SUSTAINABILITY OF CANADIAN AGRICULTURE CONFERENCE

FARMING FOR SOLUTIONS

MARCH 12 & 13

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Holos
A tool to estimate and reduce GHGs from farms

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Workshop #1

HOLOS v.4

Holos
A tool to estimate and reduce GHGs from farms

Instructor: Roland Kroebel, Research Scientist, AAFC Lethbridge, AB

Holos is a whole-farm model and software program that estimates greenhouse gas (GHG) emissions based on information entered for individual farms. The main purpose of Holos is to test possible ways of reducing GHG emissions from farms and is available at no cost to users. Users can select scenarios and farm management practices that best describe their operation and then adjust these practices to see the effect on carbon dioxide, nitrous oxide and methane emissions. Examples of these adjustments include changing livestock feed, reducing tillage, manure management or cropping systems that include perennial forages in rotation. Carbon storage and loss from lineal tree plantings and changes in land use and management are also estimated. The result is a greenhouse gas emission estimate for the whole farm that can help the user identify ways to reduce farm emissions.

AAFC's Holos team has completed a new version 4 of the Holos model, ready for the testing by our stake-holders. The model features numerous updates over version 3, most prominently the inclusion of a carbon budget model and multi-year modelling features. Other updates consist of an updated nitrous oxide emission factor, updated enteric methane calculations, and the inclusion of a feed database for ration formulation. Other new features, such as the simulations of carbon from perennials and grassland, as well as the impacts of grazing and haying are under development. The workshop will include presentations and opportunities to learn how the new model works, what features it contains, and what modelling options there are. We will invite participants to test and provide feedback on the interface and the model setup, and hope to instill their interest in helping us testing the model rigorously before its release.

Workshop #2

The Canadian Agri-food Life Cycle Data Centre (CALDC): Database Development Update, Industry Data Set Submission Initiatives, and Example Applications in the Egg Industry

Instructor: Nathan Pelletier, NSERC/Egg Farmers of Canada Industrial Research Chair in Sustainability
University of British Columbia - Okanagan, Kelowna, BC

Life cycle thinking refers to sustainability measurement and management approaches that consider all relevant supply chain interactions associated with a product, service, activity, or entity. The goal of life cycle thinking is essential to understanding and preventing unintentional burden shifting. Life cycle thinking and tools have become central to sustainability science.

The Canadian Agri-food Life Cycle Data Centre (CALDC) is a new, publicly available repository for data sets characterizing resource inputs, outputs and emissions associated with key food system activities. The data sets hosted by the CALDC will be contributed by and made freely available to researchers, consultants, industry, government, and other stakeholders undertaking life cycle assessment, environmental footprinting, and other sustainability measurement, management and communication initiatives. The CALDC database recently underwent a period of public testing and revision, is now beginning to host data sets. This session will begin with an update on the CALDC and a short demonstration of its capabilities and uses. Participants will be exposed to a series of life cycle assessment case studies from research of the Canadian egg industry and other sectors to showcase how data sets from the CALDC can be used to support sustainability initiatives in the Canadian agri-food sector.

ORAL PRESENTATION ABSTRACTS: Day 1

Session #1: Enhancing Biodiversity in Agriculture

1.1 Investigating New Approaches to Encourage Livestock Producers to Conserve Species at Risk Habitat in Southwest Saskatchewan

Tom Harrison[1], Kelly Williamson[1], Krista Connick Todd[1]
Dr. Diego Steinaker[1], Mel Toppi[1] and Chad MacPherson[2]
[1] SODCAP Inc
[2] Saskatchewan Stock Growers Association

Southwestern Saskatchewan is home to the some of the most intact native grasslands in the Northern Great Plains and two million acres of combined critical habitat for species at risk. With funding from Environment and Climate Change Canada's (ECCC) Species at Risk Partnership on an Agricultural Landscape (SARPAL) program and the National Fish and Wildlife Fund, Saskatchewan Stock Growers Association (SSGA) and the South of the Divide Conservation Action Program Inc. (SODCAP Inc.) have been investigating new and innovative programs over the last five year that would effectively encourage producers to make species at risk a priority in their management decision making on their ranches. Since 2015, SODCAP Inc. and SSGA have engaged hundreds of ranchers and farmers. These agencies have signed 45 agreements with over 34 producers or producer groups who manage approximately 250,000 acres of critical habitat and/or native grasslands. These lands are located in the Milk River Watershed and the Missouri Coteau of southwest Saskatchewan. These agreements consisted of 18 Results Based Conservation Agreements, 15 Habitat Management Agreements, 6 Habitat Restoration Agreements, 2 Grass Banking initiatives and 2 Niche Product Branding initiatives. While no Conservation Easements were signed, the Saskatchewan Stock Growers Foundation was created and approved for charitable status by the Canadian Revenue Agency and approved to hold Conservation Easements by the Saskatchewan Ministry of Environment. Four producers have expressed interest in signing a Term Conservation Easement. The diversity of operations and opinions derived from the engagement of producers indicate that a 'one size fits all' approach does not work for ranchers and multiple programming options are required to achieve biodiversity goals. An independent assessment of the programming options delivered showed that there were high levels of producer acceptance of the programs as well as trust in the delivery agents. Independent valuations of the socio economic impacts are being carried out. It is expected that ECCC will roll out the next iteration of the SARPAL program in 2020.

1.2. Does retaining ponds in agroecosystems enhance biodiversity? Tales of tree swallows and their insect prey

Lisha Berzins[1*], Christy Morrissey[1], and Robert Clark[1,2]

[1] Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, S7N 5C8
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Agricultural practises in the Prairie Pothole Region (PPR) have intensified in the last several decades to increase crop production. Not surprisingly, agricultural expansion into natural habitats and increased agrochemical use are key drivers of biodiversity loss. Prairie ponds (i.e., wetland basins flooded with water) provide important aquatic food sources for terrestrial species; however, up to 70% of ponds in the PPR have been impacted by agriculture. Whether pond losses negatively affect successful breeding of avian species by reducing their aquatic food supply remains underexplored. During 2018 and 2019, we set up nest boxes in intensively cropped agricultural (i.e., canola) areas to examine how pond abundance (low to high) influences reproduction and the quality of nestlings produced by an aerial insectivore, the tree swallow (*Tachycineta bicolor*). Our results showed lower, and more variable, nest box occupancy by swallows at sites with low pond abundance. Additionally, adult swallows breeding at sites with low pond abundance produced smaller, lighter nestlings. Nestling body mass prior to fledgling is strongly related to food supply, suggesting that sites with low pond abundance may lack high-quality aquatic food resources for rapidly-growing nestlings. Overall, that tree swallows are more likely to breed and produce higher quality nestlings at intensively cropped agricultural sites containing abundant ponds provides support that retaining ponds in cropland-dominated agroecosystems enhances biodiversity.

1.3. Breeding productivity, habitat use and post-fledging survival of swallows across a gradient of agricultural habitat near Vancouver BC.

Chloe Boynton[1], **Nancy Mahony[2]**, Olga Lansdorp[1], Tony Williams[1]
[1]Simon Fraser University
[2]Environment and Climate Change Canada

Populations of birds that forage on aerial insects have been declining across North America for several decades, a probable cause being agricultural intensification, resulting in fewer flying insects. We examined breeding productivity in Tree and Barn Swallows and foraging and post-fledging habitat use and survival in Barn Swallows across a gradient of agricultural intensification, at livestock farms, crop farms and non-agricultural sites near Vancouver BC. There was little effect of habitat type on breeding productivity for either species, despite the fact that livestock farms had greater insect abundance. Natal habitat (crop, livestock or non-agriculture) had no effect on fledgling quality or movement distance and fledglings used crop habitat more frequently in relation to its availability than other habitat types, including livestock pasture, although fledgling survival may be low compared to other studies. We found no difference in the abundance of adult Barn Swallows foraging over grassland set-aside and cultivated fields, though the insect communities were different. These results differ from studies done in Europe and eastern North America, which showed that livestock farms provided higher quality breeding habitat than crops for swallows. The small fields bordered by hedgerows and heterogeneity of crop types in our study area may provide sufficient food resources to support breeding swallows and should be encouraged as a way to manage agricultural habitat for declining aerial insectivores.

1.4. Win-wins are within reach: links between non-crop areas, biodiversity and crop yield in Alberta

Paul Galpern[1]
[1]Department of Biological Sciences, University of Calgary

How can agriculture increase food production to meet growing demands while also minimizing impacts on biodiversity? An opportunity may lie in harnessing nature's contributions to people, and its potential to increase crop yield through ecosystem services such as pollination and biological control. The animals that deliver these services require habitat, but this can be limited in the regions of the Canadian Prairies where annual crops are grown. However, widespread small footprint features within fields, such as wetlands or low-spots, could be the locus of so-called "win-wins." By providing the habitat for service-providing organisms, these non-crop areas within fields may contribute to yields while supporting a broader community of animals and plants. Here, I report on the first four years of the Beneficial Insects Surveillance Network (funded until 2023), an initiative the aims to: (1) understand how non-crop areas in Alberta fields may support arthropods providing ecosystem services; and, (2) measure the contribution of these areas to crop yields. I present analyses from this network that combine a database representing ~170,000 arthropods of nearly 400 species sampled at 335 sites across the province, with crop yield data collected at both field and provincial scales. Initial results suggest that non-crop areas may be important habitats for biodiversity, and that these areas make a small but measurable contribution to crop yields. I argue that the potential to achieve win-wins for food production and biodiversity are well within reach in Canadian Prairie croplands.

1.5. Invasive Wild Pigs Threaten Biodiversity and Agriculture Sustainability on Farmland Across Canada

Ryan Kendall Brook[1]
[1]College of Agriculture and Bioresources, University of Saskatchewan

Wild pigs are not native to North America but were brought to Canada in the 1980s and 1990s to be used for meat production and penned shoot farms as means of diversifying agriculture and were brought to all provinces and the Yukon Territory. Widespread escapes and purposeful releases through the 1980s to present have introduced and continuously supplemented established free-ranging wild pigs. Wild pigs are a global problem across all continents except Antarctica. Occurrences of wild pigs were rare in 1990's but have increased exponentially during the last decade, especially in the three Prairie Provinces, Alberta, Saskatchewan, and Manitoba. Wild pigs have very broad diets and habitat requirements so they threaten biodiversity across farmland in Canada directly through consumption and indirectly through competition, habitat destruction, and potential disease transmission. Wild pigs are a rooting species that rip up the soil and they threaten the last remaining population of Endangered Prairie Skinks in southwestern Manitoba. Wild pigs co-occur in space and habitats with native wildlife, most commonly with moose. Wild pigs contaminate water, wallow in wetlands, and can significantly alter moose habitat. Species that avoid wild pigs include elk, white-tailed deer, and raccoons. Limiting the spread and impacts of invasive wild pigs will require intensive monitoring, ecological research and development and implementation of science-based management plans. Ground-based

trapping, helicopter capture, and the use of Judas pigs (GPS-collared animals that are tracked to find and help remove sounder groups of wild pigs) are proven control measures. A comprehensive approach is essential.

1.6. Fall-seeded croplands provide significant benefits to breeding birds in prairie agroecosystems

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Given the vast area under annual cropland in prairie Canada, and typical disturbance regimes (tillage and seeding) during the breeding season of many bird species, annual croplands are generally viewed as low-value for breeding birds. However, fall-seeded crops like winter wheat, fall rye, and triticale are seeded in the fall and generally provide undisturbed nesting opportunities for species that require low to moderate vegetative cover at nest sites. Between 1996 and 2012, a series of research studies in prairie agroecosystems in Canada and the U.S. documented breeding bird use and breeding success in spring and fall-seeded croplands and grasslands. The results of these investigations provide strong evidence that fall-seeded croplands can provide attractive and productive habitat for several species of waterfowl, shorebirds and grassland birds. Fall-seeded crops are comparable to grasslands in terms of hatched nests/hectare for mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), and blue-winged teal (*Anas discors*), provide productive nest sites for shorebirds like long-billed curlew (*Numenius americanus*), marbled godwit (*Limosa fedoa*), and willet (*Tringa semipalmata*), and receive high use by a grassland songbird of conservation concern, the horned lark (*Eremophila alpestris*). These results suggest that planting fall-seeded crops can provide biodiversity benefits in cropland-dominated landscapes. For winter wheat specifically, the benefits to prairie birds, in combination with average agronomic returns, provides a rare win-win for farmers and biodiversity conservation in prairie Canada.

1.7. Multi-functional landscapes – a path to sustainable and resilient agriculture

Branimir Gjetvaj[1]
[1]Nature Saskatchewan

Production of food, fibre and fuel to support human population needs to be based on sustainable and resilient agricultural systems, especially in the context of increasingly variable climate change conditions. The current model of high-input, intense production of agricultural commodities provides high yields. However, this intensification led to simplification of agricultural landscape structure, loss of biodiversity, and potential reduction in resilience of the system to disturbance. Loss of biodiversity threatens provisioning of ecosystem function and services, ultimately impacting food security and agriculture sustainability. Formerly heterogeneous landscapes are becoming more uniform, with annual crops dominating over the greatly reduced and fragmented natural habitats of wetlands, woodlots and native grasslands. Increased compositional and structural complexity of multi-functional agricultural landscapes under biodiversity-based management may be an important component of supporting biodiversity and improving system resilience. I will argue for the need to consider designing agricultural landscapes as a mosaic of land uses; comprising of protected areas, wildlife-friendly working lands, and agro-ecology based farmland. This high-quality agroecological matrix will complement the biodiversity conservation goals of protected areas by providing necessary habitat for some species, while facilitating dispersal and adaptation to climate change for others. Environmental and other nongovernment organizations will play an important role in engaging agricultural producers, policy makers and other stakeholders, to develop solutions for redesigning agricultural landscapes for sustainable and resilient agriculture.

1.8. Role of field boundary habitats in agro-ecosystems health and productivity

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Canada contributes significantly to world food production, but this has not occurred without environmental costs. The fragmentations of the agro-ecosystem and associated habitat destruction for monoculture production have contributed to a loss of flora and fauna diversity. Producers often regard field boundary habitats as non-productive land that potentially limits crop production. We hypothesized that non-crop areas provide a mixture of habitats that contribute to the diversity and dynamics of the agro-ecosystem, with net positive impacts on adjacent crops. To test this hypothesis we: 1. spatially analyzed the extent and distribution of field boundary habitat influences on in-field variability using precision agriculture approaches, such as micro scale

in-field measurements of soil moisture, above- and below-ground biodiversity, insect pests, pathogens and weeds, crop metrics from UAV-based sensors; and 2. quantified the benefits of conserving non-crop areas on crop yield and quality. We collected data from 40 sites representing one of two field boundary habitat types in the black soil zones of Saskatchewan, Canada: planted shelterbelt, natural hedgerow, and open field with no field boundary habitat. The data is currently being analyzed. The intent is to provide science-based information on the functioning and value of field boundary habitats and the extent of their influence into adjacent field crops.

Session #2: Enhancing Soil Health and Soil Carbon on the Farm

2.1 Piloting a Canadian Agricultural-Resiliency and Food-Security Pathway in the Climate War

James Irwin

Riding Mountain UNESCO World Biosphere Reserve

Facing the Global spectrum of evolving, dynamic changes and potential challenges that might or might not be anticipated in the coming one or two decades, agricultural-resiliency and food-security must be considered a top Canadian priority in concert with our carbon-management considerations to address the climate emergency.

Accordingly, a Canadian, high-level, non-profit, inclusive, agriculture and food-security organization (aka, an agriculture and food-security war-room) is proposed to enable Canadian agricultural organizations (and supporting organizations) to work in partnership with the Federal and Provincial Governments and International organizations.

The role of the organization would be to strategically facilitate a climate adaptation and mitigation transition of our Canadian agricultural systems and rural communities to increasingly more resilient agroecological systems and localized food systems to enable steadfast adaptation in a transition to a new production-resilient, low-carbon, self-sufficient, food-secure economy, for all Canada.

To enable the rapid, wide-spread adoption of agroecological practices, a strategic outline is offered for an incentivized, land-stewardship, carbon-management program, with reference to progress in this field in other countries. An argument is also made that this high-level organization would be well positioned to access funding streams to expedite the transition – especially as things 'heat up'.

2.2 Soil Carbon Pools Before and After 21 Years of Conservation Management in Prairie Soils

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Soils are the largest terrestrial carbon sink on Earth and increasing soil organic carbon (SOC) content is a means of sequestering atmospheric CO2. Limited work has been done to examine the effect of long-term conservation management practices on the stability of SOC in prairie soils. The objective of this study was to assess the nature and permanence of sequestered SOC in contrasting Saskatchewan soils after 21 years of conservation management practices. Ninety fields were sampled in 1996 and again at the same locations in 2018. The fields represent a diverse collection of soil types from within the five soil zones of the province. Comparisons were made between the 1996 and 2018 soils (0-10 cm) in SOC concentration, along with various labile and dynamic SOC fractions: water-extractable (WEOC), light fraction (LF-C), microbial biomass (MB-C), and respirable CO2-C during a six-week incubation. Regardless of soil zone, soils with the smallest initial SOC content accumulated more SOC (ranging from 4.7-9.8 Mg C/ha or 220-454 kg C/ha/year). There was a minor increase in WEOC content (3%), no change in LF-C content, and a substantial increase in MB-C content (41%). Except for greater CO2-C emissions from the 2018 Black soils, there was no difference in CO2-C emissions or percentage of SOC respired between the 2018 and 1996 soils, which suggests similar or greater permanence of the sequestered SOC. Our results suggest that after 21 years of conservation management practices, more of the SOC is present in an active, dynamic fraction that contributes to soil health and nutrient cycling.

2.3 Soil carbon modelling for annual crops using the Introductory Carbon Balance Model

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Agricultural soils, when sustainably managed, can be an important store of soil organic carbon (SOC), which underpins important ecosystem services including climate regulation. On-farm changes in SOC dynamics in response to environmental conditions and management practices can be estimated using the Introductory Carbon Balance Model (ICBM), integrated into Holos Version 4. To model SOC dynamics, the ICBM runs on an annual timestep and uses crop-specific coefficients that describe the allocation of C in the aboveground (product and residue) and belowground (roots and root exudates) plant biomass. These coefficients determine the amount of C input annually to the soil from the different plant fractions, and, consequently, the changes to the young and old (stable) soil C pools.

This study assessed the effects of ICBM parameterization on estimates of SOC stocks for different crop rotations – primarily annual and wheat-based - in western Canada (Lethbridge and Breton, AB; Swift Current and Scott, SK). The overall aim was to determine the impacts of parameterization on model outputs for the following input scenarios: (1) a measured starting vs. an estimated near-equilibrium SOC; (2) constant vs. annually variable crop yield; and (3) constant vs. annually variable climatic conditions. The errors associated with using simplified vs. more complex model inputs were quantified to determine the level of detail needed in the model. Model outputs were also compared with available field SOC measurements at different points in time.

2.4 Importance of crop and drive rows in soil carbon sequestration: a regional study of grape, apple and cherry cropping systems in the Okanagan Valley, BC

Andrew J Midwood[1], Kirsten D. Hannam[2], Thomas Forge[2], Denise Neilsen[2], Lori A. Phillips[3], David Emde[1], and Melanie D. Jones[1]

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Vineyards and orchards are usually planted in rows that alternate between woody perennial crops and drive strips that support less actively managed vegetation. Differences in crop and drive row vegetation create spatially distinct soil carbon (C) storage profiles across agricultural fields. We conducted an extensive study in the semi-arid Okanagan Valley, BC, to characterise soil C stocks in orchard and vineyard systems; samples were collected from 34 drip- or micro-sprinkler-irrigated apple orchards, 22 microsprinkler-irrigated cherry orchards and 24 drip-irrigated vineyards across a range of soil textures. Soils were sampled to 60 cm depth in both crop and drive rows and analysed for organic C and 13C content. Across the four cropping systems (fruit crop x irrigation method), drive rows contained significantly more soil C than crop rows, with the most pronounced differences at the soil surface. Cropping system also influenced soil C content: cherry orchards contained the most carbon and vineyards the least. We found little impact of irrigation type, with no difference between apples irrigated using drippers or microsprinklers. Results from stable isotope analyses suggest that relatively unprocessed, 'new' carbon, with a depleted 13C composition was responsible for the higher soil C content in surface soils of drive rows, most likely due to inputs from shallow rooted grasses and freshly mulched pruning materials. Our results suggest that drive row soils could be deliberately managed for C sequestration.

2.5 Increasing Profits While Lowering Carbon Footprints in Cow-Calf Management

Sheilah Nolan[1]

[1]Alberta Agriculture and Forestry

Although beef producers are under pressure to operate viable businesses while maintaining public confidence in responsible beef production, information to evaluate the economic impacts of management to lower carbon footprints or greenhouse gases (GHGs) is lacking. This proof-of-concept study assessed whether management to increase the profitability ($ / unit of production) of cow-calf operations can also decrease GHGs / unit of production. A case study approach evaluated the potential for fall pregnancy checking (PC) and culling open (non-pregnant) cows to eliminate both feeding costs and GHGs. Six feeding strategies for 10 open cows in a 120 head herd were simulated over a 135 day winter feeding period, using five year average prices (2012-2016) and Holos software. The potential impacts of changes in the soil carbon sink were also estimated for each ration. Results suggest that fall PC and fall culling could reduce overwintering costs by about 8%, while reducing annual GHG emissions from the herd by about 4%. If the open cows were overwintered for spring sale, fall PC and feeding high energy rations could increase net revenue by $80 to $174 per head while decreasing GHG emissions by 62% per unit of weight gain, compared with no PC and feeding open cows with the pregnant herd. Including estimates of soil carbon removals increased the variation in net GHGs, with

one ration resulting in a net GHG sink. These results indicate good potential for cow-calf operators to increase profitability while demonstrating responsible resource management to reduce carbon footprints.

2.6 Market estimates of carbon storage potential in restored wetlands

Purbasha Mistry[1] and Dr. Irena Creed[1]

[1] School of Environment of Sustainability, University of Saskatchewan

Wetlands play an important role in the global carbon cycle by sequestering carbon in the soil. Carbon sequestration by wetlands converts atmospheric carbon dioxide, a potent greenhouse gas to soil organic matter. The continued loss of wetlands from agricultural landscapes is resulting in the release of carbon dioxide and methane to the atmosphere accelerating climate change. In this study, we estimate the economic value of carbon sequestration by wetlands. Our study results using Cs-137 radioisotope analysis on the soil cores collected from the centre of the wetland indicate that the wetlands have significant carbon sequestration potential although the rate varies geographically. The economic value of carbon sequestration is based on Canadian federal carbon pricing of $30. In southern Ontario, the carbon sequestration rate was highest for wetlands restored 20 years ago (369 g C m-2 yr-1 or 13.5 Mg CO2 ha-1 yr-1) showing an increase from wetlands restored 10 years ago (142 g C m-2 yr-1 or 5.2 Mg CO2 ha-1 yr-1) generating a carbon value of $406 and $156 per hectare respectively. Our results illustrate that wetland restoration could promote a viable carbon market for landowners and help inform policymakers to develop wetland conservation strategies. Our ongoing research is estimating the carbon sequestration rate for different agricultural landscapes in Canada.

2.7 Mycorrhizal interactions with biochar

Gorzelak, Monika A.[1]; Kim, Keunbae[2]; Neuberger, Patrick[1]; Ortego Polo, Rodrigo[1]; Li, Chunli[1]; Jin, Long[1]; Romero, Carlos[1]; Hao, Xiying[1]

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[2]University of Alberta, Department for Renewable Resources

Mycorrhizas are symbiotic fungi that improve plant access to nutrients, trading phosphorus and nitrogen for plant-derived carbon. They colonize root cells and send hyphae into soil expanding the reach of the root system. Mycorrhizal hyphae increase soil aggregation, feed the soil food web, and impact the soil carbon cycle. Biochar is pyrolyzed biomass that immobilizes carbon for long(er) term sequestration. Biochar can improve nutrient and water retention when applied to soils, although characteristics vary depending on the feedstock (wood, manure, organic wastes, for example). Here we asked whether naturally occurring mycorrhizal fungi on barley roots would colonize nutrient-amended biochar. We found that a subset of mycorrhizal species grew into root-exclusion mesh bags containing biochar, and that the species differed depending on the nutrient amendment. We tested this effect in soils ranging in pH and found significant differences in mycorrhizal community structure based on soil type. This work illuminates factors impacting naturally occurring mycorrhizal communities in prairie soils and demonstrates that some mycorrhizas actively seek out nutrient sources as part of their lifecycle. Biochar amendments may be useful in supporting mycorrhizal network development in soils, thereby improving soil health.

2.8 Biochar amendment mitigates global warming potential, greenhouse gas intensity and nitrogen losses in dairy manure based agricultural soil under boreal climate

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Dairy manure (DM) application is a common practice to improve soil organic carbon, mineral nutrients and dry matter yield (DMY) of forage crops. However, it leads to nitrate leaching and greenhouse gases (GHGs) emission in different cropping systems. Biochar (BC) amendment is known to sequester carbon, reduce nutrient and gaseous losses, improve soil physiochemical properties and enhance DMY. A field experiment was conducted to determine the effects of DM and inorganic nitrogen (IN) fertilizer application alone and with BC amendments on GHGs emission, global warming potential (GWP), greenhouse gas intensity (GHGI), DMY, nitrate (NO3-) and ammonium (NH4+) retention in 20 and 40 cm soil depth during 2016 and 2017 growing seasons. Experiment was laid out in a randomized complete block design with four replications. Experimental treatments were: 1)

DM with high N conc. (DM1: 0.37% N); 2) DM with low N conc. (DM2: 0.13% N); 3) Inorganic nitrogen (IN); 4) DM1+BC; 5) DM2+BC; 6) IN + BC; and 7) Control (N0). BC amendment to DM1, DM2 and IN significantly reduced cumulative CO2 emission by 16%, 25.5% and 26.5%, CH4 emission by 184%, 200% and 293% and N2O emission by 95%, 86% and 93%, respectively. BC amended treatments enhanced DMY by 6.8% (17.9 to 19.1 Mg ha-1), 4.8% (17.6 to 18.4 Mg ha-1), and 11% (16.9 to 18.5 Mg ha-1), reduced GWP by 25%, 35% and 37%, and GHGI by 30%, 38%, and 43%, respectively. Additionally, BC amendment significantly enhanced NO3- and NH4+ retention in 20 cm soil and reduced NO3-movement to 40 cm soil depth. Here, we propose that, BC application demonstrated a great potential in reducing GHGs emission, GWP, GHGI and nitrogen losses and enhanced DMY of silage corn following DM and IN fertilizer application under boreal climate.

Invited Speakers - Day 2

Session #3: Solutions for Climate Change- Mitigating GHG Production in Agriculture

REYNOLD LEMKE, Research Scientist, Agriculture Agri-Food Canada

"The where, why and how of greenhouses gases associated with farming activities?"

Our planet is warming rapidly, raising important concerns about the resulting risks to, among other things, food security, human health, and biodiversity. Despite evidence that the human-induced build-up of atmospheric greenhouse gases is a primary driver of the rapid warming, emissions continue to increase year-over-year. Activities on the farm can contribute substantive amounts of greenhouse gas to the atmosphere, however, with a clear understanding of the factors that drive emissions it should be possible to devise practical strategies to reduce that contribution. This presentation will provide a synopsis of current understanding of the where, why and how of greenhouses gases generated from farming activities.

ANNE WASKO, Chair, Canadian Roundtable for Sustainable Beef

"Climate Change and Sustainability Solutions from the CRSB Perspective"

This presentation will identify the current state of science on the carbon balance of the Canadian beef value chain from a systems perspective, and will outline the multi-stakeholder sustainability strategy to reduce the greenhouse gas footprint of Canadian beef per unit of product produced. In addition, the presentation will describe an exploratory project being undertaken by the Beef Cattle Research Council, the Canadian Cattlemen's Association and the Canadian Roundtable for Sustainable Beef. The project utilizes stakeholder interviews and a modelling exercise to better understand greenhouse gas-related opportunities for the Canadian beef industry.

TRISTAN SKOLRUD, Assistant Professor, Department of Agricultural and Resource Economics, University of Saskatchewan

"Optimal GHG regulation in agriculture: Mitigating climate change and preserving efficiency"

Canada's agriculture sector accounts for approximately ten percent of national greenhouse gas emissions, yet the federal climate change strategy does little to incentivize meaningful, efficient reduction. In this presentation, I detail research explaining the implications for greenhouse gas-reducing technical change and discuss solutions to minimize the cost of greenhouse gas abatement in agriculture.

CLAUDIA WAGNER-RIDDLE, Professor, Ontario Agricultural College and School of Environmental Sciences, University of Guelph

"Managing greenhouse gas emissions from agro-ecosystems"

Agro-ecosystems contribute significantly to greenhouse gas (GHG) emissions through farm-scale carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) emissions. These emissions can be managed for long-term sustainability of the agricultural sector and to contribute solutions to climate change. An overview of mitigation practices focused on nitrogen fertilizer (4R practices), manure, tillage and crop management will be presented. Integrated assessments of practices considering economic aspects for N2O emission reduction from corn production and GHG emission reduction from milk production in Ontario will be presented as case studies.

DARRIN QUALMAN, Freelance researcher and Author, representing National Farmers Union

"The Real Source of Agricultural Greenhouse Gas Emissions"

Agriculture does not produce greenhouse gas emissions; agricultural inputs produce greenhouse gas emissions. Farmers farmed for about 9,900 years did not affect atmospheric concentrations of GHGs. But then, starting about 100 years ago, farmers began using ever-greater quantities of petro-industrial inputs. The result has been continuously rising emissions. It is these inputs, not agriculture, that are

the source of emissions. The inescapable but provocative conclusion is this: any low-emission agricultural system will be a low-input agricultural system. A recent paper from the National Farmers Union www.nfu.ca points the way to that future.

Invited Speakers - Day 2

Session #4: Solutions for Climate Change: Water Management for Agroecosystem Resilience to Climatic Extremes

JOHN POMEROY, Professor of Hydrology and Director of Global Water Futures, University of Saskatchewan

"Sustainable Water Futures for Agriculture"

Canada's water resources are changing and this will provide challenges and opportunities for the agricultural community. The climate has warmed and in some areas has become wetter and less snowy over time. These trends are expected to continue for some time to come. Extreme weather as floods and droughts has become more common and more extreme and is expected to become more severe in the near future. This talk will review the changes currently occurring in and expected to occur over the 21st century in water supply for irrigation and local precipitation available on farms. Snowpacks, soils and drainage can be managed to sustain soil moisture and reduce downstream impacts on downstream water supply and water quality – how this can be done will be shown. New forecasting abilities to predict water supply and water quality will help in managing water sustainably on the farm or ranch. Research using UAVs to measure snow depth, wetlands, crop status and water use will be shown. This research is all part of the Global Water Futures program – the largest university-led freshwater research program in the world. It is part of the search for solutions to water threats to sustainable agriculture in an era of global change.

PAUL THOROUGHGOOD, Professional Agrologist, Ducks Unlimited Canada and Board member of the Canadian Roundtable for Sustainable Crops

"Climate Extremes: A View from the Farm"

There is an urgent need for producers to manage the impacts of unpredictable drought and flooding within crop production systems. Paul will discuss current practices that can help mitigate crop damage and will also explore practices that can help protect water quality on and off farm. The Canadian Roundtable for Sustainable Crops is in the early stages of building a Code of Practice for crop production in Canada. This is an important step and he will discuss how the Code can influence adoption of "best" practices or outcomes.

MITCHELL TIMMERMAN, Nutrient Specialist, Manitoba Agriculture

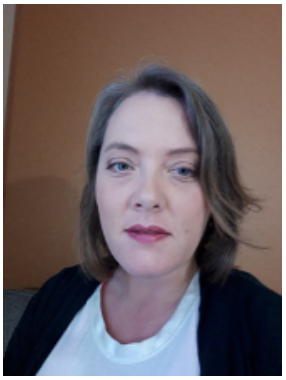
"Too much and not enough…and in the wrong place, at the wrong time! Manitoba's setting, experience and aspirations"

Manitoba presents a daunting water management paradox rivalled by few other places in the world. Lake Winnipeg continues to be among the world's most impaired surface water bodies with a large watershed dominated by agriculture. Excess moisture has been the principal reason for crop insurance claims. Rotations have shifted from short-season, cool-season crops to include long-season crops that have large water demand well into the summer. Livestock production, be it large or small scale, is also vulnerable to big swings in water levels. Amidst these pressures, Manitoba's agriculture industry is striving to adapt. How feasible is the adoption of next-level water management practices? Obstacles remain but Manitoba farmers are expressing rising interest in techniques, technologies and infrastructure. Uptake of incentive programming and collaboration with Watershed Districts reflect that interest. Provincial specialists have explored the potential for increased water storage. Buffering against climate change will be critical for the long-term viability of agriculture in Manitoba.

JANE ELLIOTT, Research Scientist, Environment and Climate Change Canada

"Adapting agricultural water management for agroecosystem resilience in future climates."

Climatic uncertainty will bring challenges to agricultural water management in Canada. Changes in the form, timing, quantity, frequency and intensity of precipitation will impact the quantity and quality of water available for and affected by agricultural production. Management practices will need to adapt to the changing climatic conditions. Some practices that are currently effective in maintaining production while protecting water quality will not be successful in future climates and others may become increasingly effective as the climate changes. Understanding the processes controlling the movement of water and its quality will help us predict the effectiveness of agricultural management practices in future climates. In this presentation we will use examples from the prairies and eastern Canada to illustrate how the suitability of management practices is affected by changing climatic drivers.



LANA SHAW, Research Manager, Saskatchewan South East Research Farm

"Mixed Grain Intercrops: The Value Proposition"

Mixed grain intercropping is a new popular technique of growing two grain crops simultaneously and separating the grain. There are many possible combinations of crops, but some of the most advantageous pairings have seen commercial success. Mixed grain intercropping seems to be one of those rare situations where improved farmer profitability and environmental sustainability align in an exciting trend. For example, chickpea-flax intercrops reduce the need for fungicide compared with monocrop chickpea, which has benefits for the environment and for profitability. It is likely that there are positive effects of the intercrops on beneficial insect diversity, which might mean less demand for insecticides. Improved economic thresholds are likely for use of seed treatments, fungicides, herbicides, insecticides, and nitrogen fertilizer with intercropping, but research is needed. In wet years, intercrops with pulses are typically more successful and less prone to lodging, disease, and harvest losses. However, we don't know what effect intercrops might have on soil water infiltration or snow trapping but there are indications that it could be positive. Residue from intercrops is often taller and more robust, which could reduce soil erosion and improve retention of moisture over the winter months. Observations of reduced water use and variability in total crop growth across a landscape may present solutions for climate change and improved sustainability but experimental work is still needed.

Poster Presentation Abstracts

T = Thursday
F = Friday

T1. Biocontrol potential of entomopathogenic nematodes (EPNs) against selected key insect pests of canola in Alberta

Shabeg S. Briar[1] and Paul Tiege

[1]Olds College Centre for Innovation Olds, Alberta, Canada

The economic impact of canola insect pests is substantial. Resistance to chemicals is a growing problem as the number of chemical control options is shrinking. Therefore, new and environmentally-benign control options are needed for the canola producers. Entomopathogenic nematodes (EPNs) are commercially available biocontrol agents for management of insect pests primarily in the turf grass and green house industry. The ability of foliar-applied infective, predatory nematodes is not been explored in the Prairies. Four EPN species (*Steinernema carpocapsae, S. kraussei*, *S. feltiae* and *Heterorhabditis bacteriophora*) were tested at different rates against foliar insect pests including adults of flea beetles (*Phyllotreta cruciferae*) and larval stages of diamondback moth (*Plutella xylostella*), lygus (Lygus sp.), and two below ground pest including cabbage root maggots (*Delia radicum*) and black cutworms (*Agrotis ipsilon*). Bioassays were performed under controlled laboratory conditions. EPNs were inoculated into the petri dishes or plastic cups for performing bioassays. Mortality was assessed after 72 hours of exposure to the nematodes and observed under the microscope to confirm infection. Steinernematid species (*S. carpocapsae, S. kraussei* & *S. feltiae*) provided significant mortality (80-90%) of diamondback moth, lygus, cabbage root maggots and black cutworms. *H. bacteriophora* provided significant larval mortality of >80% for black cutworms and 70% for diamond back moth. EPN species showed very low host penetration of flea beetles adults and therefore provided only low mortality. The results of this study demonstrate that EPNs may be a useful component of integrated pest management programs for western Canadian growers.

T2. Diversity and Abundance of Native Bees in Canadian Prairie Agroecosystems

Samantha Morrice[1], Jim Devries[2], Sean Prager[1]

University of Saskatchewan[1], Ducks Unlimited Canada[2]

Habitat loss due to agricultural intensification has negative implications for native bee communities throughout Western Canada. Wetland remnants are a common feature within the Prairie Pothole Region of Saskatchewan and are threatened due to increased conversion to agricultural land. Twenty-four million acres of canola and wheat were grown in Saskatchewan in 2018. Wetlands found in this region are embedded in the these agricultural matrices and may act as an important nesting and floral resource for many native bee taxa. Bees were sampled from wetland and field margins into the surrounding cropland across a growing season in three field types (canola, cereal and perennial grassland) in order to quantify the role that these wetlands play in supporting native bees. The purpose of this study is to determine whether conserved natural habitats, such as wetlands, within a highly cultivated landscape support native bee and pollinator diversity that is both ecologically and economically beneficial. Data presented will highlight trends in bee diversity and community structure found within agroecosystems containing wetland habitat. It will also examine the contrast in community structure as it pertains to bees sampled from fields versus those found in natural margins.

T3. Intercropping: are there co-benefits for farmers and farmland birds?

Margaret L. Eng[1], Christy A. Morrissey[2]

[1]Toxicology Centre, University of Saskatchewan

[2]Dept of Biology, University of Saskatchewan

Agricultural land in the Canadian prairies provides important breeding, foraging, and migratory stopover habitat for many birds. At the same time, birds associated with farmland habitat are exhibiting steep population losses, which have been linked to agricultural intensification and associated increases in agrochemical inputs. A possible solution to biodiversity losses associated

with input intensive farming is the "ecological intensification" of farms – farm management practices that promote biodiversity to maintain production and profitability through increased ecosystem services (e.g. biological pest control, crop pollination, nutrient cycling) while minimizing the unintended negative environmental impacts of farming. Intercropping (growing two or more crops in proximity) has the potential to reduce the need for chemical inputs while increasing yield. Such changes in structural diversity and chemical use could also benefit bird abundance and health, which could in turn increase avian ecosystem services (i.e. pest insect control), improving yield even further. Research is needed to test whether intercropping benefits farmland birds, and whether birds play a role in improving crop yields through providing ecosystem services. This poster will outline a proposed project to work with canola growers in Saskatchewan to test the effects of intercropping on 1) avian biodiversity, 2) nest productivity and survival of representative farmland bird species from different guilds, 3) pesticide concentrations in farmland birds, 4) diet diversity of farmland birds as an indicator of ecosystem services, 5) yield and farm profits. The broader goal of this research is to identify agricultural practices and land management strategies that co-benefit farmers and farmland birds.

T4. Public Pastures - Public Interest: A Vision for Multi-Use, Publicly-Owned Grasslands in Saskatchewan

Kristen Martin[1] and Joanne Havelock[1]

[1]Public Pastures – Public Interest group

The original prairie grassland is vital for providing habitat for species-at-risk, pollinators and other wildlife. These grasslands also sequester carbon, enrich and stabilize soil and aid in water retention and filtration. Grazing by herbivores is an essential component of grassland ecosystems. Much of Saskatchewan's remaining grasslands, both native and tame, exist as publicly-owned lands, including community pastures and Crown lands. Public Pastures – Public Interest (PPPI), formed in 2012, brings together urban and rural citizens with a vision for multi-use, publicly-owned grassland spaces in Saskatchewan. PPPI supports the retention of publicly-owned lands in public hands to ensure the preservation of native grasslands and grazing opportunities for producers. In addition, these publicly-owned lands are a resource for scientific research, nature appreciation and traditional Indigenous practices. A significant portion of grasslands are also privately owned, maintained by ranchers, and PPPI works to build relationships with ranchers and other stakeholder groups who have an interest in conserving grasslands. PPPI raises public awareness about grasslands, and advocates for better government policies. Collaboration and connections are needed between environmentalists, agricultural producers and consumers to ensure public understanding of temperate grasslands as the most endangered biome on our planet (International Union for the Conservation of Nature), the environmental and economic contribution of grasslands, the vital role of herbivores in maintaining temperate grassland health through sustainable grazing as compared to livestock production as compared to livestock production that may be harmful in other ecosystems, and to encourage consumer appreciation of these factors in purchasing sustainably produced agricultural products.

T5. Mitigating pesticide and nutrient contamination of agricultural wetlands in Canada's Prairie Pothole Region

Andrea Wade[1], Karsten Liber[1,2], Claudia Sheedy[3], John-Mark Davies[4], Kerry Peru[5], Egina Malaj[1], Christy Morrissey[2,6]

[1]Toxicology Center, University of Saskatchewan,[2]School of Environment and Sustainability, University of Saskatchewan,[3]Trace Residue Analysis and Immunochemistry, Agriculture and Agri-Food Canada,[4]Water Security Agency, Saskatchewan Government,[5]National Hydrology Research Center, Environment and Climate Change Canada,[6]Department of Biology, University of Saskatchewan

Wetlands in the Prairie Pothole Region of North America are a valuable resource to humans and the environment alike. However, intensive agriculture has led to the loss and degradation of wetlands in this region which are frequently contaminated by pesticides. Preliminary work has found that wetlands in this region and frequently contaminated by pesticides, often at concentrations predicted to be hazardous to aquatic life. This project investigates the effects of perennial vegetation plantings (PVP) around wetlands in wheat and canola fields. Our aim is to determine the efficacy of different PVPs and what configurations best protect wetlands from pesticide and nutrient contamination. Aquatic invertebrate communities will be used to assess differences in wetland health as a result of the PVPs. 38 wetlands were sampled in the summer of 2019. These wetlands were located on 9 canola or wheat fields that are part of a Ducks Unlimited Canada or ALUS program. As a result of participation in either of these programs, producers had planted these fields with a perennial forage mix surrounding at least one wetland on the field. Each field contained at least one wetland completely surrounded by crop, at least one wetland surrounded by the PVP, and some fields contained additional wetlands encompassed by the PVP to varying degrees. This allowed for a blocked study design where multiple wetlands on each field were sampled for pesticides, nutrients, and aquatic invertebrates. Pesticide and nutrient contamination as well as aquatic invertebrate diversity metrics of each wetland will be assessed as a function of how protected each wetland is by a PVP. Percentage of the wetland surrounded by the PVP as well as width of the planting around the wetland

will be used to determine how protected each wetland is. Identifying what PVP implementation strategies are most effective will allow land owners and conservation organizations to design and prioritize incentive programs that best protect our wetland resources in working agricultural landscapes.

T6. Alberta Environmental Farm Plan Habitat Management Tool

François Blouin, **Paul Watson**[1,5], Robin Bloom[2], Jeff Harder[2], John Wilmshurst[3], David Johns

[1]Alberta Environmental Farm Plan, [2]Environment and Climate Change Canada, [3]ProofreadCanada, [4]Alberta Environment and Parks, [5]Corresponding author: efp@areca.ab.ca

The Alberta Environmental Farm Plan (EFP) program has developed a Habitat Management Tool, currently focused on species at risk (SAR) tool to enable producers to manage habitats for multiple species at risk. It uses federal, provincial, regional, and publicly-available data bases to predict what SAR habitats could potentially occur on any given ¼-section. The tool requests information on habitats from producers, then then revises predictions of SAR habitats. The tool provides habitat management options based on revised probabilities for the presence of SAR habitats.

The purposes of the tool are to provide: (i) an awareness of which SAR might be present on a ranch or farm, (ii) provide producers with simple actions they can take to preserve SAR and SAR habitats, and, (iii) to provide further resources (funding, expertise, information) to producers. As a mandatory component of Alberta EFP's workbook, this online tool is expected to reach between 10,000 and 25,000 farmers and ranchers over the next decade. It is extensible nationally and a pilot project has started to move this tool to other jurisdictions. This presentation will demonstrate the tool and briefly explain its theoretical underpinnings.

T7. Diversity and Abundance of Beneficial and Pest Insects in Canadian Prairie Agroecosystems

Adam Jewiss-Gaines[1], Sean Prager[1], Jim Devries[2]

[1]University of Saskatchewan, Dept. of Plant Sciences,[2]Ducks Unlimited Canada

The prairie pothole region (PPR) is a specialized ecosystem that extends throughout the Canadian prairie provinces and several northern US states. The PPR contains numerous 'potholes', which are temporary or semi-permanent water bodies that fill after the winter months, becoming prominent wetland habitats for a wide range of organisms. Potholes are commonly associated with agricultural fields throughout Saskatchewan, and therefore provide environments for insect fauna to utilize within those croplands. These may include beneficial taxa that promote development of local plantlife or crops through actions such as pollination or soil nutrient cycling, but also pests which can adversely affect the vegetation. In summer 2018 and 2019, fifteen fields near Humboldt, SK were examined, which were composed of wheat, barley, canola, or semi-restored grassland; each field also contained a prairie pothole. Two transects were established for each field, with one extending 150 m inward from the edge of the field, and the other extending 150 m into the field from the edge of the prairie pothole. Insect traps (pitfalls, pans, vanes, and sticky cards) were set at 0, 75, and 150 m along each transect at five different times throughout the summer to sample the insect population in each field. Insects are currently being identified and their taxonomic information databased for future data analysis. This research will shed light on the insect composition in Saskatchewan agricultural ecosystems, while also identifying beneficial and pest insects that exploit prairie pothole wetlands to exist in these ecosystems as well as the effects they confer.

T8. Influence of Wetland Pesticide Pollution on Waterfowl Distribution, Abundance and Productivity in the Prairie Pothole Region.

Tyler Bryan[1] and Christy Morrissey

[1]Dept. of Biology, University of Saskatchewan, Saskatoon, SK

The Prairie Pothole Region (PPR) provides critical stop-over and nesting habitat for many migratory avian species, namely waterfowl. The majority of the region has been converted to cropland, in-turn, dramatically changing the landscape from its historic condition. Current conventional agricultural practices often rely heavily on insecticides, fungicides and herbicides to maintain crop health throughout the growing season. Recent studies have shown alarming levels of pesticide pollution in wetlands throughout the PPR. The levels are high enough to cause detrimental impacts on aquatic macroinvertebrate and macrophyte populations; in-which, many species of waterfowl rely strongly upon. Direct effects on waterfowl abundance and distribution such as water availability and habitat quality are well studied however, indirect effects of agrochemicals on waterfowl

abundance, distribution and productivity, is lacking. For this study, we will examine the relationship between wetland pesticide pollution and the distribution and abundance of waterfowl across the PPR. In addition, I will conduct focal studies on selected wetlands in the PPR portion of Saskatchewan to assess brood productivity for species of diving and dabbling ducks.

T9. U of M Long-term agronomic studies

Sarah Wilcott[1], Rob Gulden[2], Mario Tenuta[1], Don Flaten[1], Yvonne Lawley[2], Katherine Stanley[2], and Martin Entz[2]

[1]Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada
[2]Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada

Long-term studies increase our understanding of sustainability, yields, economics, and crop rotations that often requires many years to see. The difficulties of maintaining long-term studies are continued funding, ensuring practices and equipment can be consistent or comparable, and ensuring the data produced is meaningful. The University of Manitoba has five long-term agronomic studies that are discussed. The Glenlea Long-term Rotation study began in 1992 and is the oldest study of organic cropping systems in Canada. This study compares two rotations under organic and conventional management. The Pesticide Free Production (PFP) study began in 2000 to investigate the effects on weed populations and crop performance in two rotations, with the goal of maintaining productivity and reduce pesticide applications. The new phase is looking at row spacing and seeding density. The National Centre for Livestock and the Environment aims to further the economic and environmental sustainability of integrated livestock and crop production. This field trial compares several types of manure and manure management on annual and mixed annual/perennial cropping systems. Optimizing Systems Productivity, Resilience and Sustainability in Major Canadian Ecozones is a long-term study that began in 2018. The study is one of seven sites that will look at six cropping systems and determine the best one for each ecozone. Early adopters are growing cover crops in Prairie Canada, but questions about their viability, impact, and benefits remain. This project will evaluate cover crops in rotations in MB, SK, and AB over a four-year period.

T10. Promoting Soil Health through Extension and Incentives

Mitchell Timmerman[1], **Matthew Wiens**[1]

[1]Manitoba Agriculture and Resource Development

Despite challenges in tracking soil carbon changes, government departments are moving ahead in promoting practices that show promise in building soil carbon. Manitoba Agriculture and Resource Development provides extension and funding for a number of practices that are likely to build soil carbon and provide other soil health benefits. These practices include planning, cover cropping, intercropping, adding perennials to annual crop rotations, establishing perennial forages on sensitive land, and improving grazing management. This poster presents the soil health and soil carbon benefits attributed to each of these practices, with references to studies and resources that support the practices. Also described are the Manitoba Agriculture and Resource Development initiatives that promote soil health through extension and incentives.

T11. Organic Soil Amendments, Carbon Dynamics and Plant Productivity in Non-Saline and Saline Soils from South-Central Saskatchewan

P. Hrycyk, **J. Schoenau**, G. Wang, D. Peak and H. Steppuhn

Department of Soil Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8
Soil carbon storage and productivity of salt affected soils may be enhanced through the use of high carbon content soil amendments along with growing salt-adapted crops. A field experiment was established in the Brown soil zone in southern Saskatchewan in the spring of 2017 to assess effects of adding leonardite, humic acid, and composted steer manure and growing three crops (AC Saltlander green wheatgrass, Invigor canola and Tully Champion willow) on total soil organic carbon (SOC), carbon fractions and crop growth. The soil samples collected in the spring of 2017 prior to establishment of treatments revealed similar SOC concentrations of 1.47% and 1.23% in the saline and non-saline sites, respectively. Soil samples taken in the fall of 2017 and spring of 2018 revealed that the total SOC mass in the 0-10 cm depth was significantly greater by 23% and 16% in the leonardite amended treatment compared to all other treatments in the non-saline and saline soils, respectively. The green wheatgrass had the largest impact on soil carbon fractions measured. After one year, the total SOC mass in the 0-10 cm depth in the non-saline site treatments seeded to green wheatgrass was significantly higher than under canola and willow. Biomass production in 2017 was significantly lower on the saline than the non-saline soil, and the organic amendments did not

significantly increase yield of any of the crops. However, in subsequent years (2018 and 2019), the biomass yield of the green wheatgrass on the saline site was observed to be catching up with yield on the non-saline soil.

T12. The Road to Fossil Fuel Free Farming - One Farm's Journey

David Rourke MSc, Minto Manitoba

1. Motivators for change and evolution of our farm practices…. locally and globally
2. Our crop rotation template.
3. Our optimization curve
4. Our goals, 4x more profit, 2x rate of carbon sequestration, feed at least the same number of people, reduce fossil use by 90%
5. Our experience with intercropping, green manure, catch crops, smother crops, under seeding, green seeding
6. Replacement motive energy….. short term –long term
7. Evidence for successful organic based solutions
8. Continuing the journey… next steps

T13.Soil carbon and nitrogen fractions as affected by soil physical disturbance in grazed legume-grass pasture systems

G. Issah[1], J. Schoenau[1], B. H. Lardner[2] and J. D. Knight[1]

[1]Department of Soil Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada
[2]Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada

Tillage, like any other form of forage termination, is frequently employed to regenerate the productivity of a pasture stand or prepare the land for annual cropping. Tillage alone, or in combination with other forage termination methods, has proven successful as part of the process in rejuvenating old pasture stands. However, the effects of tillage on C and N fractions in the short-term have not been determined in long-term pasture systems in western Canada. The objectives of this study, conducted at the Western Beef Development Centre (WBDC) at Lanigan, SK, were to determine the impacts of tillage on C and N fractions in legume-grass pastures containing three different legume species: alfalfa, cicer milkvetch and sainfoin. Tillage was imposed in the fall of 2018. The tested hypothesis was that the disruption of soil aggregates through tillage would increase microbial respiration and organic C loss. In the spring of 2019, no significant measurable effect on total, light fraction and dissolved organic C and N were observed. However, by the summer of 2019, dissolved organic N was reduced due to the tillage operation (p<.0001). Microbial biomass C (MBC) was lower in tillage treatments in both the spring (p=0.0002) and summer (p=0.0027). The aggregate disruption that occurred with tillage in the fall may have increased initial decomposition, followed by a decrease in microbial populations and activity later in the season. There was no apparent effect of legume species on the C and N fractions after one growing season. The trend suggests that all the legume species evaluated may similarly respond to a disturbance.

T14. Second-Year Decomposition and Nutrient Release Characteristics of Ten Annual Crop Residues in South-Central Saskatchewan

Ryan Hangs* and Jeff Schoenau
Dept. of Soil Science, University of Saskatchewan, Saskatoon, SK

Quantifying crop residue decomposition will help to improve our understanding of carbon (C) sequestration and nutrient cycling within agroecosystems, while providing valuable data for model development and validation. The objective of this study was to quantify the decomposition and nutrient release dynamics under field conditions of post-harvest residues from a variety of annual crops grown in Saskatchewan: barley, wheat, oats, field pea, lentil, faba bean, soybean, canola, flax, and hemp. Litter bags were placed on the soil surface in the fall, prior to snowfall, and then collected after four time intervals (six months, one year, two years, and three years), for modelling the rates of mass loss and release of nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) to the plant available soil nutrient pool. After two years, the differences in mass loss (20-83%) and cumulative N, P, K, and S release (-5 to 86%) among the crop residues, were attributed to variation in the specific surface area and quality among residues. Average residue N, P, K, and S additions to the soil nutrient pool differed among nutrients (10, 1, 15, and 2 kg/ha, respectively) and crop residue. Unlike the legume and oilseed crop residues that contributed N via net mineralization (19 and 12 kg N/ha), the cereal crop residues immobilized soil N (-4 kg N/ha). There were no apparent P, K,

and S loss trends among residues. Despite similar mass (and C) losses, there were considerable differences in nutrient release among crop residues after two years, with initial residue quality being an important factor controlling decomposition and nutrient release, particularly for N. Generally, the cereal residues (especially oats) are decomposing and releasing nutrients slower than other residues, explained by wider C:nutrient ratios. Similar measurements after three years should provide more insight into longer term biomass and nutrient dynamics among these various crop residues.

F1. Estimating the Role of Cover Crops in Soil Carbon Change within the Holos Model

Olyvia Foster, Amara Hill, Ellise Proctor, Maja Menegotto, Patricia Sadowski, Sarah Sims, **Roland Kroebel**[1]

[1]Agriculture and Agri-Food Canada, roland.kroebel@canada.ca

The Holos model is a resource for Canadian farmers to mitigate greenhouse gas emissions based on farm inputs. Cover crops were not initially included in the Holos model because farmers within Canada only recently began to include cover crops in crop rotations. Cover crops can be utilized to sequester large amounts of carbon without negatively influencing the future crop yield. Moreover, they allow for an increase in biodiversity, reduction of soil erosion, limit drought stress and reduce nitrogen leaching. Cover crops offer an alternative to leaving the land bare during the winter, which can later be ploughed under the soil as green manure. However, there is a lack of knowledge surrounding the contribution of cover crops to soil nitrogen and soil carbon change.

A review of the literature was conducted for information on Canadian cover crop species including average yield, biomass fractions and nitrogen concentration. The species investigated included grass, legume, cereal, and broadleaf species. Unfortunately, we determined that grass species utilized as cover crops is a significant knowledge gap. It is hypothesized that the reasoning behind this gap was due to a lack of monetary incentives for research to be conducted surrounding grass species as cover crops. Identifying this knowledge gap displays the need for future research within this topic area. The collection of real-world data would allow farmers to gain a deeper understanding of the impact their farm systems have on the environment.

F2. Microbial N cycling functional gene abundance in forage grazed pasture soils and links to N_2O emissions

Tram T.N. Thai, Melissa M. Arcand and Bobbi L. Helgason.

Department of Soil Science, University of Saskatchewan

Introduction of legumes such as cicer milkvetch (*Astragalus cicer*) and sainfoin (*Onobrychis viciifolia*) in forage pasture is a common practice to improve yields and reduce bloat, but how this affects soil microbial community, particularly those involved in greenhouse gas (GHG) emissions (CO_2, N_2O, CH_4), is still poorly understood. The research was conducted at Termuende Research Farm at Lanigan, SK. The pasture was a grass-legume stand dominated by brome grass (*Bromus madritensis*) and alfalfa (*Medicago sativa*). In 2015, cicer milkvetch and sainfoin were sod-seeded on the existing pasture ad here we compare these to the original pasture composition (control). Static chambers were used to monitor GHGs; PRS^{TM} probes were used for monitoring soil nutrients; Environmental conditions (daily temperature and precipitation) were recorded on site and soils were sampled for microbial analysis in 2017-18. Quantitative real-time Polymerase Chain Reaction (qPCR) was conducted to quantify the abundance of N cycling functional genes (*amoA*, *nirS/nirK* and *nosZ*). Gene abundances are linked with gas, soil and environment conditions to explore their role in N_2O emission. This research will give a more comprehensive understanding of key drivers/indicators of soil N cycling and GHG, which will help shape management practices that mitigate GHG emission in grazed forage pasture.

F3. Adaptive Multi-Paddock Grazing Lowers Soil Greenhouse Gas Emission Potential as Compared to Conventional Grazing

Bharat M. Shrestha[1], Edward W. Bork[2], Cameron N. Carlyle[2], Timm F. Döbert[3], Scott X. Chang[1], Dauren Kaliaskar[1], Mark S. Boyce[3]

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Grazing management, including grazing intensity and system of rotation, can influence fluxes of greenhouse gases (GHG) within grasslands. Adaptive multi-paddock (AMP) grazing system is a modified rotational grazing in which small paddocks are grazed with high densities of livestock for short periods, with long recovery periods between successive grazing events. In this study, we compared the fluxes of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) from soils of AMP to those of more conventionally grazed (Non-AMP) grasslands, and tested their sensitivity to varying temperature and moisture levels in a

laboratory incubation experiment. We collected soils from 11 ranch pairs across a climatic gradient in Alberta, Canada, and incubated them at field capacity (FC), 40% of FC (0.4FC), or permanent wilting point (PWP), for 102-days, at either 5 or 25 ºC. The 102-day cumulative flux of CO2, N2O and CH4 was affected by both soil temperature and moisture levels ($P < 0.05$). While fluxes of N2O were independent of grazing treatment, CH4 flux varied in relation to grazing treatment, and there was an interaction of grazing × temperature ($P < 0.05$) on CO2 flux. Cumulatively, AMP soils emitted 17% more CO2 than non-AMP soils when incubated at 5 ºC, but 18% less when incubated at 25 ºC. When incubated at 25 ºC, the AMP soils emitted 32% less N2O and absorbed 147% more CH4 than the Non-AMP soils. The temperature sensitivity (Q10) of CO2 flux increased with soil moisture levels (i.e., PWP < 0.4FC < FC). The net GHG flux (CO2-e, sum of fluxes of CO2, N2O and CH4 equivalent to CO2) increased from 885 ± 120 mg CO2-e kg-1 at 5 ºC, to 4190 ± 603 mg CO2-e kg-1 at 25 ºC in AMP soils, compared to 759 ± 152, and 5126 ± 851 mg CO2-e kg-1, respectively, in Non-AMP soils. We conclude that AMP systems have the potential to mitigate the impact of a warmer soil on future climate change by emitting less CO2 and N2O, and oxidizing more CH4, as compared to conventional grazing in northern temperate grasslands.

F4. Microbes, primed and ready: higher protein in cattle forage can increase primed soil N2O and CO2 emissions in the urine patch

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Within pasture systems, methane is produced by enteric fermentation in cattle. Additionally, cattle urine patches increase soil carbon dioxide (CO2) and nitrous oxide (N2O) fluxes. Producers include non-bloat legumes in pasture forage to increase cattle protein uptake and reduce enteric methane emissions. However, increased protein content in forage can increase urine nitrogen (N) content, potentially increasing N2O emissions from the soil by providing more N substrate to soil microorganisms in the urine patch. While urine patches can shift soil microbial community structure, it remains unclear how this influences the abundance and activity of N-cycling, N2O-producing soil microbes. Soil microcosms were constructed and spiked with urine containing two levels of urea-N and compared to a water control. Urea containing 13C and 15N isotopes was added to the urine to distinguish urea-derived fluxes from soilderived fluxes of CO2 and N2O. The introduction of urine primed the decomposition of soil organic matter (SOM). Doubling the urine urea-N concentration more than doubled urea-derived and primed SOM derived CO2 gas fluxes. Treatment N2O flux trends were more variable. However, the addition of urine increased the priming of soil N to N2O with the highest urea-N concentration having the largest urea- and soil-derived N2O fluxes. Gas data will be correlated with gene and transcript abundances of microbial N cycling genes. This study will contribute to the understanding of microbial N2O sources in the urine patch and underscores the need to weigh the global warming potential of methane reduction against increased N2O production.

F5. Practices with Potential for On-Farm Greenhouse Gas Mitigation in Manitoba: What's next?

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The types and sources of agricultural greenhouse gas emissions are well understood, as are numerous practices that may reduce these emissions. This poster illustrates the main sources of agricultural greenhouse gas emissions in Manitoba, and identifies applicable mitigation practices. Many of these practices have been promoted by government, industry and academia for decades, with notable successes, particularly in terms of reduced emission intensity. However, total greenhouse gas emissions have generally risen over the last three decades. Can we move from incremental to transformational improvements? Potential initiatives and practices are discussed with this question in mind.

F6. Does the federal carbon pricing policy increase the cost of grain transport to Canadian producers?

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Carbon pricing has the potential to create economic incentives for industry stakeholders via: i) adoption of environmentally sustainable and strategic management strategies; ii) redirected investments and iii) reduced greenhouse gas emissions and the

overall carbon footprint by substituting carbon-intensive products such as fossil fuels, with alternatives that have a lower or no carbon content. The recently imposed federal levy, adopted in Ontario, New Brunswick, Manitoba, Saskatchewan, Yukon, and Nunavut, applies a charge to fossil fuels with a rate of $10/t CO2e in 2018, rising by $10/t CO_2e per year to $50/t CO_2e by 2022. Although primary agricultural producers using dyed fuels are exempt from this levy, many producers and commodity groups have expressed concern regarding additional costs associated with carbon pricing on crop inputs including fertilizer and transportation. As farms become more specialized, custom hauling grain to market has become increasingly popular. Therefore, an examination of the impact of carbon pricing on transportation is a reasonable first step to examine potential overall cost increases incurred by grain producers. A model was developed using a case farm consisting of 810 hectares, three different crops (wheat, canola, and corn) with two projected yields (4050 kg/ha and 4513 kg/ha, 2980kg/ha and 3278kg/ha, and 9380 kg/ha and 10318 kg/ha for wheat, canola and corn, respectively), four different trailer/truck combinations (tandem/tandem, semi/straight, semi/triaxle, and semi/super B). Analysis of these scenarios indicated that additional costs associated with the carbon tax range from $0.54/ha to $2.54/ha. The next step in further development of the model is to include additional inputs including fertilizer to allow for a more complete examination of the impact of the federal levy.

F7. The effects of crop rotation and nitrogen fertilizer additives on mineral N and gaseous losses in a boreal climate

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Northern boreal regions will become more conducive for agricultural production as the climate warms. This ecozone covers 35% of the total land area in Canada. Agricultural activities contribute 10% of Canada's greenhouse gas (GHG) emissions and effects of expansion to boreal regions are not understood. Nitrous oxide (N_2O), a GHG with ~300 times the global warming potential than CO_2, is emitted from soils following nitrogen (N) application, land cultivation, and the breakdown of crop residues. However, N transformations in agricultural lands under boreal climatic conditions, as it relates to GHG emissions and nitrogen use efficiency, is largely unknown. The objective of this study is to investigate the effects of crop rotation and N fertilizer additives (urease and nitrification inhibitors) on CO_2 and N_2O emissions and mineral N (NO_3^- and NH_4^+) dynamics. A three-year field study was initiated on a long-term fallow field (20+ years) at the Pynn's Brook Agricultural Research Station, Newfoundland and Labrador. Experimental treatments include two crop rotations (continuous corn (control); corn/canola/faba; corn/faba/canola) and five N fertilizers (urea, urea + ammonium nitrate, Agrotain™, eNtrench™, and Super U™). The static chamber method will be used to collect gas samples weekly for one month post-planting then bi-weekly until harvest. Soil temperature and moisture measurements will be taken using integrated time domain reflectometry (TDR) probes. Soil samples will be collected (0-20 cm) to determine mineral N; and denitrification potential will be determined using the acetylene inhibition technique. This study will contribute new knowledge about N dynamics and GHG emissions resulting from different crop rotations and nitrogen fertilizer additives in boreal agriculture.

F8. Estimating national livestock feed and land area requirements in Canada

Kebebe Gunte, Genet Mengistu, Marcos Cordeiro, Getahun Legesse, Tim McAllister, Sarah Jensen, Sarah Pogue and Kim Ominski

Satisfying increasing food demand while sustainably using natural resources is a significant challenge facing humanity. This is a complex endeavor that may include several sustainability metrics such as greenhouse gas emissions, water and nutrient use efficiency, water quality monitoring, carbon sequestration accounting and biodiversity conservation. At the cornerstone of these metrics, is the need to clearly understand the feed requirements and underlying land base necessary to produce the feed consumed by Canadian livestock. However, current data regarding aggregate demand for livestock feed and land area in Canada is not readily available. Livestock feed production is driven by the demand to produce animal-based foods, which is in turn influenced by the choice of diet by consumers. Therefore, we estimated the total amount of each feed type required by 11 livestock classes of commercial relevance in Canada, including aquaculture. Feed requirements for each livestock species were estimated based on the daily intake of typical diets, the number of animals in a given life phase, and the duration of each life phase. Total requirements of each feed type were then used to estimate the area required to produce each feedstuff based on Canada's total farm animal population, crop, and pasture productivity in 2016. It was estimated that over 71 million tonnes of feed dry matter (DM) were required to meet the needs of Canada's livestock species. Pasture, dry forages and other roughages accounted for 52.36% of the total estimated feed DM required. Energy feeds such as cereal grains, protein supplements, and silages accounted for the remaining 47.64% of feed DM. Beef (51.5%), dairy (21.4%), and pigs (12.4%) accounted for the majority of feed needed to sustain Canada's livestock. Approximately 22.4 million hectares of land were required to meet the annual feed requirements of domestic farm animals. These data will enable us to examine the potential impacts of animal production on

environmental sustainability and land use in Canada, as well as explore the implications of potential changes in consumer dietary behaviour on environmental sustainability, nutritional adequacy, and land use in Canada.

F9. Balancing agronomic outcomes and greenhouse gas – nitrous oxide emissions using enhanced efficiency fertilizers in canola production.

Trang Phan, Drs. Kate Congreves, Rich Farrell, Tristan Skoruld

Due to a low Nitrogen use efficiency (NUE), canola production requires a high N input to optimize crop yields. The large amount of soil N surplus impacts the fertilizer investment for farmers and poses risks to the environment, especially in the form of nitrous oxide (N_2O). Therefore, optimizing crop yields without compromising the integrity of the environment is a significant challenge in canola production, and much attention has been directed toward the better fertilizer management. The 4R framework provides guidelines for moving toward sustainable agriculture, which suggests that fertilizer should be applied at the right source, right rate, right time, and right placement.

The potentials of enhanced efficiency N fertilizer (EENFs) to reduce N_2O emissions in dryland canola production will be the primary focus of this study. Three components of the 4R strategy, which are the right source, rate, and timing will be implemented. The crop performances such as N uptake, NUE, yield, and N_2O emissions will be quantified and compared between the fall *vs.* spring application of EENFs and conventional urea. The yield-scaled N_2O emissions factors for the fertilizer type, application rate, and timing will be calculated to determine the best balance of agronomic and greenhouse gas N_2O emissions.

F10. Soil organic carbon in irrigated agricultural systems: a meta-analysis

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The effects on soil carbon storage of adopting no- or reduced tillage, applying organic soil amendments, and maintaining continuous cover have been well-studied. By contrast, the effects of irrigation on soil carbon dynamics are poorly understood. Given the large and expanding landbase used for irrigated agriculture across the globe, this is a critical knowledge gap for climate change mitigation. We conducted a systematic literature review of the published scientific literature to compile a comprehensive dataset describing the effects of irrigation on soil organic carbon (SOC) storage for three types of studies: (1) studies that examined changes in SOC on irrigated sites through time; (2) studies that compared SOC in irrigated and rainfed agricultural systems; (3) studies that compared SOC in 'natural', unmanaged sites and sites managed using irrigated agriculture. Next, we will use meta-analysis to predict irrigation-caused changes in SOC storage and identify the conditions under which irrigation increases or decreases SOC. Preliminary results suggest that climate (aridity) and irrigation water chemistry are important predictors of changes in SOC caused by irrigation over time. On natural sites converted to irrigated agriculture, total nitrogen and soil texture are important predictors. This work could be used to develop site-specific irrigation management practices for promoting SOC sequestration.

F11. CropMetrics: A New Tool For Monitoring Crop Growth

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Canada is a global supplier of grains, oilseeds and pulses and prides itself in providing safe and innovative products that consistently surpass world standards. In order to maintain this high standard and break into new markets, governments and industry need timely access to key information and analysis to inform decision-making at regional and national levels. Agriculture and Agri-Food Canada has developed *CropMetrics*, a web-based application to link key pieces of information on historical and forecasted yield, weather conditions and risks and make these accessible to the sector in real time over the growing season. *Crop Growth Metrics*: indicators of crop health, growth, and yield with value-added social, economic and environmental information that help explain the indicator results. What the Crop Metrics application does:

1. Provides user-customized reports of major crop yield trends and the seasonal outlooks of crop yields across the agricultural landscapes of Canada.

2. Calculates crop growth and development parameters from a set of climate, satellite and modeled intermediate data sets such as soil moisture and heat units to predict crop yield and production with a lead time of 2 to 3 months.
3. Provides visualization tools to examine in detail the characteristics of predictor variables such as accumulated precipitation, heat units, risk levels from pests and diseases and gives an option to print data outputs.

The application is going through a second round of testing with clients as part of outreach before official release in the near future. Our presentation is part of this consultative process.

F12. Sustainable Nutrient Management for Balancing Crop Production and Water Quality

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Nitrogen and phosphorus play a critical role in crop production. They are also a central concern for water quality. In this poster we present recent results, and aggregate advice on nutrient management strategies to achieve dual benefits of strong crop yields while helping to meet water quality goals in the prairies. We highlight the importance of building up soil nutrients in low fertility soils and drawing down soil nutrients in soils with high nutrient loss risks. Fertilizer and manure nutrient management practices include application of nutrients at the right rate and right timing, with the right source and right method. Vegetation nutrient management include adjustment of cropping systems, using of cover crops and crop residue management to address issues of soil stratification and elevated P export from reduced tillage fields. The poster is aimed at aggregating scientific advice and presenting management recommendations, while soliciting feedback from producers and policy-makers'. Specifically, we welcome their insights into the past, present and future adoption of practices, practical considerations for the adoption, and research priorities.

F13. Agroclimate Impact Reporter (AIR), a citizen science initiative that monitors the effects of weather on agricultural production

Trevor Hadwen, Laura Richard, Raymond Ambrosi

The Agroclimate Impact Reporter (AIR) is a unique Canadian citizen science research initiative that relies on agricultural producers, industry, regional reporters, and concerned citizen volunteers across Canada to submit reports about the on-the-ground impacts of severe weather. While AAFC uses a variety of tools, including data from weather stations, satellites, and computer modeling to understand agroclimate conditions, these methods alone cannot describe the effects of weather events such as drought or flooding on field access, seeding or crop stage. Instead, we must rely on volunteer participation in AIR to provide information about on-the-ground conditions affecting agriculture.
AIR collects reports on severe weather impacts on a range of conditions including surface soil moisture, field accessibility, water quality, crop stage, livestock health, feed supply. The reports are processed to create a variety of monthly agroclimate impact maps that are used by government, universities, schools, non-profits, newspapers and media, and agricultural producers. AIR agroclimate impact maps are an integral component of AAFC efforts to monitor agroclimate conditions and to assist agricultural producers in their crucial role in food production and in the Canadian economy. Citizen science projects such as AIR face constraints in data quality and challenges in building an engaged network of volunteer reporters. Building successful citizen science projects requires careful consideration of the social nature of volunteer activity, frequent contact with volunteers, and ongoing evaluation.

F14. Spatially Explicit Modeling of Wetland Conservation Costs in Canadian Agricultural Landscapes

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Agriculture is a major driver of wetland conversion in the Praire Pothole Region of North America because there is a mismatch between private costs and public benefits of wetland retention and conservation. We applied a spatially explicit wetland conservation cost model to estimate the private economic benefit of wetland drainage in an agricultural landscape in Alberta, Canada, using a canola-wheat crop rotation for 20-years. Moreover, the estimated private economic benefits of wetland drainage were used to assess three wetland conservation policy targeting scenarios based on wetland conservation cost and environmental benefits of wetlands. The results of the study showed a negative correlation between private economic benefits of wetland drainage and the environmental benefits of wetlands; we showed that under this condition, the choice of a wetland conservation policy would be important in achieving a wetland conservation goal, given a conservation budget, in the study area. Again, our study showed that wetlands with high ecosystem values are less likely to be drained, even if they have high private economic benefits. Our study extends the literature on wetland conservation by showing that, a) targeted wetland conservation policies could be an effective policy at conserving wetlands than a uniform conservation policy based on the assumption that all wetlands within an agricultural landscape are the same; b) extending educational programs on environmental benefits of wetlands to agricultural producers could help conserve wetlands with high ecosystem benefits on agricultural landscapes.