on the metric used (GR50 for biomass or LD50 for plant survival). These results indicate that kochia populations in Alberta are resistant to one or more synthetic auxin active ingredients. Further research is required to determine whether single resistance and cross resistance are conferred by one or more resistance mechanisms.
70	**Control of annual ryegrass with spring-applied herbicides prior to seeding corn.** Nader Soltani[1], Christy Shropshire[1], Peter H. Sikkema.[1]

	[1]University of Guelph Ridgetown Campus, Ridgetown, ON. Four field experiments were conducted over a two-year period (2017, 2018) in Ontario to determine the control of annual ryegrass (ARG) seeded in the fall of 2016 and 2017 (as a cover crop) with spring-applied glyphosate alone and in tankmixure with clethodim, fluazifop, quizalofop, sethoxydim or saflufenacil prior to seeding glyphosate-resistant corn. The doses of glyphosate needed (based on visual ratings) to provide 50, 80 and 90% control of annual ryegrass were 439, 1757 and >2700 g ae ha^{-1} at 3 weeks after treatment application (WAA); 526, 2105 and >2700 g ae ha^{-1} at 4 WAA; and 703, >2700 and >2700 g ae ha^{-1} at 6 WAA, respectively. Glyphosate (1350 g ae ha^{-1}) controlled ARG 27, 61, 77, 72 and 68% at 1, 2, 3, 4 and 6 WAA, respectively. The tankmix of glyphosate (1350 ae ha^{-1}) with clethodim (30 g ai ha^{-1}), fluazifop (125 g ai ha^{-1}), quizalofop (36 g ai ha^{-1}), sethoxydim (150 g ai ha^{-1}) or saflufenacil (25 g ai ha^{-1}) controlled ARG as much as 42, 68, 84, 84 and 80%, respectively. The doses of glyphosate needed to provide 50, 80 and 90% reduction in ARG biomass were 244, 599 and 943 g ae ha^{-1} at 4 WAA There were antagonism effects when Group 1 herbicides were added to glyphosate at 1, 2, 3, and 4 WAA, however, these antagonistic effects were not significant at 6 WAA. Reduced ARG interference with glyphosate (1350 g ae ha^{-1}) applied alone increased corn yield 61%. ARG control with the tankmixes of glyphosate (1350 ae ha^{-1}) with the Group 1 herbicides evaluated increased corn yield as much 66%. Additionally, reduced ARG interference with the tankmix of glyphosate (1350 ae ha^{-1}) + saflufenacil (25 g ai ha^{-1}) increased corn yield 69%. The best control of ARG was achieved with high doses of glyphosate and glyphosate (1350 g ae ha^{-1}) tankmixed with a Group 1 herbicide or saflufenacil.
71	**Farmer-directed research on crop productivity impacts of glyphosate residues in southern Alberta low-disturbance no-till soils.** Dunn, R. FarmWise Inc., Lethbridge, Alberta. Hildebrand, B. Palliser Agricultural Management Society. This three-year study evaluated glyphosate soil residue impacts on crop productivity at three southern Alberta farms that use low disturbance disk-type planting systems on fields with a long no-till history (>20 years). Glyphosate was applied pre-plant and post-harvest over a 3-year period (2014 to 2016) at 0, 1, 2, 4 and 8 kg ai ha^{-1} in a RCBD with the farmers using their normal cropping systems. Glufosinate + clethodim (.5 + .05 kg ai ha^{-1}) was applied to the "0" control and there was also an untreated control with no pre-plant or post-harvest herbicide (hand weeded). Increasing glyphosate rate reduced crop density and yield at all sites but there were differences by crop type and site-year. Flax and winter wheat plant density and yield declined with increasing glyphosate rate (3 site-years). Spring CWRS wheat, yellow pea and hemp plant density declined with increasing glyphosate rate (2 site-years). Further study at nearby locations on the same farms (2 sites in each of 2015 and 2016) evaluated the effect of glyphosate with or without surface litter. Litter was removed prior to pre-plant glyphosate (8 kg ai ha^{-1} in 2015 and 2 and 8 kg ai ha^{-1} in 2016) in a RCBD with glufosinate + clethodim (.5 + .05 kg

	ai ha^{-1}) as the "0" control. Glyphosate significantly reduced flax density and yield at both sites (2015), more so when surface litter was left intact. Glyphosate had no effect on pea or lentil in 2016 although surface litter removal increased plant density (both sites) and lentil yield (one site). Soil glyphosate and AMPA concentrations from samples taken 62 days after a pre-plant treatment in the final study year declined with glyphosate rate. For the 8 kg ai ha^{-1} treatment, soil concentration was about 1.0 mg/kg for glyphosate and 0.5 mg/kg for AMPA.
72	**Impact of tillage timing and intensity on weeds under organic management in the Brown Soil Zone.** Leeson J.Y.[1], Fernandez M.R.[2], McConkey B.[2] [1]Agriculture and Agri-Food Canada (AAFC), Saskatoon, SK; [2]AAFC-Swift Current, SK A study was established in 2015 to determine the ability of different intensities of tillage operations under organic management to control weed populations while providing an acceptably low risk of soil erosion in the Brown Soil Zone of western Canada. A tillage system with intensive tillage in the spring only (spring) and was compared to a system with intensive tillage in both fall and spring (high) and a system with more moderate tillage in fall and spring (moderate). The cropping sequence consisted of three crops (durum - flax - lentil). Weeds were counted in 20 quarter metre square quadrats in each plot prior to harvest. The total weed densities were not consistently affected by tillage until 2019 when fewer weeds were found in the spring tillage than the moderate tillage system. In 2019, the dominant species in all systems were green foxtail (*Setaria viridis* (L.) P. Beauv.), stinkweed (*Thlaspi arvense* L.), purslane (*Portulaca oleracea* L.), lamb's-quarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), spear-leaved goosefoot (*Blitum nuttallianum* Schult.), prostrate pigweed (*Amaranthus blitoides* S.Watson) and tumble pigweed (*Amaranthus albus* L.). These eight annual species accounted for 93, 98 and 97% of the weeds counted in the spring, moderate and high tillage systems, respectively. Most of the explained variance in the weed community composition was determined by year (65%), however, tillage system explained small but significant portion of the variance (1%). This is attributable to the more rapid establishment of perennial weeds (dandelion (*Taraxacum officinale* F.H.Wigg.), Canada thistle (*Cirsium arvense* (L.) Scop.) and perennial sow-thistle (*Sonchus arvensis* L.)) in the spring tillage system. The association of the perennial species with the spring tillage system indicate potential future threats to the sustainability of this system.
73	**Integration of a blade system into a cage mill for weed seed devitalization.** Tidemann B.D., Kubota H., Reid P., Zuidhof J. Lacombe Research and Development Centre, Agriculture and Agri-Food Canada, Lacombe, AB Harvest weed seed control adoption is increasing in Australia and research is ongoing globally. One of the different harvest weed seed control mechanisms, integrated mills, are evolving quickly with additional manufacturers entering the market. The Redekop Seed Control Unit is the newest integrated mill system to be commercialized. It

	integrates a blade system into a reversible cage mill with the goal of increasing airflow and thereby reducing energy requirements, but the effects of this addition on weed seed devitalization and chaff flow efficiency has not yet been evaluated. This project determined the devitalization rate of volunteer canola (*Brassica napus* L.) when processed by a cage mill with an integrated blade system. Experimental factors included an 8 fan blade system, a 4 fan blade and 4 cutting blade system, two chaff volumes (5 and 10 tons per hour) and all combinations of these factors. There was no significant effect of blade configuration or chaff volume on volunteer canola control which remained above 99% in all treatments. Volunteer canola control remained high with the integration of the blade system into a cage mill. If addition of the blade system allows for reduced energy requirements or other efficiencies, it will be a useful development in the integrated mill system evolution.
74	**Large-scale evaluation of off-target movement of Dicamba in North America** Nader Soltani[1], Maxwel C. Oliveira[2], Guiherme S. Alves[3], Rodrigo Werle[2], Greg Kruger[3], Jason K. Norsworthy[4], Christy Sprague[5], Bryan G. Young[6], Dan Reynolds[7], Peter Sikkema[1] [1]University of Guelph Ridgetown Campus [2]University of Wisconsin-Madison, Madison [3]University of Nebraska-Lincoln [4]University of Arkansas [5]Michigan State University [6]Purdue University [7]Mississippi State University Six experiments were conducted in 2018 on field sites located in Arkansas (Proctor), Indiana (Montezuma), Michigan (Fowlerville), Nebraska (Stapleton), Ontario (Dresden), and Wisconsin (Arlington) to evaluate the off-target movement (OTM) of dicamba when applied according to label directions under large scale field conditions. The highest estimated dicamba injury in dicamba sensitive soybean was 50, 44, 39, 67, 15, and 44% injury for non-covered areas and 59, 5, 13, 42, 0, and 41% injury for covered areas during dicamba application in Arkansas, Indiana, Michigan, Nebraska, Ontario, and Wisconsin, respectively. The level of injury generally decreased non-linearly as the downwind distance increased under covered and non-covered areas at all sites. There was an estimated 10% injury in dicamba sensitive soybean at 113, 8, 11, 9, and 8 m; and estimated 1% injury to non-DR soybean at 293, 28, 71, 15, and 19 m from the edge of treated field downwind when plants were not covered during dicamba application in Arkansas, Indiana, Michigan, Ontario and Wisconsin, respectively. The horizontal dicamba deposition collectors placed at 4, 8, 16, 30, 45, 60, 75, 90, 105, and 120 m downwind from the edge of the sprayed area indicated that the dicamba deposition reduced non-linearly with distance. Based on these results, the greatest injury to dicamba sensitive soybean from off-target movement of dicamba occurred at Nebraska and Arkansas (as far as 275 m). Dicamba sensitive soybean injury was greatest adjacent to the dicamba sprayed area but, injury decreased rapidly with no injury beyond 20 m downwind or any other direction from the dicamba sprayed area in Indiana, Michigan, Ontario, and Wisconsin. The presence of soybean injury under covered and non-covered areas during the spray period for primary drift indicates that secondary

	dicamba movement was evident at five sites. Further research is needed to determine the exact forms of secondary movement of dicamba under different environmental conditions.
75	**Rapid spread of glyphosate-resistant kochia [*Bassia scoparia* (L.) A.J.Scott] in Manitoba.** Geddes, C.M.[1], Ostendorf, T.E.[1], Gulden, R.H.[2], Jones, T.[3], Leeson, J.Y.[4], Shirriff, S.W.[4], Sharpe, S.M.[4] and Beckie, H.J.[4,5]. [1]Lethbridge Research and Development Centre (RDC), Agriculture and Agri-Food Canada (AAFC), Lethbridge, B; [2]Department of Plant Science, University of Manitoba, Winnipeg, MB; [3]Manitoba Agriculture, Carman, MB; [4]Saskatoon RDC, AAFC, Saskatoon, SK; [5]Present address: Australian Herbicide Resistance Initiative, School of Agriculture and Environment, University of Western Australia, Crawley, WA. Kochia is the first known glyphosate-resistant (GR) weed species in western Canada. In 2011, the first confirmations of GR kochia were from chemical-fallow fields located in Warner County, Alberta. Baseline surveys conducted in 2012 (Alberta) and 2013 (Manitoba and Saskatchewan), identified glyphosate resistance in 5%, 5% and 1% of kochia populations in Alberta, Saskatchewan and Manitoba, respectively. Unlike Alberta and Saskatchewan, the first confirmations of GR kochia in Manitoba were in the GR crops, corn and soybean. A follow-up randomized stratified survey of herbicide-resistant kochia was conducted in Manitoba in 2018 using the same methods as the 2013 baseline survey (but different sample locations). Kochia samples were collected post-harvest from 297 predetermined (township-scale) locations in Manitoba in October. Kochia seed was harvested, and seedlings were grown in the greenhouse and treated with a discriminating dose of glyphosate (Roundup WeatherMax, 540 g a.e. L^{-1}, 900 g a.e. ha^{-1}) when they were 3 to 5 cm tall. Plants were rated visually as susceptible (dead or nearly dead) or resistant (some injury but new growth, or no injury) 3 weeks after application. After five years, the incidence of glyphosate resistance increased from 1% to 59% of kochia populations in Manitoba. Unlike the 2013 survey, GR kochia was confirmed in a range of field crops, including soybean (77% of kochia populations), corn (70%), canola (53%), other oilseeds (83%), small-grain cereals (48%), pulses (20%), alfalfa/grass (50%), and ruderal areas (21%). The rapid increase of GR kochia in Manitoba coincides with similar observations in Alberta. Growers will need to shift their kochia management programs to compensate for the lack of efficacy of this important herbicide. These management programs will consist of increased reliance on alternative herbicide sites-of-action pre-emergence, adoption of herbicide-resistant crops with stacked resistance traits, and integration of non-chemical tools into current weed control programs.
76	**Shedding light on the power of plant competition.** Berardi N., Swanton C.J. Department of Plant Agriculture, University of Guelph, Guelph, ON N1G 2W1 Changes in light quality induced by the presence of neighbouring weeds is an important

	mechanism of plant competition. Alteration of the light environment is recognized via changes in the red to far-red light ratio (R/FR), in which a reduction in R/FR is induced by light that is reflected upwards off weeds and will elicit a physiological stress response in the plant. The resulting physiological responses due to the presence of neighbouring weeds are hypothesized to be the cause of significant yield losses during early season weed competition. To study the physiological responses of resource-independent plant competition, *Arabidopsis thaliana* and maize (*Zea mays* L.) were used in experiments in which ROS levels and antioxidant status was measured. Experiments using *Arabidopsis thaliana* ascorbate and carotenoid mutants will allow for further identification of the most potent antioxidants involved in combating the physiological stress responses associated with plant competition and yield loss. It is anticipated that this research will provide important insights aiding in the elucidation of the molecular and physiological mechanisms surrounding resource-independent weed competition. This breadth of knowledge on the physiological mechanisms behind plant competition will provide a crucial foundation for breeders to improve crop stress tolerance and ultimately, yield potential.
77	**Soil moisture and nutrient impacts on biocontrol of spotted knapweed by seed-feeding weevils *Larinus* spp.** Nielson K.G.[1,2], De Clerck-Floate R.[1], Pither J.[2] [1]Agriculture and Agri-Food Canada, Lethbridge, AB; [2]Department of Biology, University of British Columbia Okanagan, Kelowna, BC Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*) is a widespread invasive plant found throughout western North America that has caused significant negative ecological and economic impacts. Releases of insect biocontrol agents have resulted in inconsistent control, and it is unclear how biocontrol will be influenced by climate change. In the Southern Interior of British Columbia, which is forecast to experience increased drought and wildfires, the responses of both biocontrol insects and their host plant to shifts in moisture and nutrient regimes are unknown and may impact the future efficacy of spotted knapweed biocontrol. To assess current and predict future efficacy of spotted knapweed biocontrol in the context of changing climate, I will undertake a three-part study using the seed-feeding weevils *Larinus minutus* and *L. obtusus* (Coleoptera: Curculionidae) including: (1) a systematic literature review of spotted knapweed biocontrol response to environmental heterogeneity, (2) morphomolecular analysis of *Larinus* spp. to compare species' distributions to their purported climatic niches, and (3) greenhouse and common garden experiments comparing *Larinus* sp. and spotted knapweed development under different moisture and nutrient treatments. The results will inform management strategies and further our understanding of climate change impacts on plant-insect interactions.
78	**Update on herbicide resistance genetic testing** Obeid, K.[1], Simard, M.-J.[2], Laforest, M.[2], Nurse, R.E.[3], Page, E.R[3]. and Miville, D[4]. [1]Ontario Ministry of Agriculture, Food and Rural Affairs, Harrow, ON, Canada [2]Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu Research and Development

Centre, Saint-Jean-sur-Richelieu, QC, Canada
[3]Agriculture and Agri-Food Canada, Harrow, ON, Canada
[4]Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec City, QC, Canada

Herbicide resistant weed biotypes were surveyed in horticulture crops in Ontario and Québec to develop and trial diagnostic tests based on molecular markers. Herbicide resistant populations must be detected and managed rapidly in high value crops such as carrots, grapes, onions, strawberries and tomatoes where fewer herbicide options are available. Diagnostic tests based on molecular makers offer rapid results compared to conventional greenhouse evaluations. Since 2016 a total of 76 cases of herbicide resistance have been reported and a total of 16 genetic (five more in progress) and two species differentiation tests have been successfully developed. In 2019, these tests detected multiple resistance cases (ALS + Photosystem II inhibitors) in green pigweed (*Amaranthus powelii*) in three tomato fields. Different common ragweed (*Ambrosia artemisiifolia*) plants in the same carrot field were also resistant to either ALS or Photosystem II inhibitors. Overall, 71% of the weed biotypes surveyed tested positive for genetic mutations conferring resistance.

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