CSSS ASSW 2022

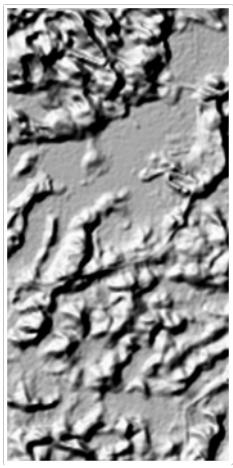
Program Book

2022 Joint Canadian Society of Soil Science (CSSS) Annual Meeting-Alberta Soil Science Workshop (ASSW)

May 23-27, 2022

Lister Conference Centre
11613 87 Ave NW
University of Alberta Campus
Edmonton, Alberta




2022 JOINT CANADIAN SOCIETY OF SOIL SCIENCE (CSSS) ANNUAL MEETING-ALBERTA SOIL SCIENCE WORKSHOP (ASSW)

MAY 23-27, 2022

LISTER CONFERENCE CENTRE

11613 87 AVE NW

UNIVERSITY OF ALBERTA CAMPUS

EDMONTON, ALBERTA

Organizing Committee

Scott Chang (Co-Chair)
Symon Mezbahuddin (Co-Chair)
Asim Biswas
Konstantin Dlusskiy
Ali El-Naggar
Christopher Nzediegwu
Monika Gorzelak
Len Kryzanowski
Tariq Siddique

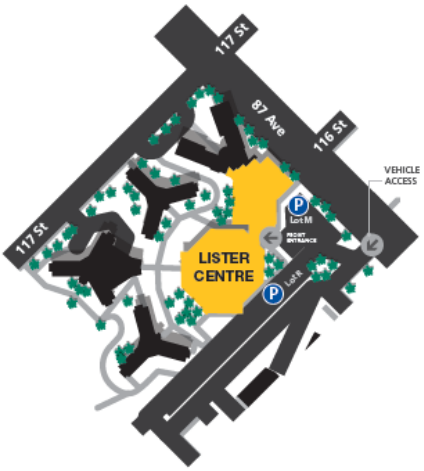
A Note on Health and Safety during the Conference

Delegates attending this conference are strongly recommended to wear masks and must do a daily personal health check (https://open.alberta.ca/dataset/56c020ed-1782-4c6c-bfdd-5af36754471f/resource/58957831-a4ab-45ff-9a8e-3c6af7c1622e/download/covid-19-information-alberta-health-daily-checklist-2022-02.pdf) prior to coming to the conference. Delegates who are sick, have COVID-19 symptoms or who are isolating must stay home/hotel room and not come to the event.

Conference Site and Meeting Room Locations

UNIVERSITY OF ALBERTA

CONFERENCE CENTRE



LEVEL 1

LEVEL 2

780.492.6057 | www.conference.ualberta.ca

UNIVERSITY OF ALBERTA
CONFERENCE SERVICES

Welcome Messages

UNIVERSITY OF ALBERTA

May 16, 2022

Dear Delegates of CSSS-ASSW 2022,

Re: Joint Canadian Society of Soil Science (CSSS) Annual Meeting-Alberta Soil Science Workshop

On behalf of the Faculty of Agricultural, Life and Environmental Sciences (ALES), it is my great pleasure to welcome you to the University of Alberta, home of one of the oldest soil science programs in Canada. Our Faculty (established in 1915) is actively engaged in teaching and research in support of Alberta's agriculture, food, forestry and energy sectors. In 2019, the soil science program celebrated its centennial. It is fitting that this soil science conference is being held at the University of Alberta.

We wish you a very warm welcome to Edmonton, North America's northernmost city with over one million people. As an Edmontonian I am proud of the rich culture and heritage the city has to offer. I hope that you will take advantage of your presence in Edmonton to explore what this beautiful city has to offer. Take some time to explore our beautiful river valley!

As our society is facing a myriad of challenges ranging from climate change to food security, it is timely that this conference will discuss "Soil Science for Sustainable Development". I believe that soil science has a pivotal role to play in addressing many of our challenges. If our soil is mismanaged the viability of our civilization will be in danger.

Finally, I wish you a pleasant stay in Edmonton and a huge success with the conference.

Sincerely,

Stanford F. Blade, PhD, P.Ag.
Dean, Faculty of ALES

Dean's Office
College of Natural + Applied Sciences
Faculty of Agricultural, Life & Environmental Sciences (ALES)
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UNIVERSITY OF ALBERTA

FACULTY OF AGRICULTURAL, LIFE & ENVIRONMENTAL SCIENCES
DEPARTMENT OF RENEWABLE RESOURCES

751 General Services Building
Edmonton, Alberta, Canada T6G 2H1
Tel: 780.492.4413
www.rr.ualberta.ca

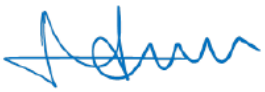
Welcome Message from the Chair of the Department of Renewable Resources, University of Alberta

On behalf of the Department of Renewable Resources, I would like to extend my warm welcome to all of the participants, and in particular, the plenary and invited speakers of the 2022 Joint Canadian Society of Soil Science (CSSS) Annual Meeting-Alberta Soil Science Workshop (ASSW) to Edmonton and to the University of Alberta campus.

I believe this conference, on "Soil Science for Sustainable Development", will provide many opportunities for sharing and exchanging original research, inspiring young researchers, and broadening knowledge about various fields in soil sciences amongst conference participants.

I also want to express our sincere appreciation to members of the Organizing and Program Committees for the time and energy they have devoted to the joint conference. Last but not least, I would like to extend our gratitude to the University of Alberta, Paragon Soil & Environmental Consulting Inc., Element and many other sponsors for their support to this conference.

I will be making a presentation in the "Soil and Plant Microbiomes" session and am looking forward to meeting with you in person.



Nadir Erbilgin
Professor & Chair
Department of Renewable Resources
University of Alberta, Edmonton
E-mail: erbilgin@ualberta.ca

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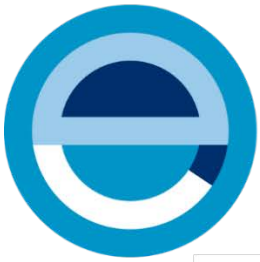

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Territorial Acknowledgement

The Lister Conference Centre as part of the University of Alberta campus is located on the traditional territory of Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, and Ojibway/Saulteaux/Anishinaabe nations; lands that are now known as part of Treaties 6, 7, and 8 and homeland of the Métis. The University of Alberta respects the sovereignty, lands, histories, languages, knowledge systems, and cultures of First Nations, Métis and Inuit nations.

Internet Access

Find the WiFi connection called University of Alberta "Guest", scroll down the page that comes up and "accept" the terms, then you should have access to the internet.

Registration

Monday, May 23 and Tuesday May 24, 2022

13:00-21:00, Hallway off the Dining Hall, on the second level of the Lister Conference Centre

Reception

Monday, May 23, 2022

18:30-21:00, Reception, Maple Leaf room, Lister Conference Centre

Virtual Attendance

For virtual attendance, please access the program through the conference website https://csss-assw2022.ca/programvirtual.html. Select the session you would like to attend, click on the link to that session. You will need a password to attend the meeting. The password is emailed to registered participants and is not to be shared with those who have not registered.

Schedule at a Glance

Starting time	23-May	24-May				25-May			
7:30		Breakfast				Breakfast			
7:45									
8:00									
8:15		Opening Ceremony							
8:30		Plenary Ok - Metal Contamination and Bioremediation of Agricultural Soils for Food Safety and Sustainability				Plenary Turetsky - The Future of Northern Organic Soils: Threats and Opportunities			
8:45									
9:00									
9:20		Plenary Shotyk - Soil: The Key to Understanding Trace Elements in Air, Water, and Plants, from Source Assessment to Ecological Significance				Plenary Arcand - Reciprocity in Soil Science: Knowledge Sharing and Co-Creation for Soil Management on First Nations Agricultural Lands			
9:30									
9:45									
10:10		Break (Soil Health Leadership Meeting)				Break			
10:15									
10:30		Session15 Beyond Soil Test P: Phosphorus Biogeochemistry in Canadian Soils	Session 4 Soil Taxonomy and Pedology	Session 19 Soil and Water Conservation in the Face of Climate Change	Session 2 Data Science, Modelling and AI in Soil Science	Session 9 General Land Reclamation Session	Session 18 Fostering Soil Carbon Sequestration and Protection: Advances in Our Understanding and the Practical Implications	Session 20 Soil and Plant Microbiomes	Session 5 Advances in Predictive Digital Soil Mapping
10:45									
11:00									
11:15									
11:30									
11:45									
12:00		Lunch (Pedology Committee AGM)				Lunch (Soil Education Committee AGM)			
12:15									
12:30									
12:45									
13:00	Registration	Session 21 Soil Structure and Soil Health	Session 1 General Soil Science	Session 16 Greenhouse Gas Emissions from Agricultural Soils	Session 2 Data Science, Modelling and AI in Soil Science	Poster Session			
13:15									
13:30									
13:45									
14:00									
14:15									
14:30		Break				Break			
14:45						Session 13 Soil Fertility and Nutrient Management to Mitigate the Impact on Water Quality	Session 18 Fostering Soil Carbon Sequestration and Protection	Session 20 Soil and Plant Microbiomes	Session 5 Advances in Predictive Digital Soil Mapping
15:00		Session 12 Soil Fertility and Nutrient Management for Sustainable Crop Production	Session 1 General Soil Science	Session 16 Greenhouse Gas Emissions from Agricultural Soils	Session 2 Data Science, Modelling and AI in Soil Science				
15:15									
15:30									
15:45							Session 9 General Land Reclamation Session	Session 22 Special Graduate Student Session	Session 6 Digital Agriculture
16:00									
16:15									
16:30									
16:45									
17:00		CSSS AGM		Graduate Student Social					
17:15									
17:30									
17:45									
18:00									
18:15									
18:30	Welcome Mixer					Banquet			
18:45									
19:00									
19:15									
19:30									
19:45									
20:00									
20:15									

Starting time	27-May					28-May
7:30	Breakfast					Breakfast
7:45						
8:00						
8:15						
8:30	Session 12 Soil Fertility and Nutrient Management for Sustainable Crop Production		Session 17 Canada's National Inventory Reporting of Greenhouse Gases: Meeting Target Reductions Rests on Sound Emission Estimates	Session 3 Soil Data Curation		Workshop
8:45						
9:00						
9:20						
9:30						
9:45						
10:10						
10:15	Break					
10:30						
10:45	Session 10 The Good, the Bad, and the Ugly: Integrating Technology in the Field, Lab and/or Classroom		Session 11 Soil Properties in Nutrient and Water Transport in the Vadose Zone	Session 8 Advances in Material Synthesis for Soil Remediation		
11:00						
11:15						
11:30						
11:45						
12:00	Lunch (ASSW AGM)					
12:15						
12:30						
12:45						
13:00						
13:15						
13:30	Workshop Canadian Digital Soil Mapping Workshop	Workshop Alberta Soil Information Viewer Presentation and Workshop		Workshop Trace Elements Analyses of Soil, Water, and Plants: Challenges and Strategies	Workshop HOLOS V4 Training	
13:45						
14:00						
14:15						
14:30						
14:45			Workshop Land Reclamation and Community Outreach - Educating Through Dungeons and Dragons			
15:00						
15:15						
15:30						
15:45						
16:00						
16:15						
16:30						
16:45						
17:00						
17:15						
17:30	Note: Best student presentation awards need to be selected before the banquet					
17:45						
18:00						
18:15						
18:30						May 28-30: Post-conference field trip
18:45						
19:00	* Session 8: 3 student presentations moved to May 25					
19:15						
19:30	* Sessions 3, 11, and 17: 1 student oral presentation moved to May 24-25					
19:45						
20:00						
20:15						

Oral Presentation Time Table

Contents

Tuesday, May 24, 2022

Time	Name	Title
Opening Ceremony, Maple Leaf room		
8:15-8:30	Scott Chang & Symon Mezbahuddin (MC)	Scott Chang Stan Blade Nadir Erbilgin Asim Biswas Symon Mezbahuddin

Session I – Plenary. Maple Leaf Chairs: Scott Chang and Symon Mezbahuddin		
08:30 - 09:20	Yong Sik Ok	Metal Contamination and Bioremediation of Agricultural Soils for Food Safety and Sustainability
9:20- 10:10	William Shotyk	Soil: The Key to Understanding Trace Elements in Air, Water, and Plants, from Source Assessment to Ecological Significance
10:10-10:30	Coffee break (sponsored by Canadian Natural Resources Limited (CNRL)) (Derek MacKenzie: Soil Health Leadership Meeting. Room: Dining Hall)	

Session 15 - Beyond Soil Test P: Phosphorus Biogeochemistry in Canadian Soils. Maple Leaf Conveners: Aimé J. Messiga, Barbara Cade-Menun#, Noura Ziadi#		
10:30 – 10:45	Pablo Raguet*	Dynamic of organic phosphorus in ploughed soil layer of three contrasting long-term field experiments
10:45 – 11:00	Busayo Kodaolu*	Phosphorus accumulation and availability in a long-term field experiment treated with inorganic phosphorus fertilizer and organic fertilizers from different sources
11:00-11:15	Sylvia Nyamaizi*#	Starter phosphorus on silage corn biomass, root growth and soil phosphate changes in the Fraser Valley
11:15-11:30	Thidarat Rupngam*#	Phosphorus solubility and redox reactions in a soil under waterlogging conditions
11:30-11:45	Barbara J. Cade-Menun#	Phosphorus biogeochemistry differs in rhizosphere compared to bulk soils in long-term wheat fertilization trials in Saskatchewan, Canada
11:45-12:00	Discussion	
12:00-13:00	Lunch (Pedology Committee AGM, Aurora Room)†	

* Student presentation competing for the best CSSS presentation awards

Virtual presentation

¶ Students who are affiliated to an institute in Alberta and competing for the best ASSW presentation awards

† For virtual access of the Pedology Committee AGM and Soil Education Committee AGM, use the Zoom meeting set up for Aurora (https://csss-assw2022.ca/programvirtual.html)

Session 21 - Soil Structure and Soil Health. Maple Leaf Conveners: Richard Heck, Mary Thornbush#, Adam Gillespie, Olatunbosun Ayetan		
13:00-13:15	Jeff Battigelli	Assessing soil mesofauna communities using long-term soil quality monitoring plots in agricultural soils across Alberta
13:15-13:30	Yelena Gomez*	Drainage of a cultivated organic soil by biomass-filled drainage trench
13:30-13:45	Ekene Mark-Anthony Iheshiulo*¶	Do Diversified Crop Rotations Influence Soil Structure? A Global Meta-Analysis Examining Species Diversity and Management Practices
13:45-14:00	Mary Thornbush#	Computed Tomography Image Analysis used to Identify and Quantify Crusts in Agricultural Soils
14:00-14:30	Discussion	
14:30-15:00	Coffee break (sponsored by Canadian Natural Resources Limited (CNRL))	

Session 12 - Soil Fertility and Nutrient Management for Sustainable Crop Production. Maple Leaf Conveners: Tom Jensen, Len Kryzanowski		
15:00-15:15	Jilene Sauvé	Monitoring of Soil Salinity and Sodicity for Wastewater Irrigation
15:15-15:30	Manushi Henagama Liyanage*	Agronomic response of spring wheat to struvite as affected by green manure crops in a crop rotation
15:30-15:45	Hiral Jariwala*	Are controlled release fertilizers (CRFs) ready for climate-smart agriculture?
15:45-16:00	Ibrahim Mohammed*	^{13}C Solid-state NMR investigation of functional groups distribution and molecular structure of reactive soil organic matter fraction after long-term application of organic amendments
16:00-16:15	Kwame Ampong*¶	Applying humalite for enhancing wheat production and soil health
16:15-16:30	Leah Ritcey-Thorpe*	It's in the roots: nutrient acquisition strategies of field crops in response to seed inoculation and organic soil management
16:30-16:45	Tom Bruulsema	Furthering 4R Nutrient Stewardship for Future Farming
16:45-17:00	Discussion	

Session 4 - Soil Taxonomy and Pedology. Aurora Conveners: Daniel Saurette, Angela Bedard-Haughn This session is dedicated to the memory of Dr Steve Pawluk, Pedologist, Teacher and Mentor, Professor Emeritus, University of Alberta		
10:30 – 11:00	A. Bedard-Haughn	Soils Are Dynamic: So Why Is The Canadian System Of Soil Classification Static?

11:00-11:15	Daniel Saurette	A Proposed Framework for Assigning Soil Drainage Classes to Non-Redoximorphic Soils in the Canadian System of Soil Classification
11:15-11:30	Miles Dyck	Gray Luvisols are Polygenetic
11:30-11:45	Jim Warren#	Proposed Leptosolic Order for The Canadian System of Soil Classification
11:45-12:00	Discussion	
12:00-13:00	Lunch (Pedology Committee AGM, Aurora Room)	

Session 1 - General Soil Science. Aurora

Conveners: Tariq Siddique, Scott Chang

13:00-13:15	Wenjie Chi*	Verify and Characterize the Effects of New N_2-fixing inoculant for Use with Wheat, Canola, and Soybean
13:15-13:30	Xinli Chen	Plant diversity differentially affects soil phosphorus in bulk and rhizosphere soils
13:30-13:45	Maria Luna*	Characterization of soil geochemical and colour properties across two contrasting land uses
13:45-14:00	Emmanuel Mapfumo	Impacts of management change on organic carbon under perennial and annual grass-legume mixtures on a Black Chernozemic soil
14:00-14:15	Erika H. Young*#	The impacts of rock pulverization on functional properties of boreal lands converted from forest to agricultural use
14:15-14:30	Discussion	
14:30-15:00	Coffee break (sponsored by Canadian Natural Resources Limited (CNRL))	

Session 1 - General Soil Science. Aurora

Conveners: Tariq Siddique, Scott Chang

15:00-15:15	Emmanuel Mapfumo	Pre-1980 versus post-1980 climate trends at Breton Plots, Alberta: is there any evidence of local climate change?
15:15-15:30	Jawaria Johar*	Phyto-microbial Remediation of PAHs and HMs Contaminated Soils using Biochar and Bacterial strains and metagenomic studies for PAH degrading genes
15:30-15:45	Alsu Kuznetsova	Soils as environmental reservoir of chronic wasting disease prions
15:45-16:00	Jingyu Zhang*¶	Quantification and visualization of soil health under long-term fertilizer and rotation treatments in Alberta
16:00-16:15	Joseph G. Crudo	The Long-Term Effects of Compaction and Organic Matter Removal on Forest Soil
16:15-16:30	Upama Khatri-Chhetri*#¶	Adaptive multipaddock grazing reduces soil microbial complexity in Canadian prairie

16:30-16:45	Amana Jemal Kedir	Comparison of agri-environmental phosphorus tests for boreal agricultural and natural Podzols
16:45-17:00	Discussion	

Session 19 - Soil and Water Conservation in the Face of Climate Change. Prairie Conveners: Henry Wai Chau, Asim Biswas, Bing Cheng Si		
10:30 – 10:45	Mengfan Cai*	The Effect of Conservation Measures and Climate Change on Water and Soil Erosion on the Hilly Loess Plateau
10:45 – 11:00	Charles Frenette-Vallières*#	Electrostatic charging of organic dust emission in south Quebec cultivated histosols
11:00-11:15	Pouya Khalili*¶	Evaluation of crop production in response to changes in blue and green water resources in Canadian Prairies
11:15-11:30	Anne Paquette*	Root Water Uptake of Spring Wheat in the Dark Brown and Black Soil Zones of Saskatchewan
11:30-12:00	Discussion	
12:00-13:00	Lunch (Pedology Committee AGM, Aurora Room)	

Session 16 - Greenhouse Gas Emissions from Agricultural Soils. Prairie Conveners: David Pelster, Aaron Glenn#, Joann Whalen		
13:00-13:15	Bobbi Helgason	Higher than expected N_2O emissions from canola residues: stable isotope tracing reveals soil organic matter as the dominant source of N2O-N
13:15-13:30	Kathryn Webb#	Effect of fall rye cover crop on CO_2 and N_2O fluxes in the Red River Valley, Manitoba, Canada
13:30-13:45	Erin Daly*¶	Soil nitrous oxide emissions from novel perennial grain systems and their relationship to soil physical and hydraulic properties
13:45-14:00	Kira Borden	Optimizing the benefits of cover crops to reduce nitrous oxide emissions: the impact of freeze-thaw
14:00-14:15	Nicole Menheere*#	Mitigating nitrous oxide emission from corn using nitrification and urease inhibitors following cover crop use
14:15-14:30	Discussion	
14:30-15:00	Coffee break (sponsored by Canadian Natural Resources Limited (CNRL))	

Session 16 - Greenhouse Gas Emissions from Agricultural Soils. Prairie

Conveners: David Pelster, Aaron Glenn#, Joann Whalen		
15:00-15:15	Kody Oleson*	4R Options to Reduce N_2O Emissions from Corn in Sandy Soils
15:15-15:30	Siyuan Wang#	Biochar mitigates N_2O emissions from sandy soil by improving soil pore structure and increasing nosZ gene abundance
15:30-15:45	Waqar Ashiq*	Understanding the complex interconnections between topography and soil physical, chemical, and biological controls of N_2O emissions
15:45-16:00	Emmanuel Badewa*#	Effects of biobased residues on greenhouse gas emissions during growing and non-growing seasons
16:00-16:15	Jiancan Liu*	Greenhouse gas emissions from beef cattle urine and dung patch as affected by the non-bloat legumes
16:15-16:30	Jayamini Rathnayake*#	Greenhouse gas emission during composting of different mixing combinations of natural resource by-products: Incubation study
16:15-16:30	Hannah Keenes*	Survey of Cow-calf Operations to Characterize Manure Management, Nutrient Composition, and Greenhouse Gas Emissions
16:30-16:45	Discussion	

Session 2 - Data Science, Modelling and AI in Soil Science. Glacier Conveners: Symon Mezbahuddin, Kiah Leicht		
10:30 – 10:45	Roland Kröbel	Holos V4 release – updates and open source development
10:45 – 11:00	Jamin Achtymichuk*¶	Modelling soil organic matter dynamics at the University of Alberta's Breton Plots using CQESTR
11:00-11:15	Camile Sothe#	Mapping Canada's soil organic carbon from space
11:15-11:30	Gleb Kravchinsky*¶	Assessing the risk of deep percolation at a phosphogypsum reclamation site that has been phyto-capped
11:30-11:45	Chih-Yu Hung	Modelling shadow and cover effects on manure temperature
11:45-12:00	Discussion	
12:00-13:00	Lunch (Pedology Committee AGM, Aurora Room)	

Session 2 - Data Science, Modelling and AI in Soil Science. Glacier Conveners: Symon Mezbahuddin, Kiah Leicht		
13:00-13:15	Adrienne Arbor*#	Improving the performance of equation based pedotransfer functions from literature using a non-linear least squares approach

13:15-13:30	Vanessa Caron	Using Artificial Intelligence and Earth Observation Technology to Identify Mineral Soil Pads in Peatlands
13:30-13:45	Symon Mezbahuddin	Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM) Version 3.0
13:45-14:00	Timm F. Döbert	Scenario-based modelling of soil organic carbon under avoided grassland conversion
14:00-14:15	Kate Kuntu-Blankson#	Process-based modelling of N2O emissions from cattle urine patches using ecosys
14:15-14:30	Discussion	
14:30-15:00	Coffee break (sponsored by Canadian Natural Resources Limited (CNRL))	
Session 2 - Data Science, Modelling and AI in Soil Science. Glacier Conveners: Symon Mezbahuddin, Kiah Leicht		
15:00-15:15	Nikisha Muhandiram*	Modelling soil health indicators under an Intermediate Wheatgrass perennial forage grain system
15:15-15:30	Junye Wang	Machine learning applications to water quality analysis
15:30-15:45	Natalie Shelby-James	The Alberta Background Soil Quality System Project
15:45-16:00	Solmaz Fathololoumi	A machine learning based approach for downscaling soil water index (SWI) derived from satellite imagery
16:00-16:15	Paul Fuellbrandt	Soil and Groundwater Remediation Guideline Calculator
16:15-16:30	Tegbaru B. Gobezie*	Harmonized Ontario Soil Data: the Basis for Ontario Soil Information System (OSIS)
16:30-16:45	Discussion	

Tuesday, May 24, 2022

17:00-19:00	**CSSS AGM**
17:00-21:00	Student activities

Wednesday, May 25, 2022

Session II – Plenary. Maple Leaf Chairs: Asim Biswas, Len Kryzanowski

08:30 - 09:20	Merritt Turetsky	The future of northern organic soils: threats and opportunities
9:20 - 10:10	Melissa Arcand	Reciprocity in soil science: knowledge sharing and co-creation for soil management on First Nations agricultural lands
10:10-10:30	Coffee break	

Session 9 - General Land Reclamation Session. Maple Leaf Conveners: Sebastian Dietrich, Deo Heeraman, Gregory Hook, Mark Bateman This session is dedicated to the memory of Dr. Larry Turchenek, Pedologist and Soil Reclamation Scientist		
10:30 – 10:45	Clemence Muitire*#	Temporal changes in soil hydraulic properties of cropland soils following restoration of pipeline corridors on cropland
10:45 – 11:00	Maryam Firoozbakht*¶	Biodegradation of polycyclic aromatic hydrocarbons under different redox conditions
11:00-11:15	Takudzwa Nawu*#	Revegetation of oil wellsites reclaimed with suboptimal topsoil replacement depth and organic amendments in northeastern Alberta
11:15-11:30	Theresa Adesanya	Phosphorus release from municipal biosolids under simulated flooding during terrestrial phytoremediation
11:30-11:45	Iram Afzal*¶	Effect of Iron-oxide minerals on the biodegradation of mono-aromatic hydrocarbons
11:45-12:00	Discussion	
12:00-13:00	Lunch (Soil Education Committee AGM, Aurora)	
13:00-14:30	Poster session	
14:30-14:45	Coffee break/Poster session	

† For virtual access of the Soil Education Committee AGM, use the Zoom meeting set up for Aurora (https://csss-assw2022.ca/programvirtual.html)

Session 13 - Soil Fertility and Nutrient Management to Mitigate the Impact on Water Quality. Maple Leaf Conveners: Don Flaten		
14:45-15:00	Sepideh Kheirkhah*¶	Effects of Ecological Farming on Soil and Water Quality of Agricultural Lands in Canadian Prairies
15:00-15:15	Madelynn Perry*	Long-term benefits of soil amendments in reducing phosphorus losses from soils during simulated snowmelt flooding

15:15-15:30	Haven Soto*	Quantifying the transport potential of antibiotics and their degradation products in spring-thaw snowmelt runoff from manure-amended cropland
15:30-15:45	Viranga Weerasinghe*	Phosphorus release from manured soils under simulated snowmelt conditions
15:45-16:00	Blake Weiseth*	Impact of fertilizer P source, rate, and placement strategy on wheat yield and P uptake across variable topographies in Saskatchewan
16:00-16:15	Jian Liu#	Targeting Soil Phosphorus Management for Improving Water Quality
16:15-16:30	Kokulan Vivekananthan#	Optimizing crop production while minimizing environmental phosphorus losses using struvite: A case study
16:30-16:45	Discussion	

Session 18 - Fostering Soil Carbon Sequestration and Protection: Advances in Our Understanding and the Practical Implications. Aurora

Conveners: Cole D. Gross, Adam Gillespie

10:30 – 10:45	Brian Wallace	Elevation Gradient Drives Distribution of Soil Carbon and Plant Communities in a Semiarid Grassland in British Columbia
10:45 – 11:00	Inderjot Chahal	Long-term effects of tillage and crop rotation on soil C and N storage in a temperate humid climate
11:00-11:15	Chantel Chizen*	Looking Deeper at Soil Organic Carbon Storage in Prairie Potholes
11:15-11:30	Jeewan Gamage*#	Molecular characterization of soil organic matter (SOM) under different land uses by DRIFT and ^{13}C DP-MAS NMR spectroscopy
11:30-11:45	Gazali Issah	Forage quality improvement and soil carbon and nitrogen dynamics in grazed pastures: the role of non-bloat legumes
11:45-12:00	Discussion	
12:00-13:00	Lunch (Soil Education Committee AGM, Aurora)	
13:00-14:30	Poster session	
14:30-14:45	Coffee break/poster session	

Session 18 - Fostering Soil Carbon Sequestration and Protection: Advances in Our Understanding and the Practical Implications. Aurora

Conveners: Cole D. Gross, Adam Gillespie

14:45-15:00	Cole D. Gross*¶	Agroforestry Perennials Reduce Nitrous Oxide Emissions and Their Live and Dead Trees Increase Ecosystem Carbon Storage

15:00-15:15	Reza Khalidy*	Field demonstrations in Southern Ontario of silicate mineral amendment effect on soil carbon sequestration (inorganic and organic)
15:15-15:30	Thea Whitman#	Tracing pyrogenic organic matter stocks and fluxes using CO2 flux tracing, three-part partitioning, and nanoSIMS
15:30-15:45	Zhengfeng An	Quantifying past, current, and future forest carbon stocks within agroforestry systems in central Alberta, Canada
15:45-15:55	Discussion	

Session 9 - General Land Reclamation Session. Aurora

Conveners: Sebastian Dietrich, Deo Heeraman, Gregory Hook, Mark Bateman

This session is dedicated to the memory of Dr. Larry Turchenek, Pedologist and Soil Reclamation Scientist

16:00-16:15	Chrissie Smith	Reclamation Certification Achieved using Remote Sensing Technology
16:15-16:30	Henian Guo*¶	Methanogenic Degradation of PAHs in Oil Sands Tailings
16:30-16:45	Laura Manchola-Rojas	Buried wood effects on nutrient supply and microbial activity in oil sands reclamation soils in northern Alberta
16:45-17:00	Akshit Puri	Investigating the role of tree microbiome in sustaining the growth of pioneering pines in an unreclaimed aggregate mining ecosystem
17:00-17:15	Discussion	

Session 20 - Soil and Plant Microbiomes. Prairie

Conveners: Derek MacKenzie, Monika Gorzelak, Luke Bainard#, Francois Teste

10:30 – 10:45	Angelica M. Aguirre*¶	Drivers of soil bacterial community composition and co-occurrence in agricultural systems of Alberta
10:45 – 11:00	Kris Guenette*¶	Optimizing Nitrogen use-efficiency and Arbuscular Mycorrhizae Inoculation Potential in Canadian Cereal Crops
11:00-11:15	Jean-Thomas Cornelis	Soil controls on root exudate functions
11:15-11:30	Jacynthe Masse	No-till and variable P- and N-fertilization levels led to contrasting soil bacterial, fungal and nematodes communities in a 29-years long-term experimental site
11:30-11:45	Claudia Goyer#	Influence of Chemical Fumigation on Soil N and C Cycling, and the Soil Microbial Diversity
11:45-12:00	Discussion	

12:00-13:00	Lunch (Soil Education Committee AGM, Aurora)	
13:00-14:30	Poster session	
14:30-14:45	Coffee break/Poster session	

Session 20 - Soil and Plant Microbiomes. Prairie

Conveners: Derek MacKenzie, Monika Gorzelak, Luke Bainard#, Francois Teste

14:45-15:00	Patrick Neuberger#	Assessing soil storage strategies for microbial community characterization of long-term agricultural plots
15:00-15:15	Alan Lee*¶	Arbuscular mycorrhizal fungi in oat-pea intercropping
15:15-15:30	Nadir Erbilgin	Legacy effects of disturbances on above ground pine metabolites
15:30-15:45	Joann K. Whalen	A pull-pull model to describe nitrogen transformations in soil-plant systems
15:45-15:55	Discussion	

Session 22 - Special Graduate Student Session. Prairie

Conveners: Xinli Chen, Ali El-Naggar

16:00-16:15	Abhijeet Pathy*¶	Activation Methods Increase Biochar's Potential for Heavy-Metal Adsorption: A Global Meta-Analysis
16:15-16:30	Keshav Parameshwaran*	Physical-based hydrological modelling to predict soil moisture in the vadose zone in a mesoscale catchment
16:30-16:45	Nageshwari Krishnamoorthy*¶	Electro-coagulation modified microalgal biochar for enhancing struvite crystallization
16:45-17:00	Deborah Cristina Crominski da Silva Medeiros*¶	Reclamation materials from an oil and gas industry as adsorbents of naphthenic acids from oil sands process water: preliminary experiments
17:00-17:15	Juan C. Santana*¶	The impact of reclamation and vegetation removal on compositional and functional attributes of soil microbial communities in the Athabasca Oil Sand Region
17:15-17:30	Discussion	

Session 5 - Advances in Predictive Digital Soil Mapping. Glacier

Conveners: Brandon Heung, Asim Biswas, Angela Bedard-Haughn, Daniel Saurette

10:30 – 10:45	Daniel Saurette	Divergence metrics for Optimizing Sample Design in Digital Soil Mapping

10:45 – 11:00	William Bethel*	Use of LiDAR and machine-learning to predict soil attributes of managed forests in Eastern Nova Scotia
11:00-11:15	Raphaël Deragon*	Mapping maximum peat thickness of cultivated Organic soils in the southwest plain of Montreal
11:15-11:30	Christopher Blackford#	A comparison of predictive soil map uncertainty metrics and their methodologies
11:30-11:45	Jim Warren#	Application of Radiometric Data to Predictive Digital Soil Mapping in Ontario
11:45-12:00	Discussion	
12:00-13:00	Lunch (Soil Education Committee AGM, Aurora)	
13:00-14:30	Poster session	
14:30-14:45	Coffee break/Poster session	

Session 5 - Advances in Predictive Digital Soil Mapping. Glacier

Conveners: Brandon Heung, Asim Biswas, Angela Bedard-Haughn, Daniel Saurette

14:45-15:00	Babak Kasraei#	Predictive Digital Soil Mapping with Uncertainty Estimation for British Columbia
15:00-15:15	Preston Sorenson	Improved Parent Material Map Disaggregation Methods in the Saskatchewan Prairies Using Historical Bare Soil Composite Imagery
15:15-15:30	Tahmid Huq Easher*	Disaggregating Organic Matter Map of Agricultural Soils, Québec, Canada
15:30-15:40	Discussion	

Session 6 - Digital Agriculture. Glacier

Conveners: Asim Biswas, Reem Zeitoun, Mervin St-Luce#, Viacheslav Adamchuk, Len Kryzanowski

15:45-16:00	Mervin St. Luce#	Introducing GLOBAL-LOCAL: A new approach to predict soil organic carbon at the local field scale from large soil spectral libraries
16:00-16:15	Farzad Shirzaditabar	Evaluation of topsoil Magnetic Susceptibility as a criteria for distinguishing soils in Ontario
16:15-16:30	Claudia Quilesfogel-Esparza*	Standardizing Optical Sensor Canopy Reflectance to Improve Grain Corn Yield Predictions
16:30-16:45	Clinton Mensah*	Multi-Frequency Electromagnetic Induction Soil Moisture Characterization Under Different Land Uses in Western Newfoundland
16:45-17:00	Louis-Étienne Lessard*	Deficit irrigation effect on almond yield and water consumption
17:00-17:15	Discussion	

Wednesday, May 25, 2022

Banquet	
18:00-20:30	**Banquet and CSSS awards**

Thursday, May 26, 2022

Mid-conference field tour

Friday, May 27, 2022

Session 12 - Soil Fertility and Nutrient Management for Sustainable Crop Production. Maple Leaf Conveners: Don Flaten, Len Kryzanowski		
8:30-8:45	Tom Jensen	Assessing Acidification of Cultivated Soils in the Southern Prairies
8:45-9:00	Adebusoye O. Onanuga	Carbon emission, soil properties, intercropping of cucumber-tomato and carrot-cabbage crops performance affected by application of biochar, urea, and rock phosphate
9:00-9:15	Thierry Fonville	Nutrient availability of management practices to advance farm profitability and sustainability
9:15-9:30	Lina Du	Size fractionation of trace elements in soil solutions recovered from soils under contrasting long-term agricultural management
9:30-9:45	Judith Nyiraneza#	Soil nitrate, soil properties and potato yield responses to different preceding forage crops
9:45-10:00	Ahmed Lasisi#	Types and Diversity of Pulses for Wheat Nitrogen Utilization in Two 4-Year Pulse-Wheat Rotation Cycles
10:00-10:15	Discussion	
10:15-10:45	Coffee break	

Session 10 - The Good, the Bad, and the Ugly: Integrating Technology in the Field, Lab and/or Classroom. Maple Leaf Conveners: Thomas Yates, Maja Krzic, Amanda Diochon		
10:45 – 11:00	Tom Yates	Introducing mobile technology in a field-based course – student and instructor perceptions
11:00-11:15	Maja Krzic	Question banks in teaching and learning basic soil science concepts
11:15-11:30	Sandra Brown	What students want versus what is effective: lessons learned for the post-COVID classroom
11:30-12:00	Tom Yates, Maja Krzic, Amanda Diochon	Using apps to support teaching of soils skills and knowledge – round table discussion
12:00-	Lunch (ASSW AGM)	

Session 17 - Canada's National Inventory Reporting of Greenhouse Gases: Meeting Target Reductions Rests on Sound Emission Estimates. Aurora Conveners: Mario Tenuta, Rich Farrell		
8:30-8:45	Doug MacDonald #	Revisions to GHG estimates from Canadian agricultural soils: Emission factor updates and alignment of carbon and nitrogen methods
8:45-9:00	Steve Del Grosso #	National inventory reporting of nitrous oxide emissions from agricultural soils in the USA
9:00-9:15	Annette Freibauer #	Nitrous oxide emission reductions reflected in the German greenhouse gas inventory
9:15-9:30	David Pelster	CongrUpdating non-growing season:annual N_2O emission ratio from Canadian croplands
9:30-9:45	J. Y. Yang#	Changes in Reactive Nitrogen Losses from Canadian Agricultural Land over 36 years
9:45-10:00	Sisi Lin#	Changes in pulse type and frequency in rotations affect CO_2 and N_2O emissions on the semi-arid Canadian prairies
10:00-10:15	Discussion	
10:15-10:45	Coffee break	

Session 11 - Soil Properties in Nutrient and Water Transport in the Vadose Zone. Aurora Conveners: Hida R Manns#, Yefang Jiang#		
10:45 – 11:15	Bing Cheng Si	The Ecohydrology of deep soil water
11:15-11:45	Y. Jiang	Seasonal release of historical nitrate from vadose zone delays underlying groundwater quality response to BMPs
11:45-12:00	Hida Manns#	The contentious size range terminology of soil pores
12:00-	Lunch (ASSW AGM)	

Session 3 - Soil Data Curation. Prairie Conveners: Asim Biswas, Tegbaru B. Gobezie, Brandon Heung, Daniel Saurette, Kara Webster		
8:30-8:45	Brandon Heung	Introducing the Canadian Soil Data Portal: The path towards renewing our digital soil information system
8:45-9:00	Daniel Saurette	Legacy Soil Survey Data Recovery in Ontario: cards to computers
9:00-9:15	Chuck Bulmer	Evaluating the reliability of soil pit locations within the BC Soil Information System

9:15-9:30	J. Zhang	Building an enhanced soil information database for British Columbia
9:30-9:45	Deepa Filatow	BC Soil Survey Data Curation – Challenges and Successes
9:45-10:15	Discussion	
10:15-10:45	Coffee break	

Session 8 - Advances in Material Synthesis for Soil Remediation. Prairie Conveners: Christopher Nzediegwu, Deborah Cristina Crominski da Silva Medeiros		
10:45 – 11:00	Christopher Nzediegwu	Hydrothermal carbonization produces more recalcitrant soil conditioners from a given feedstock than pyrolysis
11:00-11:15	Mano Krishnapillai#	Effect of Combining Biostimulation using Compost and Rhizoremediation using Grass and Dandelion for Bioremediating an Oil-contaminated Soil
11:15-11:30	Ali El-Naggar	Biochar effectively remediates Cd contamination in acidic or coarse- and medium-textured soils: A global meta-analysis
11:30-11:45	Michael D. Preston	The feasibility of using municipal compost cover over Cu-Ni tailings as a growth medium for biofuel crops
11:45-12:00	Discussion	
12:00-	Lunch (ASSW AGM)	

Friday, May 27, and Saturday, May 28, 2022

Workshops			
Workshop #	Organizers	Workshop title	Location/time
1	Daniel Saurette and Brandon Heung	Canadian Digital Soil Mapping Workshop	Aurora Room, May 27, 1:30-5:30 pm and May 28, 8:00 am-12:00 pm MDT
2	David Spiess	Alberta Soil Information Viewer Presentation and Workshop	Prairie Room, May 27, 1:30 - 3:30 pm MDT
3	Valerie Miller and various members of LRIGS (Land Reclamation International Graduate School)	Land Reclamation And Community Outreach - Educating Through Dungeons and Dragons	Maple Leaf Room, May 27, 3:00 - 5:00 pm MDT

4	Fiorella Barraza and William Shotyk	Trace Elements Analyses of Soil, Water, and Plants: Challenges and Strategies	SAB 150 (South Academic Building, Room 150, U of A campus), May 27, 1:30 - 5:00 pm MDT
5	Roland Kroebel, Aaron McPherson and Sarah J. Pogue	HOLOS V4 Training	Glacier Room, May 27, 1:30 - 4:30 pm MDT

Poster Presentation Time Table

May 25 (Wednesday)

13:00-14:30, Wild Rose Room		
Poster Number	Poster Title	Corresponding Author
P011	The effectiveness of plant material-based amendment with differing particle sizes in acid soil reclamation	Syazwan Sulaiman*
P012	Mobility of arsenic, selenium and vanadium from manured and non-manured fields during snowmelt flooding after addition of soil amendments	Srimathie Indraratne
P013	Oxidative stress response of Eisenia fetida after exposure to copper in soil amended with residual fertilizing materials	Noura Alsarawi#
P014	Influence of Concentration and Speciation of Trace Elements in Soil Solution on Plant Uptake and Accumulation by *Hordeum Jubatum* L.	Dulani H. Kandage
P015	Impact of Burial Duration on Nutrient Supply to Plant Root Simulator (PRS□) Probes	Eric Bremer
P021	Modelling Nitrogen Release Patterns To Determine If Environmentally Smart Nitrogen Can Increase Nitrogen Use Efficiency	Kiah Leicht*¶
P022	Machine Learning-Process Modelling Hybrid: A Novel Approach in Predicting Changes in Agricultural Soil Organic Carbon	Manjila Shahidi
P061	Improving the annual crops mapping accuracy using feature level based fusion of Surface biophysical properties	Solmaz Fathololoumi
P081	Bioremediation of Hydrocarbon-contaminated soil using Various Organic Soil Amedments under Flooded Condition	Mano Krishnapillai#
P091	Development of soft tailings capping technology – first step towards creating stable and sustainable boreal landscapes	Kaitlyn Trepanier
P092	Spatial distribution of selected geochemical properties in anthropogenic soils on Aldermac site, Quebec, Canada	Jean-Benoit Mathieu#
P093	Amelioration of two acidic soils using chicken eggshell waste	Raghad Soufan*#
P094	Combined application of lime and organic amendment to ameliorate exposed soils for vegetation establishment	Chibuike Chigbo
P095	Management Practices For Creating A “Sun-Grown” Organic Amendments In Post-Mining Landscapes	M. Baah-Acheamfour
P111	A comparison of water evaporation rates from ponds, peatlands and soil pores	Hida Manns#
P121	Rebuilding the Fertility and Productivity of Eroded Knoll Soils in South-Central Saskatchewan: Second-Year Results	Ryan Hangs
P122	Larger root surface area increases plant nitrogen uptake in nitrogen-deficient soil	Yutong Jiang*
P123	Impact of Including Brassicaceae Oilseed Crops on The Performance of Pulse and Wheat-Based Cropping Systems in Canadian Prairies	Piumi Gallage*
P124	Fall Nitrification Inhibition of Anhydrous Ammonia in Manitoba	Muhammad Junaid Afzal*

P125	Variations in Crop Productivity across Western Canadian Wheat Classes and Fertilizer Formulations	Kris Guenette*¶
P126	Revising the Crop Nutrient Uptake and Removal Guidelines for Western Canada	Gazali Issah
P151	Effects of increasing soil pH to near-neutral using lime on phosphorus saturation index and water extractable phosphorus	Sylvia Nyamaizi*#
P161	Mulch application influences N2O flux from organic soils under lettuce production	Lucy Ross-Blevis*
P162	Effect of soil moisture status and non-bloat legume diet on greenhouse gas emissions from the manure patch	Jiancan Liu*
P171	Modelling beneficial management practices in agriculture to analyze effects on greenhouse gas emissions and environmental sustainability	Chloe Ducholke*¶
P181	Prediction of subsoil organic C stocks from measurements of topsoil organic C for carbon accounting in a soil in Southern Ontario	Nastaran Chalabianlou Vayjoyeh*
P182	Infrared spectra of soil organic matter (SOM) in a muck soil profile	Jeewan Gamage*#
P183	Clay Aggregates as the Nucleus of Root-Driven Soil Organic Carbon Priming	Cole D. Gross*¶
P184	Investigating the controls of forest conversion on deep soil carbon dynamics	Oliver Heath
P185	Does dissolved organic carbon increase biological hydrogen oxidation in agricultural soil?	Lijun Hou*
P186	Change in Soil Organic Carbon Storage as Influenced by Forestland and Grassland Conversion to Cropland in Canada	Chang Liang#
P187	Soil carbon sequestration does not increase under adaptive multi-paddock grazing	Jessica Mehre*
P188	Carbon Content of Buried A Horizons of Saskatchewan Croplands	Amanda Mitchell*
P189	Impacts of Short Rotation Canola on Soil Microbial Dynamics and Nutrient Cycling	Meagen Reed*
P191	Decomposition dynamic of bare and cultivated organic soils amended with straw and wood chips under greenhouse conditions	Karolane Bourdon*
P192	Soil Biochar Application for Drought Adaptation in Agriculture in British Columbia	Morgan Hamilton*
P201	Biochar and nitrification inhibitor changed soil microbial biomass and ecoenzymatic stoichiometry in a Gray Luvisol	Prem Pokharel*¶
P202	Do Cover Crops Impact Soil Microbial Communities in the Prairies?	Paige Kennedy*
P203	Response of microbial communities to long- and short-term coordinated nitrogen and sulfur fertilization	Laura Bony*¶
P204	Changes in soil microbial community structure and functional potential in response to grazing management practices in a semi-arid agroecosystem	Harini Aiyer*#
P205	Effect of drought stress on nodulation, plant growth, soil enzyme activities, soil nitrogen availability, and nitrogen fixation in alfalfa	Danielito Dollete*¶
P206	Bacteria's ambivalence to the herbicide clopyralid: a microcosm experiment	Caitlin Watt#
P207	Soil-Plant microbial assemblages associated with regenerating Pinaceae trees at an anthropogenically-disturbed gravel mining site	Akshit Puri
P208	Effects of soil carbon amendments on H2-oxidizing bacteria activity and diversity	Xavier Baril*#
P209	How soil microbial diversity with different land management conditions and be used as an indicator of soil health	Roya Faramarzi*¶
P211	Comparison of two methods for calculating soil loss due to wind erosion	Andrés Silva*
P212	Cropping System Impact on Physical Soil Health Properties in Semi-Arid Southern Alberta	Ekene Mark-Anthony Iheshiulo*¶
P213	Tensile strength of aggregates and spatial distribution of different rootstocks in Ultisol under citrus production	Pedro A. N. Benevenute
P214	Does intensive organic farming influence earthworm population?	Stéphanie Lavergne*

*Student presentation competing for the best presentation awards

Posters will be on display on May 24 and 25. Poster board size: 4 x 6 ft.

Poster presenters to be present between 13:00 and 14:30 on Wednesday, May 25.

Presenting Authors

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Session I

Plenary

(Room: Maple Leaf)

Metal Contamination and Bioremediation of Agricultural Soils for Food Safety and Sustainability

Yong Sik Ok[·]

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Agricultural soil is a non-renewable natural resource that requires careful stewardship in order to achieve the United Nations' Sustainable Development Goals. However, industrial and agricultural activity is often detrimental to soil health and can distribute heavy metal(loid)s into the soil environment, with harmful effects on human and ecosystem health. In this presentation, I will examine processes that can lead to the contamination of agricultural land with heavy metal(loid)s, which range from mine tailings runoff entering local irrigation channels to the atmospheric deposition of incinerator and coal-fired power-plant emissions. I will discuss the relationship between heavy metal(loid) biogeochemical transformations in the soil and their bioavailability. I will then review two biological solutions for remediation of contaminated agricultural land, plant-based remediation and microbial bioremediation, which offer cost-effective and sustainable alternatives to traditional physical or chemical remediation technologies. Finally, I will discuss how integrating these innovative technologies with profitable and sustainable land use could lead to green and sustainable remediation strategies, and conclude by identifying research challenges and future directions for the biological remediation of agricultural soils.

Keywords: Soil contamination; Sustainable remediation; Food safety

Soil: the key to understanding trace elements in air, water, and plants, from source assessment to ecological significance

William Shotyk
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Every trace element (TE) in the environment has a natural source, in addition to possible contributions from human activities. To quantify anthropogenic contributions of TEs to the environment, natural inputs must be known. Metals such as Pb and metalloids such as Sb have been used commercially for thousands of years. Thus, to identify "background" rates of atmospheric deposition of TEs, we may need to go back in time to the middle of the Holocene to estimate natural inputs to terrestrial ecosystems. Here, soil can help: peat bogs, a unique type of organic soil, serve as environmental archives to enable detailed reconstructions of contemporary and past atmospheric deposition. These types of reconstructions have shown that the dominant natural source of many TEs in the air is soil, in the form of dusts supplied by wind erosion. Similarly, to understand the impacts of human activities on water quality, whether soil solutions, surface waters, or groundwaters, the natural abundance of TEs in pristine waters must be known. For most TEs in surface waters, the dominant source by far is soil. Finally, when we begin to study TEs in plants from remote locations, we find that the dominant natural sources are soil, supplied via root uptake (both essential and non-essential TEs), as well as atmospheric deposition of soil-derived dusts.

Whether TEs are derived from natural or anthropogenic sources, the key to understanding their ecological significance is their bioavailability; this, in turn, requires distinction between particulate, colloidal, and truly dissolved (ionic) chemical species. At the interface between air, water, and biota, soils represent the medium of transformation where TEs may become more or less bioavailable, depending on the chemical behaviour of the element, the physical properties of the host mineral (or amorphous phase), and the composition of the water. Here, some examples are presented which illustrate recent advances in understanding how soil and the particles derived from them, play an inordinate role in TE transformations at the air-water-plant interface, while identifying future research needs and opportunities.

This presentation is dedicated to the Bocock family, with thanks and appreciation for their supreme generosity, on the occasion of the 10th anniversary of the Bocock Chair for Agriculture and the Environment.

Keywords: trace elements, atmospheric deposition, peat bogs, natural waters, plants

Session 15

Beyond Soil Test P: Phosphorus Biogeochemistry in Canadian Soils

(Room: Maple Leaf)

Dynamic of organic phosphorus in ploughed soil layer of three contrasting long-term field experiments

Pablo Raguet[1, 2, 3, *], Alain Mollier[1], Noura Ziadi[4], Sabine Houot[5], Denis Montenach[6], Antoine Karam[2], Christian Morel[1]

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Soil organic phosphorus (*SOP*) mineralization plays an important role in crop nutrition, but its quantification under cropped fields conditions is still unknown. The aim of this study was to determine *SOP* mineralization over several decades in the soil ploughed layer of three French long-term field experiments. We suppose that applications of organic waste products (*OWP*) might improve *SOP* mineralization, and thus significantly contribute to plant P nutrition. One site (*S1*) was on a silt loam luvic Arenosol, cropped under maize monoculture and fertilized for 17 yrs at three annual rates of triple superphosphate. Another (*S2*) was on a loamy Luvisol cropped for 18 yrs under maize-wheat rotation and fertilized with four OWP applied at 4 t C ha^{-1} $2yr^{-1}$. The third (*S3*) was a calcaric Cambisol cropped for 14 yrs under a 4-yr rotation (maize-wheat-sugar beet-barley) fertilized with 5 *OWP* at 170 kg N ha^{-1} yr^{-1}. Yield, aboveground residues and their P concentrations were measured every year for each site. We calculated belowground residues using P in aboveground residues and shoot-to-root ratio. Ignition method were used to determine regularly organic P in both *OWP* and ploughed soil layer. The gross annual rate of mineralization (*garm*) was calculated using *SOP* dynamics modelling, with initial SOP stock, gross mineralization coefficients (*K*), organic P in *OWP*, P in residues and their coefficients of decomposition (<1 yr): releasing P or incorporating to *SOP*. The average of yield and P offtake were 8.5 (±2.7) t ha^{-1} yr^{-1} and 23.8 (±7.8) kg P ha^{-1} yr^{-1} with little differences between sites and treatments. The initial *SOP* stock were 446, 595, 1145 kg P ha^{-1} for *S1*, *S2*, and *S3*, respectively. In average for all sites, P applied as crop residues and *OWP* was 18.2 (±10.5) kg P ha^{-1} yr^{-1} with significant differences between sites (20.1 for *S2*, 18.3 for *S3*, and 14.9 for *S1*). On average, during the decomposition over one year, 12.4 (±3.6), 10.2 (±4.1), 9.6 (±4.4) kg P ha^{-1} yr^{-1} were released in solution for S1, S2, and S3, respectively, whereas 2.5 (±0.7), 9.9 (±11.8), 8.7 (±6.9) kg P ha^{-1} yr^{-1} supplied *SOP* stock. The model calibration with time series of *SOP*, gave on average $K = 0.010$ yr^{-1}, *i.e.* 100 yr residence time. The *garm* values were 2.1 (±1.7), 12.2 (±11.0) and 5.7 (±5.8) kg P ha^{-1} yr^{-1}, for *S1*, *S2* and *S3*, respectively, in relation with organic P inputs. Taking into account all these P fluxes, the resulting effect on SOP stocks was a steady state for *S1* and increases for *S2* (+4.7 (±2.2)) and *S3* (+7.9 (±2.2)). In general, orthophosphates ions flux from P input decomposition (<1yr) was higher than SOP mineralization. Further studies are required in order to compare orthophosphate ions fluxes from P input, *garm* and diffusion at the solid-to-solution interface.

Keywords: Soil organic phosphorus cycle, Organic fertilization, Long-term field experiment

Phosphorus accumulation and availability in a long-term field experiment treated with inorganic phosphorus fertilizer and organic fertilizers from different sources

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Recent calls to improve soil health have emphasized the importance of organic matter for sustainable crop production. This is usually promoted by the need to include organic fertilizers as a nutrient source on fields. Organic fertilizer have also been promoted as an alternative source of phosphorus (P) for crop production, considering the P resources (rock phosphate) are finite, and the urgent need to increase P use efficiencies across the food chain. However, concerns have been raised about the impact of organic matter on the chemistry of soil phosphorus (P), as the nutrient composition and the organic matter chemistry in these fertilizers has been thought to interfere with P availability in the treated soils. The objective of the study is to understand the impact of organic fertilizer on P accumulation, transformation and availability in soils treated with different organic fertilizers including swine liquid (SW-L), swine solids (SW-S) and swine compost (SW-C) compared with that of inorganic fertilizer (IP). Soil samples (top 15- cm) were collected from a Brookston clay loam soil that have received inorganic fertilizer and different swine manures. This field has been under corn-soybean rotation since 2004 with P applied only to the corn phase. Results showed an increase in pH in soils that have received SW-C and SW-S compared to SW-L, IP and control plots. Similarly, water extractable P WEP, a rapid measure of both agronomic and environmental P availability revealed an increase in SW-S compared to IP, SW-C, SW-L and control. Trends of labile P forms (i.e. the sum of both H_2O-P and $NaHCO_3$-P in Hedley sequential fractionation) follows SW-S > IP > SW-C > SW-L > control. The swine solid manure increased the soil's pH, P availability and labile P forms compared to the inorganic fertilizer and other organic fertilizer source. This shows that organic fertilizers behave differently in soil, and affect the soil P chemistry differently. Also, organic P source can be a suitable substitute for inorganic fertilizer; Caution should however be place on it use in places where risk of P loss is high.

Keywords : Organic fertilizer, Phosphorus availability, Labile phosphorus forms, Sustainable production, soil health

Starter phosphorus on silage corn biomass, root growth and soil phosphate changes in the Fraser Valley

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Understanding the time scales and magnitudes of phosphorus (P) release from high legacy P soils is important to sustain silage corn yield while minimizing fertilizer costs and risk to the environment. The objectives of this work were to assess the effect of starter P fertilizers (1) on silage corn dry matter yield (DMY), P uptake and root growth at early growth stages (3- and 6-leaf stage) and 2) on in-situ phosphate concentrations in the soil solution using Anion Exchange Membranes (AEMs) during the early growing season. Field trials were established in 2020 and 2021 using increasing starter P fertilizer rates (0, 5, 10, 15 and 20 kg P ha^{-1}) on eight farmers' fields across the Fraser Valley (British Columbia, BC). Corn DMY increase with starter P fertilizer was obtained only at 3-leaf stage in two sites (25%) and the critical starter P rate was 5 kg P ha^{-1}. Corn P uptake at 3- and 6-leaf stages was positively related to root surface area and volume by quadratic and linear regressions (R^2 = 0.33-0.94). The concentrations of AEM-P remained high one week after planting (WAP) at starter P rates 10-20 kg ha^{-1} but decreased significantly at two WAP. Our results showed that low starter P fertilizer rates can be used by dairy farmers without negative effects on the growth of young plants and subsequent DMY at harvest in the Fraser Valley.

Keywords: anion exchange membrane; corn dry matter; starter fertilizer P; root surface area and volume; 3- and 6-leaf stages

Phosphorus solubility and redox reactions in a soil under waterlogging conditions

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Waterlogging conditions and redox reactions in agricultural soils can be exacerbated by extreme weather events while altering the dynamics of phosphorus (P) and metal cations such as iron (Fe) and increasing environmental risk. The objective of our study was to assess the effects of three moisture regimes on (i) the reduction of ferric (Fe^{3+}) to ferrous (Fe^{2+}) iron and (ii) the solubility of soil P. Small volumes of soil (Gleyed Dystric Brunisol) samples were collected from the surface of an agricultural field site located in the Fraser Valley (British-Columbia) and mixed to make one composite sample. A 120-day incubation experiment using three soil moisture regimes (field capacity, water saturation, and waterlogging) and two Fe^{3+} levels (iron addition and no iron addition) was conducted in a growth chamber. Soil and water samples were collected throughout the duration of the experiment at 0, 3, 7, 14, 21, 28, 35, 49, 63, 90, and 120 days (d) of incubation. The redox potential (ORP) decreased with incubation time in waterlogged soils, from 180 mV to 110 mV and 50 mV, at 0, 90 and 120 d, respectively. The decrease of ORP coincided with a reduction of Fe^{3+} to Fe^{2+} of about 1190 mg kg^{-1} and an increase in soil pH from 5.2 to 5.4. Meanwhile, the concentration of water-extractable P (Pw) in the incubated soil samples decreased in the following order : waterlogging > water saturation > field capacity, indicating an increase of Pw with increasing moisture content. Our results showed that soils maintained under prolonged anoxic conditions could increase the solubility and availability of P and subsequent risk of P transport to surface and drainage waters.

Keywords*:* flooding; redox potential; iron reduction; soluble phosphorus

Phosphorus biogeochemistry differs in rhizosphere compared to bulk soils in long-term wheat fertilization trials in Saskatchewan, Canada

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Many soils need phosphorus (P) fertilization for optimal crop yields. Maintaining crop growth while minimizing loss of excess P requires knowledge of P biogeochemistry, both of P speciation and of the biochemical processes governing P cycling. These will vary spatially, with bulk soil differing from the root zone (rhizosphere), and with crop rotation and management practices. Rhizosphere and bulk soils were sampled in Swift Current, SK, Canada from treatments including: continuous wheat plots established in 1967 (CW) with nitrogen (N) and P fertilization or with P fertilization alone; plots established in 1982 with a legume, lentils, and wheat (WL) in alternate years with N and P in the wheat phase only; and subplots where P fertilization stopped in 1995 for CW and in 2008 for WL. Samples were analyzed for soil pH and cations, and for a range of P pools including total and organic P, soil test P, and sequential fractionation. Phosphorus speciation was determined by P-NMR and P k-edge XANES spectroscopies. Soil processes were examined with *in situ* phosphate release by anion-exchange resin and P enzyme activity assays, while qPCR was used to estimate the abundance of fungal and bacterial communities. Soil pH decreased significantly with N fertilization in the CW plots and in the LW plots, from 6.5 in CW plots without N to 5.5 in CW plots with N and in LW plots, which altered exchangeable cations. However, there were no significant differences in pH or cations between bulk and rhizosphere samples. Stopping P fertilization reduced P concentrations in many pools, including total P, Olsen P, Mehlich 3-P and $CaCl_2$-P. Spatially, there were significant differences between the rhizosphere and bulk soil for soil P pools by fractionation, forms determined by P-NMR, activities of diesterase and acid and alkaline phosphatase, and enzyme gene and fungal abundances determined by qPCR. These results clearly demonstrate that both geochemical and biochemical data are needed to understand P cycling and manage P in cropping systems.

Keywords: phosphorus; rhizosphere; P-NMR; P-XANES; P fractionation; phosphatases

Session 21

Soil Structure and Soil Health

(Room: Maple Leaf)

Assessing soil mesofauna communities using long-term soil quality monitoring plots in agricultural soils across Alberta

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Density, diversity and distribution of soil biota reflect differences and complexity in soils across landscapes, climates, land-use patterns, and management practices. Soil biota is well correlated with various soil and ecosystem functions. The structure of this below-ground community may link land management decisions to the productivity and health of plants and animals in agricultural soil ecosystems. Measuring, maintaining and/or improving soil quality is a priority for Alberta farmers, landowners, and agricultural industry stakeholders. The AESA Soil Quality Program is a series of benchmark sites located on agricultural areas across several different ecoregions in Alberta established in 1997 to monitor long-term changes of various soil chemical and physical properties. Recent financial support from the Agricultural Funding Consortium provided an opportunity to revisit these sites, collect another round of soil chemical and physical data and establish baseline data on soil biological properties. Soil mesofauna responds at a larger scale, from meters to hectares, and can live from days to years. Information on the structure of this below-ground community can provide land managers with the ability to assess the temporal and spatial impacts of agricultural practices to ensure long-term sustainability and maintenance of soil quality. Soil samples were collected at three different slope positions from each of 38 sites. Mesofauna was extracted, sorted, identified, and enumerated to calculate density and relative abundance values and assess mesofauna community structure among ecoregions, slope positions and agricultural practices. Morphotaxa of all oribatid mite and collembolan specimens from all samples collected were also determined for diversity analyses. From 350 samples, we documented 47,335 specimens. Mesofauna densities differed among ecoregions and slope positions. Assessment of Oribatida and Collembola specimens identified 58 and 66 unique morphotaxa, respectively. Collembola diversity was higher than Oribatida diversity in all ecoregions and at all slope positions. We will discuss the link between biological parameters with other soil quality metrics that may represent a better indicator for assessing soil quality in agricultural soils.

Keywords: soil quality, mesofauna, long-term monitoring, agricultural practices, Alberta, Acari, Collembola, diversity, density, community structure

Drainage of a cultivated organic soil by biomass-filled drainage trench

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Drainage trench filled with high-permeable materials has been widely used to improve drainage rates in poorly structured mineral soils. However, in cultivated organic soils, few studies have been conducted under controlled conditions, suggesting a field evaluation of this practice.The objective of this study was to evaluate the drainage of a cultivated organic soil using trenched drains. Two parallel trenches 0.6 m wide were excavated down to the drain tile in two 30 m long sections, to backfill the trenches, a mixture of equal proportions of crushed pine biomass and excavated organic soil was used in the first section (BT) and only excavated organic soil in the second section (ST). A third section containing the conventional drainage system (CD) with no trenches was included in the study as a control. Soil matric potential (h_s) at the 0.15 cm depth and water table level (WT) measurements were taken in the fall season a year after trenches installation to evaluate drainage efficiency in each section. 24 hours after complete soil saturation by rainfall, the water table depth was 0.20 m for BT and 0.15 m for ST and CD. Additionally, the BT, ST and CD presented h_s values at the 0.15 m depth of -1.0, 1.0 and 2.3 kPa, respectively. The CD and ST sections show h_s values higher than expected based on the water table depth, which confirms a perched water table and a possible air entrapment that inhibited an adequate drainage, indicating that the trenches filled with biomass, besides improving the drainage rate, allowed the release of gases trapped in the cultivated organic soils.

Keywords: Trench drainage; biomass; Soil matric potential; water table level.

Do Diversified Crop Rotations Influence Soil Structure? A Global Meta-Analysis Examining Species Diversity and Management Practices

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Soil structure can be modulated by management practices, such as crop rotation, as well as environmental and edaphic factors. However, the magnitude of rotation benefits on soil structural indicators under different conditions still remains uncertain and under-quantified. To address this, a meta-analysis was conducted on 867 paired comparisons from 150 studies to examine i) how crop species diversity affects soil structural indicators: bulk density, aggregate stability, porosity, infiltration rate, and saturated hydraulic conductivity, and ii) how management practices, environmental, and edaphic factors influence crop diversity effects. Overall, increased crop diversity (i.e., number of crop species) led to significantly reduced bulk density (-1.4 ± 1.3%), enhanced soil aggregation (15.9 ± 12.7%), and improved porosity (4.4 ± 4.0%) and saturated hydraulic conductivity (112.8 ± 57.9%), but did not improve infiltration rate (92.2 ± 98.7%) compared to less diverse systems. Rotations combined with conservation tillage and grain legumes performed better in enhancing soil structural indicators, except for bulk density and infiltration rate, compared to conventional tillage and cereals only rotations. Compared to North America, crop diversity impact on soil structural indicators were more pronounced in Asia, except for infiltration rate. Also, crop diversity managed for 5- to 10-yrs had greater benefits in regions with mean annual precipitation > 900mm and in medium textured soils. Among soil structure indicators, aggregate stability and saturated hydraulic conductivity were the most sensitive to management practices. Based on this meta-analysis, we conclude that having diverse crop species and grain legumes in rotations under conservation tillage is best for improving soil structure, and thus should be considered when designing and developing sustainable cropping systems that promote soil health and crop productivity.

Keywords: crop rotation; species diversity; conservation practices; soil structure; soil health

Computed Tomography Image Analysis used to Identify and Quantify Crusts in Agricultural Soils

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Image processing offers many opportunities to characterize and quantify physical soil properties, including for crusted soils. Physical (structural) soil crusts were subject in this research as part of a study examining disaggregation associated with slacking produced by rainfall impounding uncovered soil surfaces leading to crust development. Soil crusts are smooth and compacted layers with reduced porosity and greater density typically than bulk soil. Their physical properties are consistent in terms of fine particle size causing reduced porosity and smooth surfaces. They harden the surface, and have more surface resistance to penetration than uncrusted soil surfaces, impeding infiltration and plant growth. There are ramifications for agricultural soils that need to support crop growth in arable agricultural systems. This presentation demonstrates a plugin used in ImageJ image processing software that is used to characterize the physical properties of soil crusts and used to identify and quantify crust thickness. The main goal in developing this new plugin was to find the crusted surface, with some smoothing employed to close pore space, mapping back to the original greyscale stack of images for each core sample. The soil surface was used as a reference point from which to enable profiling and quantification along the z-axis. The strategy was to progressively evaluate the soil structure moving downwards in the image stack using structural criteria to differentiate between crust and the zone of unaltered (bulk) soil. The plugin was subsequently applied to CT images obtained from a long-term cover crop experiment (including radish, rye, mixed radish and rye, oats, and no cover control). Crust thickness was measured as the selected property of the soil crust to quantify the effects of using cover crops on agricultural lands.

Keywords: Image processing; Image analysis; Quantification; Crust thickness; Crust development

Session 12

Soil Fertility and Nutrient Management for Sustainable Crop Production

(Room: Maple Leaf)

Monitoring of Soil Salinity and Sodicity for Wastewater Irrigation

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Nutrients present in wastewater produced from industrial processes can be applied to land as a nutrient source for crops. Irrigation of wastewater for agronomic purposes can reduce conventional water use, improve soil fertility by delivering nutrients in wastewater to crops, and reduce the amount of fertilizers applied to land. However, the wastewater must be treated and meet the quality standards set out by Alberta Environment before it is released to the environment. The Guidelines for Municipal Wastewater Irrigation (Alberta Environment 2000) outline treated wastewater quality standards for a set of parameters. Alberta's Environmental Protection and Enhancement Act (EPEA) approvals outline requirements for wastewater irrigation for salinity (EC) and sodicity SAR. In addition, soil EC and SAR must be monitored to ensure wastewater application does not result in changes to baseline soil conditions beyond specified limits. If the treated wastewater or the soil do not meet the approval requirements, irrigation of treated wastewater is not permitted. If an industry is not permitted to irrigate then watersource lagoons may reach capacity and result in production concerns including production shutdowns. For most industries, alternative discharge options are not readily available.Soil EC and SAR data were evaluated from three locations in southern Alberta which had long-term irrigation with treated wastewater. The objective of the study to understand the implications of treated wastewater chemistry on resulting soil quality following long term application of treated wastewater. The null hypothesis is the EC and SAR of treated wastewater has no effect on the EC and SAR of the receiving soil. To determine the relationship, soil EC and SAR point location data were assessed against the treated wastewater EC and SAR values over time using regression analyses. Conclusions and implications of the analysis will be presented.

Keywords: salinity, sodicity, wastewater, irrigation, EC, SAR

Agronomic response of spring wheat to struvite as affected by green manure crops in a crop rotation

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Struvite ($NH_4MgPO_4 \cdot 6H_2O$) is a phosphorus (P) fertilizer with slow-release properties. Green manure crops can increase plant availability of P from such sources, thereby reducing the risk of P accumulation in soil and its subsequent release to surface water. This study examined the response of spring wheat to the preceding green manure crop (fababean, buck wheat and field pea) as affected by factorial combinations of P source (struvite and monoammonium phosphate (MAP)) and timing of application (previous year and current year) at two organically managed field sites in southern Manitoba having alkaline soil pH. A control (no P fertilizer) was included for comparison. Fertilizers were applied prior to seeding in each phase. Wheat grain yield was highest when MAP was applied to a preceding crop of fababean. Averaged across green crops and application timings, grain yield was lower for struvite than MAP. The P source main effect was not significant for harvest index (HI). Averaged across green manure crops and P sources, HI was higher when P fertilizer was applied in the previous year compared with application in the current year. The main effect of timing of fertilizer application had no significant effect on wheat yield. This presentation will also include results on wheat biomass yield and P efficiency indices.

Key words: Monoammonium phosphate, harvest index, soil phosphorus, phosphorus use efficiency

Are controlled release fertilizers (CRFs) ready for climate-smart agriculture?

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Fertilizers play an essential role in increasing crop yield, maintaining soil fertility, and provide a steady supply of nutrients for plant requirements. The excessive use of conventional fertilizers, however, can cause environmental problems associated with nutrient loss through volatilization to the atmosphere, leaching to groundwater, loss to surface run-off and denitrification, and soil/subsoil acidification associated with a reduction in lithogenic carbonstocks. To mitigate environmental issues and improve the longevity of fertilizer in soil, controlled release fertilizers (CRFs) have been developed. While the primary goals of CRFs to date have been linked to economic and pollution-reduction benefits, it is now evident, as will be presented in this talk, that CRFs have an important role to play climate-smart agricultural (CSA) practices, with some of its potential yet unrealized. Through the use of coatings made using inorganic (gypsum, sulfur, minerals), organic (biochar), polymeric (synthetic and naturally occurring), and advanced (graphene, nanomaterials) materials, and via synthesis methods that use physical (fluidized bed reactor, rotary drum, rotary pan, spray drying) and chemical (crosslinking, polymerization, polycondensation) mechanisms, CRFs can attain desirable properties that can contribute to carbon (organic and inorganic) sequestration and reduction of greenhouse gas emissions.

We provide insights into the ongoing development and future perspectives of CRFs for CSA practices by discussing three major knowledge gaps. (1) Can CRFs prevent direct exposure of fertilizer granule to soil and prevent loss of nutrients as both nitrate and nitrous oxide emissions? Studies on different crops have shown that CRFs impact both positively or negatively on N_2O emissions. (2) Are CRFs less affected by the change in environmental parameters, which can increase longevity in soil compared to conventional fertilizers? The CRF mechanisms in soil and how they are impacted by physicochemical parameters (temperature, soil moisture, pH, soil texture) and biological activity are discussed. (3) Can CRFs maintain required soil nitrogen levels, increase water retention, reduce GHG emissions, lead to optimum pH for plant growth, and increase soil organic matter (SOM) content, concurrently? Studies on impact of CRFs on soil parameters and crop yield are discussed.

Keywords: Controlled release fertilizer (CRF); Fertilizer management; Polymers; Climate smart agriculture; Agrochemicals

^{13}C Solid-state NMR investigation of functional groups distribution and molecular structure of reactive soil organic matter fraction after long-term application of organic amendments

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Modern systems of land cultivation and crop production deplete soil organic matter (SOM) and expedite land degradation. For sustainable crop production, the content of SOM must be maintained at an optimal level. Farmers apply numerous types of organic amendments to soils to supply nutrient and to increase SOM. Commercial types of organic amendmments marketed as "humic substances" have become widespread, and are promoted for their potential to stimulate plant growth and improve soil health. However to use organic amendments reliably and sustainably, the question as to why they work must be addressed. This requires a mechanistic understanding of their behaviour, especially how the versatility of their functional groups and molecular structure contribute to plant nutrient supply and soil health. This is important to better differentiate the potentials of various organic amendments to improve soil fertility. Our research objective is to derive the mechanism and effect of long-term application of these amendment on the accumulation of SOM, and functional group distribution and molecular structure of naturally occurring humic substances. The experiment was based on a long-term field study in Ontario where the plots are amended continuously since 2004 with three forms of manure: solid swine manure (SSM), liquid swine manure (LSM), and swine manure compost (SMC). We quantified the SOM content and extracted the humic acid (HA) fractions in the soil collected from each plot and assessed the molecular structure using ^{13}C CPMAS/DPMAS solid-state NMR spectroscopy. Our results show SMC plots accumulated more SOM compared to other treatments, in the following order: SMC > SSM > LSM. However, this trend did not correlate with the functional groups distribution and carbon structure of the HA. Contrary to our hypothesis that SMC will promote the formation of more hydrophilic surfaces in SOM and enhance the nutrient binding capacity of SOM by generating more aromatic functional groups than the other two amendments, our results showed that the three forms of swine manure contributed equally to the nutrient binding capacity and hydrophilic surfaces in SOM. We conclude that in choosing organic amendments to improve soil fertility, the nutrient binding capacity as indicated by the versatility of functional groups and the number of hydrophilic structures observed in the HA are not differentiating enough between organic amendments. The amount of SOM accumulated from the application of an organic amendment is a more reliable and differentiating trait for selecting one organic amendment over another.

Keywords: Soil organic matter; humic substances; NMR Spectroscopy; Soil Fertility

Applying humalite for enhancing wheat production and soil health

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Rapid increase in inorganic nitrogen (N) fertilizer prices and lower N use efficiency (NUE) are great challenges for wheat production. Effort towards improving NUE through the combined application of inorganic N fertilizer and humic acid (HA) have recently gained more attention. HA contains functional groups that improve crop production and soil health. Humalite, which is natural soil organic amendment, contains more than 60% HA and high soluble carbon. Therefore, the main objective of this research was to evaluate the application of humalite on wheat production and soil health. The experiments were carried out at four sites in Alberta, St. Albert, Westlock, Forestburg, and Oyen, in the 2021 growing season. The treatments were humalite with five levels (0, 100, 200, 400, and 800 lbs/acre) and urea with three levels (zero, half and full recommended rate based on soil test). The humalite was broadcast and mixed into the soil seven days before seeding and the urea was side banded during seeding. In general, all sites had lower precipitation compared to the historical averages. Combined application of humalite and urea significantly increased wheat yield at only Forestburg and Westlock sites at rates of 200 lbs/acre humalite + half urea and 100 lbs/acre humalite + full recommended urea, respectively. Soil nitrate concentration was high at application rate of 800 lbs/acre + full recommended urea at St. Albert and Oyen and 400 lbs/acre humalite + full recommended urea at Forestburg and Westlock sites. Humalite did not increase soil active carbon and respiration in the short term. Correlation analysis showed that increased wheat protein content (R= 0.40 – 0.70) and soil nitrate concentration (R=0.27 – 0.79) was mainly related to urea inputs in all the four sites; urea application significantly correlated with yield increase at St. Albert and Forestburg sites (R=0.72 and 0.29 respectively). Humalite alone correlated (R=0.35) significantly with nitrate concentration at only Oyen site. Grain NUE was higher in humalite and half urea compared to humalite and full urea treatments at all four sites; St. Albert (59 – 74% vs. 39 – 42%), Forestburg (98 – 127% vs. 38 – 54%), Westlock (66 – 81% vs. 34 – 39%), and Oyen (23 – 48% vs. 18 – 26%). In conclusion, the application of humalite did not have an overall effect on wheat agronomic and soil health parameters, possibly due to short-term influence and low precipitation experienced during the growing period in all the experimental sites. The trials are expected to be carried out in four years in crop rotation, evaluating the full potential of humalite.

Keywords: humalite; wheat production; soil health

It’s in the roots: nutrient acquisition strategies of field crops in response to seed inoculation and organic soil management

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Increased reliance on inorganic fertilizers for farm productivity is in direct conflict with the long-term sustainability of soil ecosystems and therefore the ability of soil to support agriculture. Despite this, few studies have investigated the combined effort of agroecological strategies for both soil and crop health to confer sustainable cropping systems. We explored the role of combining organic nutrient management to support soil health with bacterial seed inoculation to promote crop health. Here, we utilize a root functional-trait approach to quantify crop nutrient acquisition strategies to both soil fertility management and crop inoculation over time. Soybean and wheat were grown in soil amended with worm castings, conventional fertilizer, or no amendment and with or without the addition of a growth-promoting bacterial seed inoculant. To assess nutrient acquisition strategies across management, crop root functional traits (specific root length, specific root tip density, root tissue density, average root diameter, root nitrogen content and root carbon to nitrogen ratio) were measured at two different times during the growing season. Crop response was measured as aboveground biomass, plant height, stem diameter, leaf level chlorophyll content, and leaf dry matter content. Crops were differentially influenced by amendments with only wheat roots expressing differences in root traits with management. No differences in root traits were detected with inoculation, however; both inoculation and amendments impacted crop aboveground response variables. Organic nutrient management resulted in higher expression of acquisitive traits (e.g., specific root length and specific root tip density) during the later developmental time. Root traits displayed trade-offs similar to those described in the root economic space, and both crops depicted shifts in resource acquisition patterns with ontogeny. Broadly, soil amendments had the strongest impact on crop root response when compared to seed inoculations. This study informs crop resource acquisition strategies, and crop response to interventions that emphasize agroecological crop production.

Keywords: agroecology; root ecology; functional traits; soil; organic systems, growth promoting bacteria

Furthering 4R Nutrient Stewardship for Future Farming

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Future farming systems need to intensify production, improve human nutrition, protect and enhance biodiversity, shrink environmental and carbon footprints, and make nutrient flows more circular. Canadian agriculture is pressed to demonstrate sustainability, with particular emphasis on its carbon footprint, as governments and industry seek to meet commitments to reduce greenhouse gas emissions. The New Paradigm for Responsible Plant Nutrition provides perspective to integrate 4R Nutrient Stewardship into changing farming objectives that support a wider range of sustainability outcomes. Priorities among the outcomes vary among countries, but in Canada as elsewhere, opportunities exist to increase use of data-driven digital solutions to support decisions, and to accelerate innovation using on-farm adaptive management. Choices among nutrient sources need to include more circular and climate-smart attributes, and rate, time, and place of application need to become more precise and dynamic.

The Scientific Panel on Responsible Plant Nutrition has suggested several new principles that can be applied to the 4Rs of nutrient stewardship. For Right Source, they include supplying nutrients in quantifiable and available forms, using climate-smart forms, using more recycled forms, and considering biological inoculants. Right Rate needs to address variability in crop response, both year-to-year and within and among fields. Right Time needs to address dynamics of changing nutrient need through the growing season. Right Place needs to avoid nutrient losses, particularly the small ones that generate large impacts.

The accountability for performance requires tracking of 4R practices, measurement of farm-level economic outcomes, and assessment of environmental and social benefits. Better ways to monitor adoption and key outcomes are urgently needed, including science-based targets and more profound application of digital technologies. This somehow has to be accomplished amidst a social climate increasingly protective of privacy and averse to mandatory compliance. The fertilizer industry has been collaborating with the agri-food sector to develop a National Index for Agri-Food Sustainability that includes holistic 4R practices and performance metrics. This presentation will outline opportunities and challenges to furthering 4R for future farming systems, and discuss the crop nutrition industry's needs for science support and accelerated innovation.

Keywords: nutrient stewardship, responsible plant nutrition

Session 4

Soil Taxonomy and Pedology

(Room: Aurora)

Soils Are Dynamic: So Why Is The Canadian System Of Soil Classification Static?

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The launch of inter-provicial collaboration on soil survey and classification in Canada was best elaborated by Dr. Leahy in 1945. In his opening remarks as Chair of the National Soil Survey Committee (NSSC) he described the occasion as "a momentous one in the history of soil surveying in Canada". Dr. Leahy highlighted what we now confirm to be a recurring theme that soil survey activities exist on the precipice, when he stated that "our field of work has passed through several vicissitudes…I feel that we have passed the worst of our misfortunes". The NSSC (1945-1968), Canada Soil Survey Committee (1970-1978), the Expert Committee on Soil Survey (1979-1992), and the Soil Classification Working Group (1993-1998) guided development of The System of Soil Classification for Canada (1970, 1974) and its modern counterpart, the Canadian System of Soil Classification (CSSC; 1978, 1987, 1998), which saw a substantial update to our taxonomic system every decade. Since 1998, the CSSC has remained stagnant, while other systems such as Soil Taxonomy and the World Reference Base continued to evolve. To build momentum for advancing soil taxonomy in Canada, a special issue of the Canadian Journal of Soil Science (CJSS), Soils of Canada (2011), a project of the Pedology Subcommitee sought to summarize the existing body of knowledge and provide challenges for the next generation of pedologists in Canada. A decade later, we find ourselves on the cusp of a major revision of the CSSC and have a clear path to developing the 4th edition. A special issue of the CJSS, Advances in Soil Survey and Classification in Canada, expected to be published in September 2022, has provided an avenue for pedologists to advocate for significant changes to the system. These include proposals for the 11th and 12th Orders of the CSSC, the Anthroposols and the Leptosols; advances in our conceptualization of Bt horizon formation in Luvisols; better recognition of organic materials in Cryosolic and Organic Orders; application of surface litter horizons in agricultural soils; standardization of drainage class designations using quantitative analysis; re-alignment of soil family particle-size classes for soil family classification; and a call for re-evalution of gleying and mottling criteria for soil classification. In addition to these major proposals, the Pedology Committee has created an online form for practitioners to provide feedback, edits, and request changes to the CSSC manual. These can vary from small issues such as grammatical errors to larger issues such as reorganization of various sections of the CSSC manual. Our next step is to clearly articulate the timeline and the path towards the 4th edition.

Keywords: National Soil Survey Committee; Soil Taxonomy; pedology; classification

A Proposed Framework for Assigning Soil Drainage Classes to Non-Redoximorphic Soils in the Canadian System of Soil Classification

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Drainage refers to the frequency and duration of periods of saturation, and how quickly excess water is removed from the soil profile. It is one of the central concepts used to differentiate soils within the Canadian System of Soil Classification (CSSC). In redoximorphic soils (imperfect, poor and very poor drainage classes), drainage is typically differentiated based on morphological features (i.e., the presence gleying and mottles). Non-redoximorphic soils (very rapid, rapid and well drained classes) do not display such morphological features but are differentiated based on available water holding capacity (AWHC) as inferred from soil texture. Moderately well drained soils are intermediate, in some cases defined by the presence of redoximorphic characteristics, but in other cases inferred based on texture. For all combinations of sand, silt and clay-sized particles in steps of 1% in the texture triangle (n=5,151) and all combinations of very fine to very coarse sand separates in steps of 5% (n=10,626) as input, AWHC was calculated and then classified into a drainage class based on the rules currently set out in the CSSC, and based on newly proposed criteria. We demonstrate that current AWHC criteria for assigning drainage classes to non-redoxymorphic soils are incorrect and result in assigning moderately-well drainage to almost all soils coarser than sand. These criteria should be revised, and we propose a framework for adoption by pedologists in Canada that also incorporates coarse fragment content and depth to bedrock into the assignment of soil drainage class to non-redoxymorphic soils in the field. In addition, we highlight some interesting trends in the distribution of sands, loamy sands and sandy loams when they are further subdivided into coarse, (medium), fine and very fine subclasses, which suggests the need to re-evaluate the criteria for classifying these coarse soils into their subclasses.

Keywords: soil drainage class, available water holding capacity, saturated hydraulic conductivity, sand separates, soil texture

Gray Luvisols are Polygenetic

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With respect to the pedosphere, human activities in the last 100 years have been the major driver of soil change. Despite human activities being one of the main soil forming factors recognized by soil scientists (in addition to climate, organisms, parent material, relief, groundwater, and time), the Canadian System of Soil Classification emphasizes soil as a natural body. We argue human-agricultural activities are direct and indirect drivers of significant changes to the carbon balance and carbon cycling in A horizons of Gray Luvisolic soils in western Canada, resulting in changes to A horizon carbon stocks, structure, and micromorphology. Evidence from scientific literature, in-field soil profile observations and the national pedon database are presented in support of our argument. Therefore, we propose a polygenetic, two-stage model of Gray Luvisol soil formation. The first stage is dominated by the climate forcing of the Holocene, resulting in a relatively stable boreal forest ecosystem with minor perturbations from natural and human-induced wildfire and other disturbances. The second stage is dominated by direct, human-driven disturbances such as cultivation, release of exotic fauna (earthworms), and indirect human-driven disturbances associated with anthropogenic climate change. Further, we propose modest amendments to the Canadian System of Soil Classification to reflect a polygenetic model of soil genesis in Gray Luvisolic soils.

Keywords: Breton Plots; Soil organic matter; CQESTR; Modelling; Data science

Proposed Leptosolic Order for The Canadian System of Soil Classification

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Shallow soils occurring throughout the world, recognized as Leptosols in the World Reference Base (WRB), are characterized as having a lithic contact close to the soil surface. Within the Canadian System of Soil Classification (CSSC) shallow soils are currently classified at the family level according to the depth at which a lithic contact is encountered. Shallow soils that could be recognized as Leptosols are very common in mountainous regions such as British Columbia and the Yukon; occur extensively in the vast expanses of the Canadian Shield and are very common in the Atlantic provinces. The presence of bedrock close to the surface impacts drainage, the amount of available moisture, depth for rooting, and has a major influence on soil formation. It is proposed that the importance of shallow soils be elevated to the order level, to be consistent with the frequency of their occurrence in the Canadian landscape and for consistency with other soil classification systems of the world. This requires integration at the great group and subgroup levels within all orders of the CSSC, as well as the current formal definition of soil. These proposed modifications include nullifying the minimum 10 cm depth requirement as part of the current definition of soil in the CSSC for closer consistency with ecological land classification and other soil classification systems of the world. Proposed modifications to the current key to the soil orders, great groups and subgroups are presented and discussed.

Session 1

General Soil Science

(Room: Aurora)

Verify and Characterize the Effects of New N_2-fixing inoculant for Use with Wheat, Canola, and Soybean

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Demands for food and fiber continue to increase, as does the global population. Therefore, the use on nitrogen (N) fertilizers also is increasing globally. However, as the use of nitrogen fertilizer increases, so do concerns about the impacts of N loss to the environment. Efforts to reduce reliance on synthetic N fertilizers involve multiple strategies (e.g., adoption of 4R practices, inclusion of cover crops and green manures, and the development of biostimulants). Capitalizing on microorganisms that fix N is one potential avenue for reducing the need for fertilizer N. There exist in nature many species of soil microorganisms (collectively referred to as diazotrophs) that can fix atmospheric N. One group of diazotrophs, including the species *Gluconacetobacter diazotrophicus*, are endophytes that invade plant roots and either colonize the spaces between the cells (intercellular) or the cell matrix itself (intracellular). Azotic North America recently began marketing a *G. diazotrophicus*-based inoculant (Envita™) reported to have beneficial effects including nitrogen fixation and yield improvement in crops as diverse as wheat, corn, soybean, and rice. This research is aimed at (i) confirming N-fixation in crops important to Saskatchewan producers (e.g., wheat, canola, and soybean) that have been inoculated with Envita™; and (ii) evaluate the yield improvement imparted by Envita™ to these crops. Initial experiments rely on the use of ^{15}N tracing to verify N-fixation in Envita-inoculated crops. Results from this experiment will be presented.

Plant diversity differentially affects soil phosphorus in bulk and rhizosphere soils

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Soil phosphorus (P) availability is critical to plant productivity in many terrestrial ecosystems. How soil P availability responds to changes in plant diversity remains uncertain, despite the global crisis of rapid biodiversity loss. By conducting a global meta-analysis of 742 paired observations in plant species mixtures and monocultures from 180 studies, we show that, on average across observations, soil available P, phosphatase activity and total P are 4.7, 10.2 and 7.3%, respectively, higher in species mixtures. Although the mixture effects on soil available P in the bulk soil do not change with species richness or functional group richness, these effects in the rhizosphere soil shift from positive to negative, going from stands with low to high diversity, indicating that soil available P in the root zone is utilized more completely when there is a greater diversity of plant species. The mixture effect on soil phosphatase activity becomes more positive with the increasing number of species and functional groups in mixtures, with more pronounced increases in the rhizosphere soil, demonstrating that plant diversity differentially affects soil phosphorus in bulk and rhizosphere soils. The greater total P in the mixtures suggests that more P cycled from the deeper soil to the surface in more diverse stands. These effects of mixtures are consistent among cropland, forest, grassland and pot ecosystems, and held across climate zones. The structural equation model reveals that the positive effects of plant diversity on soil phosphatase activity lead to increased plant productivity. The strong positive plant diversity-P availability feedback mechanism found in this work suggests that plant diversity conservation could increase soil total P content, phosphatase activity and P availability in the surface soil, where most plant roots reside, and sustain the current and future productivity of terrestrial ecosystems.

Keywords； Meta analysis, plant diversity, available P, phosphatase, rhizosphere

Characterization of soil geochemical and colour properties across two contrasting land uses

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Characterizing soil properties is an important part of many different types of agri-environmental research including inventory, comparison, and manipulation studies. Understanding the distribution of soil properties at a range of spatial scales are crucial in the development of appropriate, reliable, and efficient sampling campaigns. Sediment source fingerprinting (i.e., tracing) is a method that is increasingly being used to link sediment sources (e.g., land use, soil type, surface/subsurface) to downstream sediment sinks. Part of the fingerprinting method includes identifying and characterizing unique soil properties (i.e., fingerprints) within each potential source. There is currently no a standard approach to characterizing sources and the different approaches to sampling potential sources have not been well evaluated and are a contentious issue. The main objectives of this study are to: 1) compare grid, transect, and judgment sampling approaches in characterizing geochemical, colour, organic matter and grain size soil properties across forest and agricultural land uses; and 2) assess the spatial variability of theses soil properties at a field-scale (~40 ha). Overall, it was found that the importance of the sampling approach varied with respect to both the soil properties and land uses. Similarly the geostatistical analysis demonstrated that some properties exhibited a strong spatial pattern while others did not. Ultimately this research will lead to better source (soil) sampling designs which will improve the robustness and reliability of agri-environmental research, including sediment fingerprinting studies.

Keywords: Soil properties; Source characterization; Spatial variability; Sampling design; Sediment fingerprinting

Impacts of management change on organic carbon under perennial and annual grass-legume mixtures on a Black Chernozemic soil

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Management practices that improve and/or maintain soil organic carbon are important to ensure long-term sustainability of livestock-pasture systems across Canada. Impacts of annual and perennial grasses management on organic carbon (%) and equivalent organic carbon stocks (on an equal soil mass basis) were investigated on a Black Chernozemic soil and involved two separate trials (CAESA and BMP trials) conducted on the same plots between 1994 and 2012 at Lacombe Research Centre, Alberta. Treatments for the CAESA trial between 1994 and 1997 included annual pastures (barley and triticale) and perennial pastures (smooth bromegrass and meadow bromegrass) that were subjected to light, medium or heavy grazing. The BMP trial on the same plots started in 2008 and included annual (barley as silage), grazing versus haying of either meadow bromegrass, meadow bromegrass and alfalfa mixture, and meadow bromegrass fertilized with inorganic nitrogen, and oldgrass treatment that was under perennial pasture since 1994 in the CAESA trial. The distribution of soil organic carbon (%) significantly decreased ($P < 0.05$) linearly with soil depth between surface and 60 cm at a rate of approximately 0.1% per cm in all grasses and grazing treatment combinations. Data from both CAESA and BMP trials indicated between 1994 and 2012 the organic carbon % in the perennial grass treatment remained constant and was significantly greater compared to other treatments. The equivalent soil organic carbon stocks in the 0-15 cm depth interval remained relatively constant over time under the perennial grasses and averaged approximately 88 Mg C/ha. However, for the annual grass treatment equivalent soil organic carbon decreased from 89 Mg C/ha in 1994 to 72 Mg C/ha in 2012. The equivalent soil organic carbon significantly decreased over time in all treatments except for the perennial grass treatment. The rate of decrease in equivalent soil organic carbon in the annual grass treatment was approximately 1 Mg C/ha/year (equal to CO_2 emission of 3.8 Mg/ha/year). For the 0-30 cm depth interval the equivalent soil carbon stocks under the perennial grass treatment were also constant over time. Overall, continuous perennial grasses from 1994 to 2012 maintained organic carbon at a constant level, whereas annual grasses reduced organic carbon and fertilization or addition of legumes did not fully restore organic carbon to levels under perennial grasses.

Key words: Soil organic carbon; Black Chernozem; perennial grasses; annuals; grazing

The impacts of rock pulverization on functional properties of boreal lands converted from forest to agricultural use

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Rock pulverization is recommended when converting boreal soils to agriculture fields, mainly to facilitate tillage. Resulting rock dust incorporation can alter soil quality by means of physical, chemical, and biological properties of soils. We assessed soil functional parameters including nematode trophic group abundances (bacterivores (BF), fungivores (FF), herbivores (PF), omnivores, and predators), nematode indices (FF/BF, FF/FF+BF, FF+BF/PF), and soil respiration (basal and burst means and rate change) after land use conversion and pulverization on three soil types (Podzols, Luvisols, and Histosols) on the Avalon peninsula, Newfoundland, Canada. For each soil type, pulverization status was considered (*natural*: natural forest adjacent to the agricultural land, *unpulverized*: agricultural land that was not pulverized, and *pulverized*: agricultural land that was pulverized less than one year before sampling). Land conversion from forest to agricultural use had a stronger impact on soil quality parameters than the more recent rock pulverization. Nonetheless, nematode indices suggest no significant functional differences with either land use change or soil pulverization. However, as expected, irrespective of pulverization status, soil organic matter and pH were substantial direct and indirect drivers, through alteration in aluminium (Al) and iron (Fe) availability, of nematode community composition and soil respiration. The functional parameters diverged between organic and mineral soils. A significantly negative relationship between SOM and the abundance of bacterivores and fungivores, a positive relationship between pH and bacterivore abundance, and positive relationships between available Al, Fe and the abundance of bacterivores and fungivores were identified in the Histosols but not in the mineral soils. For respiration, most parameters had significant relationships with soil organic matter, pH, Fe, and Al for both mineral and organic soils however, the mean burst respiration rate change did not have significant relationships with pH, Al, or Fe in the mineral soils. The distinct relationships between soil quality parameters and soil functional indicators in mineral and organic soils are a point of interest for further investigations into the concepts of soil quality.

Keywords: Land use change; rock pulverization; rock dust; free-living nematodes; soil respiration

Pre-1980 versus post-1980 climate trends at Breton Plots, Alberta: is there any evidence of local climate change?

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Long-term trends in historic climatic variables were investigated using the data collected near the classical Breton plots (Alberta, Canada) to determine if local climate change had occurred. Climate data used for the study were obtained from the Alberta Climate Information Service (ACIS) for the years from 1901 to 2020, inclusive. Various parametric statistical analyses were conducted on the annual data as well as the 30-year climate normals to determine if monotonic trends occurred in the various climatic variables over time. Large fluctuations in annual climate variables occurred, but positive linear trends were observed in the average annual minimum air temperature over time. The average minimum air temperature increase over time during the winter period (December - February, inclusive) was much more pronounced compared to that for other seasons. Further, there was a clear distinction between the trends prior to 1980, where air temperature changes were minimal or negligible, but post-1980 much sharper rises in both minimum and maximum air temperatures were quite evident. Overall, the 30-year climate normals indicated clear increases in both minimum and maximum air temperatures over time, but the rate of increase was much larger for the minimum air temperature, especially over the winter period.

Key words: historical climate trends, Breton plots, minimum temperature, maximum temperature, 30-year climate normals

Phyto-microbial Remediation of PAHs and HMs Contaminated Soils using Biochar and Bacterial strains and metagenomic studies for PAH degrading genes

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Food insecurity is considered a global issue as well as an environmental issue. Agriculture plays a significant role, and soil being the primary candidate is a critical component. To comply with SDGs, soils should be remediated in the best possible way to achieve zero hunger and food security. Phyto-microbial Remediation is an emerging technique and showing improvements in bioremediation of contaminated soils with toxic pollutants. These potential toxic elements (PTE), especially PAHs and heavy metals, can adversely affect plants and soil microbial communities. To investigate the impact of these contaminants on soil and plants, we used PAHs and HMs degrading two bacterial strains along with biochar. The model experiment was carried out with five treatments on barley seeds in a laboratory condition. Morphological parameters, biochemical, enzymatic analysis, biodiversity indices and molecular studies were performed to assess the effect. Biochar and microbes application showed the reduced accumulation of HMs and enhanced growth of barley as compared to plants grown in contaminated soil without amendments. This indicated the presence of PAHs degrading bacteria in soil samples. A low amount of PAHs was found in pot soil with biochar and degrading bacterial strains. HMs accumulation was found in both above and underground tissues. The most noticeable impact of these amendments was observed in increased leaves' length and dry mass of plants. Moreover, a high level of Simpson and Shannon index was observed in contaminated soils. While on the other hand, total DNA was extracted from the soils and 16s rRNA sequencing analysis was performed for metagenomics studies to analyze soil microbial communities in co-contaminated and control soil samples. Whole metagenome shotgun sequencing showed a significant abundance of two major groups was present in the soils sample, i.e., Actinobacteria and Proteobacteria. Further, an abundance of PAH degrading associated taxa and genes was estimated compared to contaminated and control soils. It was revealed that even with the high PAH concentration, individual and operon-organized PAH degrading genes are present in contaminated and pristine soils with the same abundance and diversity. In our research, we were limited by the information which is already available on public databases regarding PAH catabolism. For future suggestions, we are recommending exploring soil samples with application of biochar and bacteria to know more about structure and composition of soil microbial communities and PAH degrading genes in soil samples.
The research was supported by the Strategic Academic Leadership Program of the Southern Federal University (Priority 2030).

Keywords: PAHs, HMs, Phyto-microbial remdiation, Metagenomics, PAH degrading genes
Oral Presentation and Student

Soils as environmental reservoir of chronic wasting disease prions

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Chronic wasting disease (CWD) is a fatal, transmissible prion disease affecting free ranging white-tailed deer, mule deer, elk, moose, and caribou as well as farmed cervids. One of the remarkable properties of infectious prions is their persistence in external environments, especially their ability to remain infectious for years or even decades. Soils are a natural environmental reservoir of shed CWD prions contributing to the epidemic persistence of CWD due to the direct deposition and persistence of infectious prions in soils. Variation in soil properties may affect prion persistence and transmission as prions associated with natural soils could remain near the soil surface, making them available for ingestion by grazing animals. Our study investigated the possible pathways for with the infectious prion protein (PrP^{CWD}) migration in soil profiles using lab-scale soil columns by comparing their passage through pure soil minerals, and diverse soils from boreal and prairie region. The main soil properties that may determine prion migration are mineralogical composition, texture, and soil organic matter content. We analyzed the leachate of the soil columns by immunoblot and protein misfolding cyclic amplification, and found PrP signal in the columns composed of quartz, and the upper soil organic horizon (LFH) of boreal Luvisolic and Brunisolic soils. Furthermore, the leachates from quartz, illite and Luvisolic columns were found to contain CWD-infectivity by animal bioassay. Leachates from columns with montmorillonite and prairie Chernozemic soil didn't contain detectable PrP by immunoblotting or PMCA; bioassay confirmed that the Chernozemic leachate was not infectious. Analysis of the solid phase of the soil columns confirmed the migration of PrP to lower layers in the illite, while the highest signal in the montmorillonite column remained close to the column surface. These studies demonstrate that montmorillonite, the prevalent clay mineral in prairie soils, has the strongest binding ability; in contrast, illite, the main clay mineral in northern boreal and tundra soils, does not bind prions significantly. This suggests that soils in North American CWD-endemic regions (prairie Chernozems) we can expect prions to remain on the soil surface due to strong binding to montmorillonite, while in boreal Luvisols and mountain Brunisols most of prions will be transported through the plant litter LFH, and partially through the upper soil mineral horizon into lower horizons. In light-textured soils where quartz is a dominant mineral the majority of prions will be transported through the soil profile.

Keywords: Chronic wasting desease, prions, environmental infectivity

Quantification and visualization of soil health under long-term fertilizer and rotation treatments in Alberta

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Long-term agricultural management practices affect soil health. Five long-term rotations at the University of Alberta Breton Plots were sampled as part of the Soil Heath Institute (SHI) North American Project to Evaluate Soil Health Measurements (NAPESHM) in 2019: (1) check, NPKS and manure fertility treamtents of a wheat–fallow (WF) rotation; (2) check, NPKS and manure fertility treamtents of a 5 yr cereal–forage rotation (with and without lime); (3) continuous forage (CF) receiving NPKS fertilizer; (4) continuous grain (CG) receiving NPKS fertilizer; and (5) an 8-yr "agro-ecological" rotation of barley, faba beans and forages receiving manure. In addition to the >25 soil health indicators measured as part of NAPESHM, soil water characteristic curves (SWCC), phospholipid fatty acid (PLFA) profile, size distribution of water-stable aggregates and total C, N, ^{13}C and ^{15}N within each class of water-stable aggregates were measured on additional samples taken in 2020. These soil health indicators were used to calculate a site-specific Soil Quality Index (SQI) using methods similar to those used to develop the Cornell comprehensive assessment of soil health (CASH). Multivariate PERMANOVA and non-metric multidimensional scaling (NMDS) were used to assess the significance of long-term crop rotation, fertilization and their interactions on the soil health indicators used to develop the site-specific SQI. The indicators included in the site-specific SQI included ACE protein, pH, available P, Na, available water holding capacity, the proportion of total C (PTCA) in aggregates and Phosphomonoesterase. The SQI values of each site from high to low are 8-yr with manure (0.802), 5-yr cereal-forage with manure and lime (0.79), WF manure (0.686), 5-yr with manure (0.674), 5-yr NPKS with lime (0.633), CG NPKS (0.507), 5-yr check with lime (0.477), 5-yr NPKS (0.432), 5-yr check (0.418), WF with NPKS (0.403), CF with NPKS (0.389), and WF with check (0.38). PERANOVA results indicated significant effects of fertilizer treatments (p-value =0.0064), rotation treatments (p-value =0.0482) and their interaction (p-value =0.0095) on the soil health indicators. The primary difference in SQI values was caused by the difference of C and N input in soils, PTCA and pH in response to fertilizer, manure and rotations. The positive correlation between SQI values and crop yield is only weak to moderate, mainly because manure has a great improvement on soil quality rather than crop yield, whereas NPKS fertilizers had the opposite effect.

Keywords: Gray Luvisol, Soil Health, Long-term, Fertilizers, Rotation

The Long-Term Effects of Compaction and Organic Matter Removal on Forest Soil

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The effects of soil compaction and biomass removal due to the commercial timber harvest have the potential to lead to reductions in long-term site productivity. The Long-Term Soil Productivity (LTSP) study represents the world's largest network of coordinated study sites examining the effects of soil disturbance on forest soil productivity. One of the LTSP sites, with replicates established in 1995, 1997, and 1998/99, is the Kiskatinaw boreal installation in northeast British Columbia. In the summer of 2021, soil samples and field measurements were done to determine the effects of three levels of soil compaction and three levels of organic matter removal on selected soil quality indicators 22-26 years after treatment establishment. The following soil properties were determined: bulk density, total carbon and nitrogen, pH, forest floor thickness, aeration porosity, aggregate stability, the depth of organic matter enrichment in the upper 10 cm of mineral soil, and polysaccharides. This presentation will focus on previously unmeasured indicators from the Kiskatinaw site (i.e., aggregate stability, depth of organic matter enrichment, and soil polysaccariches). The findings of this study will provide land managers with information needed to improve management practices in forested boreal ecosystems.

Keywords: LTSP, Boreal Forest, Forest Management, Aggreagte Stability, Soil Productivity

Adaptive multipaddock grazing reduces soil microbial complexity in Canadian prairie

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Soil microbial communities in grassland play a vital role in biogeochemical cycling, but may be affected by common land uses such as cattle grazing. Consequently, it is important to understand whether the different cattle grazing-management systems alter the diversity and complexity of microbial communities. We investigated the effect of intensive adaptive multi-paddock (AMP) grazing and conventional (Non-AMP) grazing on microbial communities using 16S/ITS amplicon sequencing. Samples were collected from 13 AMP ranches and 13 neighboring ranches located across the Canadian prairies. AMP grazing had significantly higher bacterial diversity while non-AMP grazing had higher fungal diversity. Network complexity of soil microbial communities was greater in non-AMP ranch soils, and had different keystone taxa. To our understanding, this is the first study to report keystone taxa for AMP grazing and it is demonstrated that AMP grazing reduces network complexity and stability.

Keywords: Grazing system; soil microbial diversity; microbial network complexity; AMP grazing

Comparison of agri-environmental phosphorus tests for boreal agricultural and natural Podzols

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Over a dozen extraction procedures have been developed to evaluate soil phosphorus (P) for agri-environmental purposes (P-*tests*). The expansion of agriculture into boreal regions dominated by Podzols requires further insights into P extractability for sustainable P management. We compared the extractability of P in 96 Podzol samples using nine P-*tests* followed by both colorimetric (P_{Col}) and inductively coupled plasma (P_{ICP}) quantifications. Samples were collected by depth or horizon from agricultural fields and reference sites in eastern, central, and western Newfoundland (Nfld), Canada. The soil P was extracted with water, citric acid, ammonium bicarbonate diethylenetriaminepentaacetic acid (AB), Morgan, Olsen, Bray-1, Bray-2, Mehlich-1 and -3 solutions, thus targeting a wide range of extractable P in managed and natural Podzols. The studied soils, with texture ranging from silty loam to sandy loam, had a pH of 3.4 – 6.9 and soil organic matter (SOM) of 0.5 – 47.2%. Water extracted the lowest P, while citric acid solution extracted the highest in all soil samples regardless of quantification methods. Variable correlations ($r = 0.23$ to 0.96) were identified between most P-*tests,* and determination coefficients (r^2) >0.50 were found for the linear relationships of *Mehlich-3-*P_{ICP} with most P-tests. Correlations also varied with quantification methods. The difference between P_{ICP} and P_{Col} was more significant in the citric acid method. Given the diversity in extractable P across management-induced soil conditions, it is evident that a fully informed P management for the Nfld Podzols requires calibration of P-*tests* against crop P uptake.

Keywords: Podzols, soil phosphorus, extractable phosphorus, colorimetric, ICP

Session 19

Soil and Water Conservation in the Face of Climate Change

(Room: Prairie)

The Effect of Conservation Measures and Climate Change on Water and Soil Erosion on the Hilly Loess Plateau

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Soil and water conservation practices (SWCPs) have obvious effects on reducing soil and water loss. Quantifying the impact of conservation practices and climate change on soil and water erosion is important for regional environmental management. In the present study, Soil Conservation Service Curve Number (SCS-CN) and Modified Universal Soil Loss Equation (MUSLE) were adopted to investigate the surface runoff and soil erosion after the employment of different SWCPs in the Hilly Loess Plateau, China. The effect of climate change under RCP4.5 and RCP8.5 scenarios was quantified between 2020and 2050. The results of this study showed that surface runoff and soil erosion were closely related to precipitation, rainfall intensity, and rainfall erosivity. Surface runoff increased with the rise of precipitation and rainfall erosivity, while soil erosion had large variations with years due to uneven distribution of precipitation and rainfall erosivity in a year under two scenarios. All SWCPs significantly reduced surface soil and water loss. Compared with bare slopes, the reduction rates were 15-40% for surface runoff and 35-67% for soil erosion under RCP4.5 and RCP8.5 emission scenarios, respectively. The combination of shrub and horizontal terracing will be the desired recommendation for controlling surface runoff and soil erosion because this combination had smaller impacts on runoff when reducing the soil erosion by similar quantities. The results of this study can be used to assess soil and water erosion, support small watershed management, and preserve the ecosystem of erosive areas.

Keywords: soil and water conservation practices; soil erosion and surface runoff; MUSLE; SCS-CN; climate change

Electrostatic charging of organic dust emission in south Quebec cultivated histosols

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Histosols are known in agriculture for their top productivity. Their high content in organic matter offers excellent growing conditions for fruits and vegetables. In Montérégie (Québec), a large proportion of these soils is cultivated. However, previous studies indicated an annual loss of 2 cm of soil depth, half of which could come from wind erosion.

A weather station was used to monitor wind speed and direction and calculate wind friction velocity. Dust particles and soil water content were also measured using respectively a dust sampler and a TDR probe. Spectral and time series analysis were performed on these data. Periodograms between wind friction velocity and PM_{10} concentration showed a dominant variability between 5 to 7 days for both parameters, as well as a unique 12-hour cycle for the PM_{10} concentration. The cross-correlation function indicated that the two variables were highly negatively correlated, without any major lag.

Preliminary results suggested that (1) The dust emission in cultivated histosols occurs mainly during calm wind episodes, and (2) In addition to wind friction velocity, another shorter cycle, not linked to wind variation, exist. It was hypothesized that this cycle could be linked to a different physical process, likely electrostatic charging of organic dust particles by triboelectric friction in dry environment.

In order to verify this hypothesis, an experiment was developed in the lab to simulate triboelectric friction in both conductive and insulated environments. A small vortex was generated with an air stream in two cylinders, one in plastic and the other in a metal grounded to earth. This allowed particles to collide with each others, generating an electric charge only in the insulated environment. After the initial pulse, the dust emission was monitored constantly for a long period with a dust decoder to assess how the electric charge impacted dust emissions and quantify the importance of this mechanism for erosion.

Keywords: Wind Erosion; Dust emission; Triboelectric friction; Histosols

Evaluation of crop production in response to changes in blue and green water resources in Canadian Prairies

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Despite the perception of being one of the most agriculturally productive regions globally, crop production in the Prairie lands of Canada is strongly dependent on variable climate and water resources. Annual and seasonal mean temperature is projected to increase in many countries globally, with larger changes in Canada. This can enhance annual evapotranspiration and shift the distribution and timing of snowmelt, which may change the availability and reliability of water supply components for crop production. Here, we developed a modeling framework for a thorough evaluation of the dynamics of blue and green water availability and their likely shift in response to global warming in the future. We enabled the Soil and Water Assessment Tool (SWAT) to assess and analyze historical (1987-2016) and future (2030-2059 and 2070-2099) hydrologic balance and spring wheat yields (SWY) at a high spatial resolution in Nelson River Basin (NRB). The simulated monthly and yearly streamflows and crop yields were calibrated and validated for the 1987-2006 and 2007-2016 periods, respectively, to represent agro-hydrologic processes in the basin. Further analyses were performed to assess the model uncertainty arising from various input data and model structures. Future climate scenarios were generated from an ensemble of downscaled Global Climate Models (GCMs) of the Coupled Model Inter-comparison Project phase 6 (CMIP6) for SSP126, SSP245 SSP370, and SSP585 scenarios. Overall, the hydrological model performance was desirable for streamflow simulation during the calibration and validation periods. The bR^2 values varied from 0.1 to 0.96 across hydrometric stations in small river tributaries, and it varied from 0.5 to 0.95 in the main stems across the NRB. The predicted SWY indicated excellent model performance (r-factor<2, p-factor>0.8, and MSE<0.15) in 40 counties, followed by a fair performance (2<r-factor<4, 0.6<p-factor, and MSE<0.35) in 10 counties. The calibrated model lays the basis for further predicting and examining blue and green water responses to climate change and their likely interchange in the short and long terms. The study can help better understand the potential impacts on food production and virtual water trade potentials across NRB.

Keywords: spring-wheat, blue water, green water, climate change

Root Water Uptake of Spring Wheat in the Dark Brown and Black Soil Zones of Saskatchewan

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Knowledge of plant water uptake patterns plays an important role in modeling hydrological processes in cropping systems and can provide insight into crop adaptations to environmental conditions. Understanding the distribution of soil water and roots as they relate to root water uptake (RWU), is important for developing "water smart" rotations. Rooting depths and water depletion in soil profiles under hard red spring wheat (var. AAC Connery) were measured during the summer of 2021 in the Dark Brown and Black soil zones of Saskatchewan, near Central Butte, SK and Langham, SK. Soil moisture was monitored using Time Domain Reflectometry (TDR) sensors installed to a depth of 135 cm to determine soil water depletion throughout the growing season. Abnormally dry conditions in the summer of 2021 provided a soil moisture depleted environment in which to monitor rooting depth and root water uptake patterns of wheat. The rooting depth, hydrogen and oxygen stable isotope abundance in wheat roots and soils were taken and applied to a Bayesian mixing model to determine RWU patterns. Additionally, the water use efficiency (WUE) and water footprint (WF) were determined. Rooting depths, soil water storage, WUE, and WF varied between sites. The resulting rooting depths of hard red spring wheat ranged between 60-80 cm, where the site near Langham, SK with a gravel lens at depth had the shallowest rooting depth at 50 cm. The wheat crop in a pothole depression south of Central Butte, SK was the only site where RWU occurred below 1 m, relying on deep-soil water. This site had the highest WUE and lowest WF. The remaining sites located in level upper slope landscape positions relied on shallow soil water stored within 1 m of the soil surface, coinciding with measured shallow rooting depths at these sites. It is probable the lack of soil water recharge from the previous season and spring drought restricted early root growth and rooting depth in the uplands. Electrical conductivity, soil moisture, and soil texture were identified as variables affecting RWU.

Keywords: Wheat Rooting depth; Wheat Root Water Uptake; Water Isotope Tracers

Session 16

Greenhouse Gas Emissions from Agricultural Soils

(Room: Prairie)

Higher than expected N_2O emissions from canola residues: stable isotope tracing reveals soil organic matter as the dominant source of N_2O-N

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Understanding and managing the fate of nitrogen (N) in crop residues is important for mitigating nitrous oxide (N_2O) emissions and optimizing N transfer to subsequent crops. Microbial utilization of residue N is dependent on the biochemical composition of the residue affecting mineralization-immobilizatoin dyanmics and gaseous N losses. Previous research showed higher-than-expected N_2O emissions following canola production in the field but the drivers of this N_2O flux are unknown. We used ^{13}C- and ^{15}N-labelled crop residues from canola, wheat, flax and field pea to track the fate of residue C and N during decomposition. Residues from each crop type were added to soil microcosms at a rate equivalent to residue production in the field. Stable isotope tracing was combined with measurement of soil N pools, gaseous emissions and microbial dynamics over a 362 h controlled-environment incubation. Total N_2O, as well as residue-derived and residue-induced N_2O emissions were highest for canola, intermediate for wheat and pea and lowest for flax ($p<0.05$). The N_2O emission factor for residue-derived emissions was 1.56% for canola compared to 0.99% for pea, 0.96% for wheat and 0.18% for flax. Measurement of soil gas fluxes combined with quantification of N functional genes showed that rapid decomposition of canola residues led to O_2 limitation and a shift to denitrification. Residue-induced N_2O emissions from canola were six times higher than residue-derived emissions indicating that most of the N_2O flux originated from soil N pools rather than residue N. This was in contrast with the source of C for microbial biomass growth which mostly came from the residues. ^{13}C-PLFA probing likewise revealed shifts in microbial community structure and abundance revealing that different functional groups were responsible for C and N turnover among the residue types. Using multiple stable isotope tracing techniques we tracked the source and fate of residue C and N, through the microbial community during residue decomposition to better understand drivers of N_2O emissions. This new knowledge will lead to improved practices for mitigating N_2O emissions, conserving residue N for subsequent crop growth and reducing N fertilizer requirements.

Keywords: nitrous oxide, stable isotope, microbial process, denitrification

Effect of fall rye cover crop on CO_2 and N_2O fluxes in the Red River Valley, Manitoba, Canada

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Although cover crops have been linked with increased carbon sequestration in soils, there is little understanding of how cover crops affect nitrous oxide (N_2O) emissions and carbon dioxide (CO_2) fluxes from soils during their growth and after their termination. The objectives of this study are to determine the effect of a fall rye cover crop planted into soils managed under zero tillage on CO_2 and N_2O fluxes from soils in the Red River Valley, Manitoba, Canada. Fluxes have been measured continuously for four years (2018-present) from four 4-ha plots using the flux gradient method. A tunable diode laser analyzer was used to measure the CO_2 and N_2O gradient from each plot, and sonic anemometer-thermometers were used to measure the transfer coefficient. Starting in 2018, two of the plots were seeded no-till with fall rye after harvest, and two plots were left in fallow. The fall rye was then terminated the following spring at seeding with a herbicide application. We alternated plots each study year to assess the effect of tillage on CO_2 and N_2O fluxes from the cover crop no-till system after it was tilled under in fall. During the growing season, the cash crops canola, oats, and spring wheat were grown in 2018 and 2020, 2019, and 2021 respectively. We report here increased net ecosystem productivity in fall and spring in years of good cover crop establishment. Termination of the cover crop in spring did not result in episodes of N_2O emissions.

Keywords: Fall rye; cover crop; flux gradient; carbon dioxide; nitrous oxide

Soil nitrous oxide emissions from novel perennial grain systems and their relationship to soil physical and hydraulic properties

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Novel perennial grain crops have been proposed as a solution to several environmental issues facing modern agriculture, such as the loss of soil physical quality and substantial N_2O emissions associated with annual monocrops. This study evaluated N_2O emissions as well as soil physical and hydraulic properties along an experimental continuum of perenniality (perennial forage, perennial grain, and spring grain) in Central Alberta, Canada over three years (2018 to 2020). Field N_2O emissions were measured biweekly every year throughout the growing season using static chambers and a micrometeorological technique based on an open-path Fourier-transform infrared gas sensor (OP-FTIR). Cores for determination of soil physical and hydraulic properties using HYPROP® system were collected in 2020 from three soil depths (5-10, 15-20 and 25-30 cm). Root samples from 0-60 cm were obtained during crop anthesis in 2018 and 2019. Perennial grain crops reduced cumulative N_2O emissions at the Breton site by 60% and 94% in 2019 and 2020, respectively ($Ps < 0.0001$). Reductions in N_2O emissions by perennial grain crops in 2019 correlated with increased root density ($R^2 = 0.39$, $P < 0.01$). Increases in bulk density in the spring grain treatment were mirrored by relative increases in total porosity of the perennial treatments for all depths. Specifically, the perennial forage treatment increased macroporosity, effective porosity and unsaturated hydraulic conductivity in the 25-30 cm depth increment ($p < 0.001$). Multiple regression and correlation analyses revealed significant inverse relationships between cumulative N_2O emissions versus effective porosity and S-index in the 5-10 cm depth increment (model $R^2 = 0.40$, $P < 0.05$). Our findings highlight the complementary benefits of perennial grain cropping and suggest that reductions in N_2O emissions are in part a result of underlying improvements in soil physical quality relative to annual grain systems.

Keywords: perennial grain; nitrous oxide; OP-FTIR; static chambers; soil quality; Hyprop

Optimizing the benefits of cover crops to reduce nitrous oxide emissions: the impact of freeze-thaw

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Adoption of agroecological principles to increase crop/plant diversity in agricultural systems can result in many enviornmental benefits, and there is growing interest in the capacity to reduce nitrous oxide (N_2O) emissions from soil. Within annual cropping systems, the use of cover crops is a form of diversification that adds plant species to fields when cash crops are not being grown. However, the impact of cover crops on soil N_2O emissions has not been clearly identified particularly for cold regions characterized by soil freezing and thaw. As freeze-thaw events can lead to spikes in N_2O production that substantially contribute to cumulative emissions, understanding how, and the extent to which, cover crops regulate emissions during those periods needs our attention.

In this talk, we will report on N_2O emissions from cover cropping and cover crop diversification trials, paying special attention to freeze-thaw events. Using the flux gradient method, field measurements were started in May 2018 on two 8-ha fields comparing a simple corn-soybean-soybean rotation with a diverse corn-soybean-winter-wheat crop rotation including a two-species cover crop mixture (annual ryegrass and crimson clover) under-seeded into corn and a four-species cover crop mixture (crimson clover, cereal rye, oats, and daikon radish) following winter wheat. Preliminary results for one complete cycle of the 3-year rotation will be presented and discussed in terms of our emerging lines of inquiry aimed at better understanding the plant-soil mechanisms that drive emission differences in cold climates. Our research is intended to inform management decisions on cover crop selection and evaluate the role of plant diversification in meeting climate change mitigation goals.

Keywords: nitrous oxide; cover crops; diversification; climate change mitigation; soil health

Mitigating nitrous oxide emission from corn using nitrification and urease inhibitors following cover crop use

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Cover crops may help maintain and increase soil organic carbon, but can also result in increased emissions of nitrous oxide (N_2O), a potent greenhouse gas. Increased N_2O emissions have a higher chance of occurring when cover crops are terminated before fertilizer application to corn. Nitrification and urease inhibitors (NUIs) have been shown to reduce N_2O emissions, but their use after cover cropping has not been well studied with year-round studies. Micrometeorological techniques used in this study, are suited for high temporal resolution of year-round measurements in a humid temperate climate in Ontario Canada. The objective of this study was to evaluate the potential of cover crops and the nitrification inhibitor (Pronitridine) and the urease inhibitor (N-butyl thiophosphoric triamide) to reduce N_2O emissions in corn following cover crop use. The flux-gradient method was deployed on four 4-ha fields using a tunable diode laser trace gas analyzer. Two 4-ha fields have been managed with a conventional rotation, consisting of soybean-soybean-corn, and two 4-ha fields were managed with a diverse rotation, consisting of soybean-winter wheat-corn with cover crops since 2018. A four-species cover crop mixture (crimson clover, cereal rye, oats, and daikon radish) was planted after winter wheat harvest (July 31, 2020) and cereal rye and crimson clover were chemically terminated before corn planting on May 14, 2021. Nitrogen starter fertilizer (4.78 kg N/ha) was applied to corn at planting, followed by urea-ammonium-nitrate (UAN) at 162 kg N/ha injected 10cm below the soil surface, at the sixth leaf stage (June 17, 2021). One of the diverse and one of the conventional rotation fields received NUIs mixed into UAN at the time of fertilization. Annual ryegrass and crimson clover were under seeded manually to corn one week after fertilization in the diverse fields. N_2O fluxes were measured from September 1, 2020, to April 30, 2022, and supporting data includes soil ammonium and nitrate concentrations, corn yield, and nitrogen uptake for each field. N_2O flux measurements indicated the use of NUIs reduced annual cumulative N_2O emissions by 13.6% and 20.3% in the conventional and diverse rotations, respectively. NUIs were effective in reducing the N_2O emissions associated with fertilizer application in the conventional and diversely managed fields. These initial results show the potential of NUIs to reduce N_2O emissions associated with cover crop use, but more studies in other climates with different soil types are necessary.

Keywords: Nitrous Oxide (N_2O); Nitrification & Urease Inhibitors (NUI); Cover Crops

4R Options to Reduce N_2O Emissions from Corn in Sandy Soils.

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In recent decades, the pillars of 4R nutrient stewardship - Right Source, Right Rate, Right Time, Right Place, have guided the development of best management practices in various soil-climatic conditions. However, 4R research investigating measures of sustainability for multiple practices simultaneously remains in short supply. The objectives of this research were to compare growing season N_2O emissions and Nitrogen (N) use efficiency measures between 1) At-planting sources of N (Urea, ESN/Urea, SuperU); 2) In-season sources of N applied as surface dribble (UAN, Agrotain, AgrotainPlus); 3) In-season placement depths of N (Surface dribble, Shallow, Deep) applied to corn in sandy soils of Manitoba, Canada. On three different commercial farm fields, treatments were replicated four times in a randomized complete block design for the 2018, 2019, and 2020 growing seasons. Static-vented chambers were used to collect gas samples in triplicate at twenty minute time intervals (0, 20, 40, 60min) from plots given the recommended rate of N (112 kg N ha^{-1}); linear interpolation was used to estimate fluxes between sampling dates and calculate cumulative seasonal emissions. PROC GLIMMIX was used in SAS to perform analyses of variance for each set of management practices. Block and site-year were treated as random variables. Across site-years, ESN/Urea showed the lowest mean area-scaled emissions among at-planting sources, however treatments did not show significant differences; area-scaled emissions of AgrotainPlus were significantly lower than UAN Surface; UAN Deep had the lowest emissions among in-season placements, however did not show significant differences. Persistent dry conditions combined with timely precipitation after fertilization lowered the potential for enhanced efficiency fertilizers and deep placement to reduce N losses. Future research aims to quantify NO_3^- leaching and NH_3 volatilization losses resulting from similar N management options in this region.

Keywords: 4R, Corn, Nitrogen; Manitoba

Biochar mitigates N_2O emissions from sandy soil by improving soil pore structure and increasing nosZ gene abundance

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Abstract: Intensive vegetable field in the red soil region of China is the main anthropogenic source of nitrous oxide (N_2O) emissions. Biochar, having large specific surface area and well-developed pores, may decrease soil N_2O emissions by improving soil permeability, providing microbial habitat and modulating the rate of nitrification and denitrification; however, the coupling mechanism of soil microstructure and denitrifying microorganism for biochar effects on N_2O emissions is poorly understood. A 40-day incubation assay was performed with seven treatments: no addition, two fertilizers (urea, and ammonium sulfate), two types of biochar combined with urea and two types of biochar combined with ammonium sulfate to study the effects and mechanism of biochar on N_2O emissions from a sandy soil in intensive vegetable field. Relative to the fertilizer treatments, biochar decreased at least 60% of N_2O emissions, due to decreased abundance of ammonia-oxidizing bacteria (AOB) and increased abundance of nitrous oxide reductase (nosZ) gene. Biochar also improved the specific surface area, pore size and pore volume of 0-5 mm aggregate particles in the sandy soil, Significantly increased the size of 0-10 μm pore - size portion from 2-5 mm soil aggregates. The results showed that biochar can significantly decrease N_2O emissions by improving soil pore structure, and soil aeration condition. Therefore, this study proposes a practical way to use biochar as a soil conditioner for reducing N_2O emissions.

Keywords: Biochar; N_2O emission; pore-size; Functional gene

Understanding the complex interconnections between topography and soil physical, chemical, and biological controls of N_2O emissions

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Agriculture sector contributes more than 52% of anthropogenic nitrous oxide (N_2O) emissions into the atmosphere. These emissions are regulated complex interactions between by soil physical, chemical, and biological properties. Additionally, landscape topography controls N_2O emissions through direct and indirect mediation on these soil properties and processes. Previous studies have focused more on direct relationships among individual soil properties and N_2O emissions. However, the interconnectedness of soil physical, chemical, and biological properties and their regulation by topography had not been studied in detail. In this study, we explored the complex interconnections between soil topography (elevation, slope, TWI, landform classes), physical (sand silt, clay, temperature, moisture), chemical (pH, electrical conductivity; EC, nitrate; NO_3^-, and ammonium; NH_4^+), and biological {abundance of N cycling genes; ammonia monooxygenase gene (amoA), nitrite reductase genes (nirS, nirK), and N_2O reductase genes (nosZ1 and nosZII)} properties to predict their direct and indirect impacts on N_2O emissions. We hypothesized that topography controls N_2O emissions by regulating soil physical, chemical, and biological properties at landscape level. The objectives of this study were (i) to determine the complex interconnections between soil topographical, physical, chemical, and biological factors controlling N_2O emissions, and (ii) to evaluate the inter-relations among these factors and their direct, indirect, and total effects on N_2O emissions using Structural Equation Modelling. Experiments were conducted at two agricultural fields (Baggs farm, Research North). Gas and soil sampling was conducted over a two years corn-soybean rotation. Three structural equation models were conceptually developed and tested using multivariate analysis (exploratory and confirmatory factor analysis). Two SEM models were developed for data sets at Baggs farm: model 1 (13 soil variables without biological parameters), model 2 (18 soil variables including 5 N cycling microbial genes). Model 3 was developed for Research North. SEM model 1 revealed that landform classes, silt, and clay had significant ($P < 0.05$) direct influence on soil moisture, NH_4^+, and pH ($R^2 = 0.49$) and total impact (direct + indirect) on N_2O emissions ($R^2 = 0.13$). Model 2 also showed strong ($P < 0.05$) direct impact of landscape parameters as well as inorganic N (($R^2 = 0.33$, $R^2 = -0.31$) on N_2O emissions. At Research North, (model 3) inorganic N (NO_3^-, NH_4^+, and EC) were major factors controlling N_2O emissions directly ($R^2 = 0.44$, $P < 0.05$). Inorganic N factor ($R^2 = 0.20$) and N_2O emissions ($R^2 = -0.20$) were directly affected ($P < 0.05$) by Landscape variables (elevation, landform classes, and silt). Based on these findings we concluded that variations in landscape topography and soil texture control soil biochemical properties and N_2O emission process. Therefore, management practices should be developed and adopted regarding topographical controls on greenhouse gas emissions.

Keywords: structural equation modelling, multivariate analysis, greenhouse gas emissions, soil, crop production

Effects of biobased residues on greenhouse gas emissions during growing and non-growing seasons

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Abstract:
Annual greenhouse gas emission from temperate agricultural land occurs due to microbial activity and fertilizer addition during the growing season, although greenhouse gas emissions can also occur during non-growing season. We monitored greenhouse gas emissions and ancillary soil data during the growing and non-growing season from soils that received urea and biobased residues in a temperate agricultural field under a corn-soybean rotation. Urea was applied annually and biobased residues (composted food waste, hydrolyzed biosolids, anaerobic digestate) were applied during the first and third field season at recommended rates. Compost had the highest CO_2 emission and urea has the highest non-CO_2 emission although treatments are not significant ($p<0.05$). Non-growing season accounted for about 19% to 78% of the annual emission. Emissions among years and seasons were different ($p<0.05$). Nitrous oxide emission was similar among seasons likely due to the availability of N substrates throughout the year and the impact of freeze-thaw conditions during the non-growing season. Soil moisture content, soil temperature, electrical conductivity, ammonium, and nitrate were significant predictors of soil greenhouse gas emissions, and explained 5% to 67% of the emissions during growing and non-growing seasons. This suggested that a varied supply of mineralized carbon and nitrogen substrates were available from the biobased residues and contributed to greenhouse gas emissions among seasons.

Keywords: non-carbon dioxide emission, composted food waste, anaerobic digestate, biosolids, soil ancillary data

Greenhouse gas emissions from beef cattle urine and dung patch as affected by the non-bloat legumes

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Sod-seeding pastures with non-bloat legumes like Cicer milkvetch (CM) and Sainfoin (SF) represents an innovative approach to reducing fermentation, but the greenhouse gas (GHG) emissions from the urine and dung patch excreted by the cattle grazed on these forage remains unclear. In Western Canada, few studies have been conducted to measure GHG emissions from urine and dung patches, and none examined the impact of the change in plant composition hence diet on GHG emissions. To address this, we collected the urine and dung excreted by the cattle either grazed on these non-bloat legumes or Alfalfa-bromegrass pasture, then applied back to the pasture field to create the diet-related excrement patch and measured CO_2, N_2O, and CH_4 from them. The manure was applied on July 30 for 2019 and August 03 for 2020 and the measurement of GHG emissions was continued till the flux back to the background levels. To account for the pasture hummocky landscape, manure patches were applied on two slope positions and we further use Lidar point cloud dataset to derive 5-meter resolution digital elevation model (DEM) coupled with geospatial analysis to determine topographic indices (i.e., elevation, slope, and topographic wetness index) for each chamber location. During the measurement, soil moisture was measured using the TDR system each time and the plant-available nitrogen was monitored by the PRS probes every 21 days. Our results would reveal the relative influence of soil and topographic properties together with the weather on excrete patch GHG emissions. We also would present the estimate on manure patch GHG emissions relate to non-bloat legumes.

Keywords: Animal waste, GHG emissions, Non-bloat legumes, Structural equation modelling

Greenhouse gas emission during composting of different mixing combinations of natural resource by-products: Incubation study

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Utilizing locally available natural resource by-products from forestry sector (Wood shavings (WS), wood ash (WA), biochar (BC), and paper sludge (PS)) with poultry manure (PM) to produce compost could be an alternative for synthetic fertilizer and help to improve soil physicochemical and biological characteristics. Emission of greenhouse gases (GHG) during composting is unavoidable which leads to increase the greenhouse effect. Objectives of this study were to; (i) compare the different mixing combinations of WS, WA, BC, PS, and PM to reduce nitrous oxide (N_2O), carbon dioxide (CO_2), methane (CH_4) and ammonia (NH_3) emission during the composting process, and (ii) find the effect of BC on GHG and NH_3 emission. Laboratory scale incubation study was carried out in the laboratory using one Litre Mason jars with six different mixing combinations of WS, PS, PM, WA, and BC (wet weight basis) in three replicates. All treatments were maintained at the same C: N (38±2: 1) in initial mixtures. Moisture content (mass basis) of the mixtures were maintained between 55% and 60%. GHG emissions were measured using Gasment DX4015 during the 60 days. According to analysis of variance (ANOVA) and t-Test: two-sample assuming equal variance analysis, there were no significant differences among the mean values of the treatments for GHG and NH_3 emission and there was no significant effect of BC on GHG and NH_3 emission.. This incubation experiment will help for development of future studies on composting of natural waste by-products to measure GHG emission. Composting will be an environment friendly and economical solution for recycling of organic by-products of industries in NL and the expansion of agriculture.

Keywords: By-products, Composting, Greenhouse gas, Incubation study, Natural resource

Survey of Cow-calf Operations to Characterize Manure Management, Nutrient Composition, and Greenhouse Gas Emissions

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A survey of ten cow-calf operations in Manitoba was conducted to characterize farm management practices, manure composition, and greenhouse gas (GHG) emissions from stored manure bedding packs of overwintering beef cows. Producers were asked about farm management decisions, including supplemental feed, animal environment, and manure handling, storage, and application from August 2019 to September 2020. Manure characterization occurred June to September 2020 and involved sampling for manure nutrient two or three times (in-pen, at manure piling, if applicable, and prior to land application), bi-weekly physical analysis, and bi-weekly determination of CO_2, CH_4, N_2O, NO_2, and NH_3 fluxes using a steady-state flow through hood with an in-line FTIR multigas analyzer. Operations that piled manure bedding packs had greater CO_2-equivalent GHG emissions than those keeping manure packs in place without piling. Farm calving season and mixing of piled manure affected the quantity and timing of emissions. Overall, the highest GHG emissions in CO_2 equivalents across all farms were from CH_4; manure piles were greater sources of CH_4, N_2O, and NO_2 than bedding packs. Understanding the influence of management on manure composition and GHG emissions will aid in developing emissions models, accurate emissions estimates, and best management practices for producers, helping to position the cow-calf sector towards sustainability.

Keywords: Manure; Greenhouse gasses; Environmental sustainability

Session 2

Data Science, Modelling and AI in Soil Science

(Room: Gracier)

Holos V4 release – updates and open source development

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Holos is AAFC's whole-farm model that uses National greenhouse gas (GHG) inventory calculation methods on the farm level to provide users with a whole-farm GHG budget. The model includes all GHG (N2O, CH4, and CO2) and covers the majority of crops and all livestock grown in Canada. The model is designed for use by non-academics, but offers opportunities for academics and students not familiar with agricultural models. Over the past years, the Holos model has undergone a complete redevelopment, completed now with a brand-new user interface, several updates of existing algorithms and several new additions that expand the models capabilities to represent Canadian farmers practices. The presentation will cover a quick overview of the capabilities of the model (livestock-crop interactions, shelterbelts, anaerobic digestion) and highlight options for collaboration on future model development and expansion.

- Canadian agricultural production systems
- Greenhouse gas emissions
- Whole farm analysis
- Model development

Keywords: Canadian agricultural production systems; Greenhouse gas emissions; Whole farm analysis; Model development

Modelling soil organic matter dynamics at the University of Alberta's Breton Plots using CQESTR

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Accurate modelling of soil organic matter (SOM) dynamics is of increasing importance to land use planning as global land use intensifies in response to growing populations. However, many models of SOM dynamics are highly complex and require prohibitive amounts of input data. CQESTR — a SOM dynamics model developed by the United States Department of Agriculture (USDA) — was created to provide an agriculture-focused model that could function with relatively little input data on timescales spanning from days to decades, at the field scale. We applied the CQESTR model to data gathered from the Breton Plots — long-term agricultural research plots run by the University of Alberta. Input data included: daily temperatures; crop rotation, tillage, nitrogen content, and yield information; applied soil amendments and their nitrogen content; as well as soil texture and moisture regime. The model effectively reproduced measured long-term trends in SOM dynamics without having to optimize or calibrate model parameters. This successful application of the CQESTR model demonstrates its potential to inform agricultural management strategies and suggests it may be a viable alternative to more complex models.

Keywords: Breton Plots; Soil organic matter; CQESTR; Modelling; Data science

Mapping Canada's soil organic carbon from space

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Soil is the largest terrestrial carbon (C) pool, storing about 1500 Gigatonnes (Gt) C at 1m depth. Comprising about one third of the world's circumpolar boreal forest and one of the largest peatland complexes of the world, Canada holds large amount of soil organic carbon (SOC) stocks that have been protected from decomposition by cold temperatures. As temperatures rise, these large C reserves are becoming available for decomposition and eventual release into the atmosphere, which makes the quantification of SOC stock in Canada critical for the assessment of climate change impacts. This study aimed to produce the first wall-to-wall estimates of SOC stocks and uncertainties in soils of Canada at 250m spatial resolution and two depths intervals (0-0.3m, 0-1m). For this, we used a large number of ground measurements associated with 40 covariates composed of multisource satellite, climate and topographic data, and a machine learning algorithm. Ground measurements of SOC concentration (g kg^{-1}) were acquired from 6,533 sites distributed in 39,621 soil layers, while bulk density (BD) measurements (kg dm^{-3}) were acquired from 2,157 sites comprising 11,068 soil layers. SOC and BD were modeled using 25 of 40 covariates selected in a recursive feature elimination procedure, and a random forest algorithm. Afterwards, SOC stock (kg m^{-2}) was computed using SOC, BD, and coarse fragment (CF) information. Rooting depth and ground ice abundance layers were used to discount shallow soils and ground ice, respectively. A mask was applied to remove water and ice/snow areas based on a land cover classification map. The final SOC stock maps revealed that Canada's soils store 111 Gt C (average of 13.2 kg m^{-2}) in the top 30cm, more than previous global estimates. At 1m soil depth, soils store 306 Gt C (average of 36 kg m^{-2}), 98 Gt C – almost one third – of which are stored in peatlands, confirming that this ecosystem dominates SOC stocks in Canada. We also find previously under-reported large soil organic C stocks in forested peatlands on the boreal shields of Canada. Given that Canada is warming twice the global average rate and Canadian soils store approximately 20.4% of world soil C stocks in top 1m, initiatives to understand their vulnerabilities to climate change and disturbance are indispensable not only for Canada but also for the global C cycle.

Keywords: Soi organic carbon; Machine learning; Satellite data; Peatlands

Assessing the risk of deep percolation at a phosphogypsum reclamation site that has been phyto-capped

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In Alberta, phosphogypsum (PG) is a by-product of phosphorus fertilizer production and is piled into large stacks that eventually require reclamation. The first step in the reclamation process is constructing a topsoil cap to facilitate revegetation. A promising, cost-effective, and environmentally beneficial alternative to traditional soil caps underlain with expensive synthetic liners, ***phytocaps*** effectively reduce deep percolation through canopy interception of rainwater, temporary water storage in the root zone and the process of evapotranspiration. A phytocap made up of fast-growing poplar trees was established on PG stack at a former phosphorus fertilizer plant in Fort Saskatchewan, Alberta, in 2015. This study focuses on quantifying the risk of deep drainage below the root zone of the phytocap. The hypothesis guiding this study was that despite variable weather conditions affecting precipitation inputs and evapotranspiration outputs of the stack, there would not be a considerable risk of deep drainage. Thus, the amount of water draining below the root zone and potentially off-site to sensitive environmental receptors would be minimal. To help quantify the water percolating through the stack, the water balance was simulated using HYDRUS 1D for four climate scenarios: 1) dry and hot; 2) dry and cold; 3) wet and hot, and 4) wet and cold represented using 60-years of historical weather data. Although variable climate conditions would influence transpiration rates and growing seasons lengths, it is expected that the model results will support the hypothesis that variable climate conditions would not significantly affect the risk of deep percolation, as the poplar phytocap would take up the incoming precipitation in all scenarios. These findings will be applied to assess the efficacy of phytocaps as an alternative practice in managing phosphogypsum stacks.

Keywords: CSSS-ASSW2022; Soil science; Edmonton; HYDRUS 1D; phytocap; deep percolation risk

Modelling shadow and cover effects on manure temperature

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Manure temperature is crucial to estimate methane emissions from manure management systems. Since measured data of manure temperature is rare, mechanistic models are used to simulate manure temperature. However, previous mechanistic models did not consider the shadow and cover effects that reduce solar radiation and impact evaporation, which results in a decrease or increase of manure temperature. The objectives of this study were (1) to develop modules for simulating the effect of shadow and tank cover effects on manure temperature, and (2) to analyze the sensitivity of the manure temperature and cumulative radiation input to different latitudes and designs of manure tanks. Modules were developed to a) estimate the shadow effect caused by the tank wall which considers the angle of direct solar radiation and the height of the wall above the manure surface, b) to estimate the effects of a polyester cover, that reduces direct solar radiation and evaporation, and c) to include the effects of snow cover in winter that increase surface albedo and enthalpy of fusion while melting. Independent validation assessment was conducted using manure temperatures at 0.5m, 1.5m, and 2.5m depth in two manure tanks (20 m in diameter, with and without polyester cover), measured in Sweden from 2020 June to May 2021. In the tank without a cover, the average annual and summer manure temperatures were 8.4°C and 15.4°C, respectively, while the modified model estimated these temperatures to be 7.9°C and 16.4°C. In the tank with a polyester cover, the average annual and summer manure temperatures were 9.5°C and 16.1°C, respectively while the modified model predicted values of 9.4°C and 16.2°C. The modified model showed high model accuracy (R^2 = 0.94 and 0.93, RMSE = 1.8°C and 1.3°C, and d index = 0.97 and 0.98, for the tank without and with a polyester cover respectively). Sensitivity analysis suggests that smaller diameter but deeper tanks should be used when feasible to reduce manure temperature in high latitude areas. The inclusion of shadow and cover effects in the manure temperature model improved model performance. These improvements are important as a foundation for simulating methane emissions using simpler (i.e. 2019 IPCC Refinement) or more complex modelling approaches.

Keywords: Methane emissions; Slurry; Heat transfer; Mechanistic model

Improving the performance of equation based pedotransfer functions from literature using a non-linear least squares approach

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To calculate soil carbon stocks, measurements of carbon concentration and bulk density are required. In legacy soil datasets, bulk density measurements are frequently unavailable, so must be estimated. As part of a project whose goal is to predict the carbon stocks of British Columbia soils, methods of improving bulk density predictions are being investigated. Pedotransfer functions (PTFs) have been used for decades to estimate bulk density and other soil attribute values, although they are usually developed for a specific region and so may need to be adjusted in order to be applied to a different region. An approach to generating new coefficients for existing equation-based PTFs is the non-linear least squares (NLS) method. This can be done using the nls() function in the R programming language. To test whether using NLS can improve the performance of existing PTFs, 59 PTFs from literature were chosen to be tested on two soil attribute datasets, one from BC and the other from Ontario. The variables included in these datasets were bulk density, organic carbon content, depth to horizon midpoint, sand, silt and clay percentages, pH, and coarse fragment content. These variables were chosen because they frequently appear in existing PTFs and are available in both BC and Ontario datasets. With few exceptions, using the NLS function generated dataset-specific coefficients for existing PTFs that improved the performance of those PTFs. The resulting average RMSE was 0.19 and average concordance was 0.68 for the PTFs that were then re-tested on the two datasets. This suggests that using the NLS function is an efficient way to improve the performance of existing equation-based PTFs from literature, by generating coefficients that are tailored to regional datasets.

Keywords: Pedotransfer function, digital soil mapping, non-linear least squares

Using Artificial Intelligence and Earth Observation Technology to Identify Mineral Soil Pads in Peatlands

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Preliminary estimates suggest that thousands of mineral soil pads have been left in place after abandonment of oil and gas well sites throughout peatland areas of Alberta. To date, there remain significant knowledge and data gaps regarding the ability of padded well sites to return to natural ecosystem functions. Our understanding of the factors that result in sustainable forest ecosystem development on pads is limited, and the long-term legacy effects on soil characteristics and land capability of adjacent peatlands have not been well studied. Consequently, practitioners, regulators, and industry stakeholders have experienced challenges with the reclamation certification of these sites. To inform these knowledge gaps and gain a better understanding of the impacts of mineral soil pads in peatland ecosystems, we must first identify padded well sites at the province-wide scale and in a cost-effective manner. In this project, we used high-resolution lidar data combined with open-access optical and synthetic aperture radar (SAR) imagery from Sentinel-2 and Sentinel-1, respectively, to develop a supervised machine learning model that predicts mineral pad presence at known well sites by exploiting the differences in elevation, texture, vegetation, and moisture characteristics on pads compared to adjacent landscapes. The imagery was accessed via Google Earth Engine (GEE) and a semi-automated processing workflow was developed using Python libraries such as Pandas and Scikit-Learn. This method leverages the high-speed computing power of GEE's cloud-based geospatial analysis platform and open-source machine learning software libraries to perform large scale analyses efficiently. Preliminary overall pad prediction accuracy is 81% and we are evaluating different algorithms to improve the model's performance. To our knowledge, this project is the first attempt of its kind to quantify the abundance and map the distribution of padded well sites in Alberta's peatlands. The results will help industry gather new information on padded well sites, enabling them to effectively collect field data, evaluate the impacts of pads left in place in peatlands, and support future best practices and decision support tools for reclamation. Furthermore, this project lays the groundwork for the development of a modelling approach utilizing Earth Observation data to address well site reclamation.

Keywords: Reclamation, mineral soil pad, machine learning, Earth Observation, Google Earth Engine

Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM) Version 3.0

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The Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM) Version 3.0 is a web-based decision support application. It helps land managers evaluate fertilizers and livestock manure management options, and formulate a fertilizer program that fits within the farm budget. This in turn optimizes crop production, minimizes nutrient losses, and supports profitable and sustainable crop production in Alberta. The AFFIRM tool helps land managers optimize crop production by determining appropriate nutrient application rates. Nutrient application rates are dependent on the principle of identifying the limiting growth factor and diminishing economic returns based on crop price, fertilizer nutrient costs and the farm fertilizer budget. The application allows the user to compare nutrient management scenarios based on the 4R nutrient stewardship principles for right nutrient source, right time of application, right placement and right rate. The user can enter information specific to their situation into AFFIRM to test various cropping, nutrient management and climatic scenarios to optimize nutrient management decisions. This presentation focuses on describing key scientific principles, models and data on which AFFIRM v3.0 is based. The presentation will also cover introductory demonstration of how to get into AFFIRM, its features and how to use it. The presentation will help stakeholders to know and get to understand the AFFIRM v3.0 tool more, which will greatly aid their decision making in ensuring economically profitable and environmentally sustainable agricultural production in Alberta.

Keywords: Yield response; 4R; nutrient management

Scenario-based modelling of soil organic carbon under avoided grassland conversion

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Western Canada's grasslands are critical carbon sinks that provide essential ecosystem services such as water purification, vital species habitats, and food security, amongst other benefits. However, most of these grasslands are at risk of loss via land use conversion to agricultural croplands or other types of development. One strategy for incentivizing grassland conservation and restoration involves carbon credit trading schemes. Canada's climate change mitigation and adaptation plans include the development of a Federal Greenhouse Gas Offset System, wherein land managers can earn revenues through avoided emissions and removals of greenhouse-gases (GHGs) through this carbon trading marketplace. Development and implementation of carbon offset protocols demand scientific data on trajectories of carbon stock change, including uncertainty estimates. Physical and process-based Eco-hydro(geo)logical models are important for simulating carbon dynamics subject to land use or climatic changes at a regional scale. Here, we conducted scenario-based analyses to better understand the future trajectories of soil organic carbon (SOC) following an avoided grassland conversion scenario. We used the Soil & Water Assessment Tool (SWAT) to expand the functionality of a fully calibrated and validated hydrological model to model carbon. This watershed-scale model covers the entire Nelson River Basin (NRB), including most of Canada's prairies. We gathered field-sampled SOC data from over a dozen independent projects across the prairies to calibrate and validate the carbon model. The calibrated and validated model provided a sound basis for our scenario-based analyses to simulate SOC and carbon dioxide (CO_2) flux coefficients for each of the 1988 subbasins within the NRB. These coefficients reflect the predicted changes in soil carbon dynamics following several decades of grassland protection. Study outputs will advance our understanding of the potential trade-offs between managing for ecological services such as water, GHG mitigation, biodiversity, and food production.

Keywords: Canadian prairies, grassland conservation, process-based modelling, soil organic carbon, Soil & Water Assessment Tool

Process-based modelling of N_2O emissions from cattle urine patches using ecosys

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In grazed grassland systems, cattle urine-patches are nitrogen (N) rich and emit high amounts of nitrous oxide (N_2O), a potent greenhouse gas. Switzerland presently uses the IPCC global default grazing-related emission factor (EF_3) value of 2% for N_2O emission inventory. It is well known, however, that a multitude of local environmental factors (soil, climate and management) drive the soil microbial processes responsible for N_2O production and emissions. This means that using a global default leads to biases in emission estimates. For this reason, it is nowadays recommended to use more advanced N_2O quantification methods, including model-based approaches. As a step towards inferring country-specific EF_3 for Switzerland, in the present study we apply *ecosys*, a comprehensive, process-based ecosystem model, to assessing N_2O emissions from cattle urine-patches in grazed systems. We set up *ecosys* to include cattle urine as a fertilizer input option, representing the latter as urea-N with rapid hydrolysis and an added amount of water per patch area to simulate liquid returns. We examine how the added urine-N is cycled in the model system, i.e., the timing and proportions going to N_2O emissions and other loss pathways. In an initial setup, we examine the fate of of 200 g N m^{-2} of urine-N applied in mid-spring after a vegetation cut, with no additional fertilization until the end of the year. The results of the simulation show urine-N to fully hydrolyze in about 3 days, with conversion to NH_4 and further to NO_3. The time scale of permanence of the added N in the system is of the order of four months, leading to cumulative N_2O emission of 8.5 g N m^{-2} over the same time. The corresponding EF_3 of 4 % is about 3 times the EF_3 (1.3 %) obtained in a field experiment with artificial urine, indicating that further work is needed to better constrain the modelled N cycling and related N_2O emissions for this type of management.

Keywords: N_2O emissions; N_2O modelling; Urine Patches; Grazed Grasslands

Modelling soil health indicators under an Intermediate Wheatgrass perennial forage grain system

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Intermediate wheatgrass (IWG, *Thinopyrum intermedium* (Host) Barkworth & D. R. Dewey) is a perennial plant species with adaptive dual-purpose capacity which can potentially be used for late fall/winter grazing of beef cattle. Therefore, it is crucial to evaluate the impact of incorporation of IWG into diverse agricultural cropping systems. This three-year study examined soil health attributes under different IWG-based perennial forage treatments: IWG with no fertilizer post-establishment, IWG with synthetic fertilizer post establishment, IWG in a mixed stand with a legume (Alsike clover, *Trifolium hybridum* L.) and a single-purpose perennial crop control consisting of a 50:25:25 mix of Tall fescue/Algonquin alfalfa/Oxley II cicer milkvetch. The experimental design was a randomized complete block with a one-way treatment structure at each of four sites in Manitoba and Saskatchewan, Canada. Treatment effects were not significant for soil health indicators three years after the start of the experiment. However, partial least squares (PLS) analysis indicated that soil health indicator (24-hour CO_2 respiration, Active C and bioavailable N) levels 3 yr post-treatment could be modeled using baseline (pre-treatment) soil properties measured 3 yr prior. A one latent variable PLS model consisting of six explanatory variables (CEC, concentrations of Ca, Mg, Olsen P, Active C in 2019 and CO_2 respiration in 2019) explained 73% of the total variability in CO_2 respiration. By contrast, a two latent variable model containing all of the above explanatory variables, plus pH and sulfate-S explained 87% of the total variation in active C. Similarly, 65% of the total variation in bioavailable N was explained by a two latent variable model containing 13 explanatory variables. These findings indicate the adequacy of PLS analysis to quantitatively model short-term soil health indicator levels based on baseline soil properties.

Keywords: IWG, active carbon, bioavailable nitrogen, soil respiration, partial least squares analysis

Machine learning applications to water quality analysis

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In any river basin, the modelling of water quality parameters are of considerable significance. The traditional modelling methodologies are dependent on datasets that involve large amount of unknown or unspecified input data. Machine leanrning provides a flexible mathematical structure to enable identifying non-linear and complex relationships between input and output data. In this talk, I present some typical datasets in monitoring water quality, such as time series data, spatially sparse data, image data by remote sensing. Also I present several machine learning algorithms that are used for water quality analyses and how they are used. Finaly I discuss advantage and limitations of machine learning approach in water quality analyses, compared to process-based modelling.

Keywords: machine learning, artificial intelligence, water quality assessment

The Alberta Background Soil Quality System Project

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Salinity and certain metals are the most common naturally elevated parameters in Alberta soils. Key members of industry, environmental consultants and regulators have identified a need for more effective identification of background salt and metals concentrations as one of their highest priorities. Our Project team is working collaboratively with numerous actual and potential users of background soil data to develop the Alberta Background Soil Quality System. This system will be used as a resource tool to assist industry and government in environmental management. The Project will use existing georeferenced baseline soil data and compile it into a comprehensive database. This dataset will be leveraged with predictive mapping technologies to create relevant spatial predictions of background soil quality variables, primarily salinity and metals. In this presentation we will provide an overview of the Alberta Background Soil Quality System components, our approach and opportunities for collaboration.

Keywords: Predictive soil mapping, salinity, metals, soil quality

A machine learning based approach for downscaling soil water index (SWI) derived from satellite imagery

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One of the limitations of daily Soil Water Index (SWI) products obtained from satellite imagery is the low spatial resolution of this data. As a result, it cannot be used for precise applications. The purpose of this study was to present a machine learning based approach strategy for downscaling the SWI obtained from the Advanced Scatterometer. Firstly, surface characteristics maps of three field sites from the USA, and France were prepared with spatial resolution of 1000 and 10000 m. Secondly, the effect of each surface characteristics on SWI was investigated. Then, a suitable model for SWI estimation based on effective surface characteristics was constructed based on the Random Forest (RF) regression model. In the third step, by applying the constructed RF model on the effective environmental parameters of 1000 m, the downscaled SWI map was prepared. Finally, the efficiency of the proposed model to downscaling of SWI was evaluated based on actual soil moisture data recorded at ground stations. The results showed that land surface temperature had the greatest effect on the spatial distribution of SWI. The impact of surface biophysical characteristics on the SWI was greater than topographical and geographical characteristics. The mean residual SWI of the USA, and France in spatial resolution of 10,000 (downscaled 1000 m) were 38.5 (28.5) and 8.3 % (6.9 %), respectively. Mean of R^2 and RMSE between measured soil moisture values and SWI 10,000 m (1000 m) were 0.15 (0.51), 23.4 (11.1), respectively. Results of this study showed that the proposed machine learning based approach is an acceptable approach for SWI downscaling.

Keywords: Soil Water Index, Spatial resolution, Surface characteristics, Random forest, Downscaling

Soil and Groundwater Remediation Guideline Calculator

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Generic Alberta Tier 1 Soil and Groundwater Remediation guidelines (AEP, 2019a) are risk-based guidelines that can be modified based on numerous factors, including historical activities at the site, site location, sub-area within the site, depth of soil, and chemical parameters of concern. Generic guidelines are intended as a screening tool, but in practice the complexity associated with the factors listed above may result in incorrect application. In addition, where practitioners are unfamiliar with requirements for modification (Tier 2), generic guidelines have been used instead of risk-based endpoints (AEP, 2019b). This results in excess soil remediation costs, unnecessary installation of groundwater monitoring wells and extended timelines to reach regulatory closure.

A digital, web-based guideline calculator is being developed to centralize data and standardize the processes used to develop both generic and risk-based endpoints. The calculator will support users in identifying the correct application of Tier 1 guidelines for screening purposes and the derivation of risk-based Tier 2 Site-Specific Remediation Objectives (SSROs). The calculator not only helps practitioners to develop appropriate guidelines, but also provides extensive help text to support correct interpretation; connect users with guidance documents; and, ensure that future site assessments are designed to gather the information and data needed most effectively develop risk-based guidelines. Ultimately this will lead to achieving regulatory closure at the greatest number of sites possible.

In this session, a prototype of the calculator will be demonstrated and an opportunity will be provided for audience questions and feedback.

Key words: Digital tool; Calculator; Regulatory guideline; Contaminated site management; Liability calculation

Harmonized Ontario Soil Data: the Basis for Ontario Soil Information System (OSIS)

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Most of the assumptions of digital soil mapping (DSM) over the past decades has been centred on the use of legacy soil data and freely or cheaply available environmental covariates to investigate the spatial and temporal variabilities of soil properties. This is due to the very demanding nature of pedological studies and soil surveying in terms of time and budget. At the same time, several soil datasets are collected and owned by different institutions in a disintegrated manner in Ontario, and all of Canada. Conversely, report showed that access to soil data has hindered study of temporal changes of soil properties. These systemic (technical and governance) challenges summoned the creation a central data warehouse where provincial soil information can be accessed and analysed in a systematic manner. Therefore, this work aimed to develop automated soil data curation algorithms for integrating different sources of soil datasets in Ontario. To attain this objective, we developed soil data harmonization framework/structure and mining algorism that embraced different soil data source and type/genre in the Konstanz Information Miner (KNIME) platform. Using this harmonization framework and data mining blocks, we integrated data from seven different projects, which included morethan seven thousand sites in Ontario, in SQLite Database. This database will serve as a foundation for creating a provincial DSM.

Keywords: Soil data; Harmonization

Session II

Plenary

(Room: Maple Leaf)

The future of northern organic soils: threats and opportunities

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A range of ecosystem types – from peatlands to black spruce forests – serve as long term sinks of atmospheric carbon because they accumulate thick peat layers. In turn, peat characteristics influence vegetation, nutrient cycling, and hydrology and also serve at the heart of ecosystem resilience to disturbances such as drought and wildfire. Peat represents a material legacy, in which the historical imbalance between plant productivity and decomposition over long periods of time influences contemporary ecosystem function. We cannot make predictions about the future of Boreal and Arctic ecosystems under a rapidly climate without understanding the future of peat. This presentation will highlight peat as a key northern ecological legacy. I will describe how peat confers ecosystem resilience to changing hydrology and wildfire, and the likely consequences if these peat-dependent resilience mechanisms are overwhelmed. Peat-rich regions of the north are critical for a variety of ecosystem services including access to freshwater, stable infrastructure, and reliable food sources. The drainage of temperate and tropical peatlands for agriculture and timber harvest could be described as one of the world's largest ecological and climate disasters. To ensure that we do not repeat the mistakes of the past, we desperately need northern-specific conservation plans and best practices that are community-driven and value the important role that peat and peatlands play in ecosystem, landscape, and climate resilience.

Reciprocity in soil science: knowledge sharing and co-creation for soil management on First Nations agricultural lands

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Agriculture is a prominent land use on First Nations reserve lands in the Canadian Prairies. Since the 1990s, reserve lands have increased through Specific Claims and Treaty Land Entitlement purchases—as a result of these purchases, total agricultural land holdings are estimated to be as high as 4 million acres in Saskatchewan alone. In spite of the increase in agricultural lands, there are fewer First Nations producers that manage this land and a high proportion of marginal lands on reserve. Indeed, the vast majority of agricultural lands are leased to non-Indigenous producers. First Nations have expressed concerns about degraded soil quality on land leased to non-Indigenous farmers that could reduce land productivity and undermine cultural ties to the land. Confronting land and soil management concerns with lessee farmers requires knowledge of soil fertility, nutrient management, and soil quality and health, among other agriculture management considerations (e.g., pest and weed control). However, Indigenous people are sorely underrepresented in soil science education programs, representing barriers to sustainable soil management. At the same time many First Nations are looking towards restoration of marginal agricultural lands to grasslands as a means to rematriate buffalo and to support other cultural and food sovereignty initiatives. In this context, there are efforts to revitilize and apply Indigenous knowledge of grassland and aspen parkland ecosystems to First Nations land management. Using examples from on-going community-based research and teaching activities, I will highlight the historical and contempory contexts of First Nations agricultural land management, identify the unique challenges and opportunities faced by First Nations, and argue for the need to apply both western soil science and Indigenous knowledge in meeting goals for land and soil management.

Keywords: First Nations, Indigenous knowledge, agriculture, grasslands, restoration, soil management, soil health

Session 9

General Land Reclamation Session

(Room: Maple Leaf)

Temporal changes in soil hydraulic properties of cropland soils following restoration of pipeline corridors on cropland

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Soil disturbance due to pipeline installation can adversely affect soil physical properties, including hydraulic conductivity and resistance to penetration, with implications on soil function and productivity. Little is known regarding progression in recovery of these properties following reclamation of pipeline right-of-ways (ROWs). The objective of this study was to examine temporal changes in soil hydraulic properties and resistance to penetration on reclaimed pipeline ROWs on cropland in NE British Columbia. Measurements were taken at three sites along pipeline ROWs that had been reclaimed 4 to 12 yr previously and along undisturbed transects in each field. Pipeline ROW age (time since reclamation, TSR) had a significant effect on saturated hydraulic conductivity (K_{fs}), with K_{fs} significantly greater for the 12-yr old (7.5 cm h^{-1}) than the 4-yr old (2.5 cm h^{-1}) ROW. However, even after 12 yr, K_{fs} was still significantly lower than that on adjacent undisturbed transects (26.4 cm h^{-1}). Unsaturated hydraulic conductivity (K_{ψ}) was significantly lower on the 4-yr old ROW (1.1 cm h^{-1}) than the other ROWs and the undisturbed transects when the suction was 3 cm but did not differ significantly among treatments at the 0.5 cm suction. Soil resistance to penetration in the 35- to 45-cm depth interval was significantly greater for the 4-yr old ROW than the 12-yr old ROW. These results indicate a significant but slow recovery in these soil physical properties over time on the reclaimed ROWs. Results for aggregate stability will also be presented.

Keywords: Pipeline ROWs; soil health; penetration resistance; hydraulic conductivity; aggregate stability

Biodegradation of polycyclic aromatic hydrocarbons under different redox conditions

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Fluid fine tailings (FFT), a waste generated during bitumen extraction and deposited in oil sands tailings ponds (OSTP), contain a variety of polycyclic aromatic hydrocarbons (PAHs). FFT in OSTP and end-pit lakes are methanogenically active metabolizing hydrocarbons into methane (CH_4), a stronger greenhouse gas (GHG). A potential GHG mitigation strategy is to biodegrade hydrocarbons under other alternative electron accepting conditions to prevent CH_4 emissions. FFT harbour diverse microbial communities including nitrate- (NO_3^-), sulfate- (SO_4^{2-}), and iron- (Fe^{III}) reducing bacteria in addition to enriched methanogenic microbial community. We investigate the biodegradation of most abundant PAHs present in FFT under aerobic, nitrate-, sulfate-, and iron-reducing conditions. FFT were mixed with nutrient media, spiked with mixture of PAHs: naphthalene, phenanthrene, anthracene, pyrene, fluorene, dibenzofuran, dibenzothiophene, benzo(b)fluoranthene, and carbazole, and incubated under different redox conditions as mentioned above. Our prelimenary results showed that under all redox conditions, pyrene, naphthalene, anthracene, and benzo(b)fluoranthene were biodegraded completely; phenanthrene and dibenzothiophene were biodegraded partially only under sulfate-reducing condition. Under aerobic condition, fluorene was biodegraded completely, whereas partial biodegradation of dibenzofuran, dibenzothiophene, and phenanthrene was observed under aerobic condition. These findings suggest the susceptibility of different PAHs under different redox conditions. Experiments are in progress to fully comprehend PAH biodegradation pathways under different redox conditions. The results highlight the metabolic capability of indigenous FFT microbial communities to biodegrade recalcitrant hydrocarbons under aerobic and different anerobic conditions, that suggests the management (decontamination) of FFT under various redox conditions. These results are also important in developing strategies to inhibit CH_4 production by diverting carbon flow to CO_2 under other redox conditions.

Keywords: PAHs biodegradation; Redox conditions; Fluid fine tailings; GHG emissions

Revegetation of oil wellsites reclaimed with suboptimal topsoil replacement depth and organic amendments in northeastern Alberta

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Anthropogenic activities such as oil exploration result in land disturbances which necessitate reclamation. Reclamation success of disturbed boreal sites depends primarily on the availability of salvaged topsoil that can be used for reclamation. Alberta's reclamation regulations require a minimum of 80% topsoil replacement depth (TRD80) for successful reclamation of disturbed wellsites. However, this is not always attainable for some wellsites with insufficient salvaged topsoil. Therefore, we investigated the efficacy of organic amendments to augment revegetation of wellsites reclaimed with suboptimal salvaged topsoil. Specifically, we assessed the response of vegetation performance and survival to 50% TRD (TRD50) alone or amended with peat (PTRD50) or biochar (BTRD50) relative to the mandatory TRD80 at a disturbed boreal site near Cold Lake, Alberta. Tree and shrub seedling mixes were transplanted into all plots and vegetation attributes were measured annually for 5 yr. Our results showed that, across all treatments, native species richness increased by 5% per year while non-native species richness decreased by 19% per year. Graminoid species richness increased by 82% for BTRD50 over the 5-yr period but did not change significantly for PTRD50 during the same period. Tree height increased significantly with time and was significantly greater for TRD80 and PTRD50 than for BTRD50 and TRD50. Throughout the study, aspen and green alder species had survival rates below 50% while other tree and shrub species had high survival rates (69% to 96%). Overall, the peat treatment (PTRD50) produced similar vegetation performance results to the mandatory TRD80 treatment, indicating that peat amendment can improve reclamation success at disturbed boreal sites where salvaged soil is insufficient to achieve the optimal 80% TRD.

Keywords: Peat, biochar, species richness, tree height, survival

Phosphorus release from municipal biosolids under simulated flooding during terrestrial phytoremediation

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Switchgrass (*Panicum virgatum* L.), due to its high biomass yields and rapid growth, can been used for phytoextraction of phosphorus (P) and metal contaminants from end-of-life municipal lagoons. End-of-life lagoons are subject to fluctuating moisture conditions due to the common flooding and re-flooding of Canadian prairie landscapes. The objective of this growth room study was to evaluate the effect of flooding cycles on P fractionation in biosolids pore water (PW) and overlying surface water (SW) of terrestrial microcosms with and without switchgrass. To simulate flooding conditions, a 15-cm deep water column was maintained above the biosolids layer for 12-d, drained for 14-d, and subsequently flooded for 12-d. Continuously flooded microcosms were included to assess the impact of continuous flooding on P accumulation by switchgrass biomass. Pore water and SW samples were collected five times during each 12-d flooding cycle. Samples were analyzed for dissolved reactive P (DRP), dissolved total P (DTP), dissolved calcium (DCa) and dissolved magnesium (DMg) concentrations. Aboveground and belowground biomass samples were collected at the end of the 38-d study period for determination of total P concentration. The presence of vegetation had no significant effect, relative to non-vegetated biosolids, on P release to SW. Total P accumulation by roots in the treatment with flooding cycles was significantly greater (14.9 mg pot^{-1}) than in continuous flooding treatments (6.8 mg pot^{-1}), despite the similar root biomass of the two treatments. The concentration of DRP in SW decreased over time but increased in PW with time. There was significantly greater DCa and DMg in SW of non-vegetated (DCa = 31 mg L^{-1}; DMg = 14 mg L^{-1}) than vegetated microcosms (DCa = 27 mg L^{-1}; DMg = 12 mg L^{-1}), reflecting plant uptake of these nutrients in the vegetated microcosms. Significant negative correlations were observed between DRP in SW and dissolved Ca and Mg in SW. The observed decrease in DRP in SW with time suggests a reduced risk of P mobility from end-of-life lagoons to surrounding waters during flooding events. These results will provide a better understanding of P movement from biosolids PW to the overlying water column when switchgrass is used for the phytoremediation of end-of-life municipal lagoons.

Keywords: aboveground biomass; belowground biomass; dissolved phosphorus; pore water; surface water; switchgrass

Effect of Iron-oxide minerals on the biodegradation of mono-aromatic hydrocarbons

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Bitumen extraction from surface-mined oil sands ores produces enormous volumes of tailings that are contained in ponds (oil sands tailings ponds; OSTP) pending reclamation. Managing a growing inventory of fluid fine tailings (FFT) currently estimated at >1.3 billion m^3 is a challenging task for the oil sands industry. One of the several environmental issues related to OSTP is the production of greenhouse gases (methane and carbon dioxide) that also impact the viability of end-pit lakes (EPL). Biodegradation of entrained labile hydrocarbons in OSTP and EPL sustain methane emissions. Fluid fine tailings FFT contain a significant fraction of iron oxide minerals that can change the pathways of hydrocarbons biodegradation under anaerobic environments prevalent in OSTP and EPL. The bioavailability of Fe^{III} from amorphous iron minerals can suppress methanogenesis while crystalline iron minerals can mediate the process of methanogenesis through interspecies electron transfer. This study examines the impact of iron oxide minerals on the methanogenesis. FFT were spiked with BTEX (benzene, toluene, ethylbenzene, and o-, m-, p-xylenes), a fraction of labile hydrocarbons and source of carbon and electrons for microbial metabolism and amended with amorphous (ferrihydrite) or crystalline (hematite) in anaerobic microcosms and incubated at room temperature. Quinone as an electron shuttling compound and BES (2-bromoethanosulfonate) as methanogenesis inhibitor were also added to facilitate electron transfer among iron-reducing bacteria. In ferrihydrite-amended cultures, methanogenesis was suppressed initially. Then, there was a significant increase in methanogenesis, and complete biodegradation of toluene followed by xylene and ethylbenzene occurred under Fe-reducing and methanogenic conditions simultaneously. Crystalline iron minerals facilitated methanogenesis, and complete biodegradation of toluene followed by xylene was observed. Analysis of microbial community by 16S rRNA gene sequencing indicated the abundance of Proteobacteria and Archeal *Candidatus methanoregula* in both ferrihydrite and hematite-amended cultures and Archeal *Methanosaeta concilli* in just hematite-amended cultures. Iron-reducing bacteria were not detected in cultures. These findings warrant further investigations to comprehend microbial metabolic pathways in the presence of different iron oxide minerals that can help develop strategies for reclaiming hydrocarbons-contaminated environments such as wetlands and OSTP.

Keywords: Iron minerals, bioremediation, methanogenesis, hydrocarbons degradation, anaerobic

Session 13

Soil Fertility and Nutrient Management to Mitigate the Impact on Water Quality

(Room: Maple Leaf)

Effects of Ecological Farming on Soil and Water Quality of Agricultural Lands in Canadian Prairies

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The intensive crop production through industrial farming has increased pressure on soils and water resources of exporting regions across the world. In cold regions such as Canadian Praries, crop production through industrial farming has contributed to national economy and global food security in the past decades. However, the accumulaton and transport of nutrients from the soils of these regions have increaesed eutrophication of receiving waterbodies. The ecological agriculture, is a promising approach that may promote soil health and alleviate water quality while meeting production requirements. However, the unique hydro-climatological condition and long non-growing season have made challenges in understanding agro-hydrological processes affecting soil-water-plant interations for a balanced “industrial” and “ecological” farming for sustainable agriculture in these regions. This research aims to improve food production and water quality with less soil disturbance by exploring the impact of long-term cover-cropping, as an ecological approach, in agricultural lands of Nelson River Basin (NRB) in the Canadian Prairies. To quantify the hydrological and biogeochemical cycles that affect the accumulation and transfer of Phosphorus (P) in both soils and water bodies, a physically-based agro-hydrological model (SWAT) was employed. Model calibration and validation was performed using monthly streamflow, monthly P, and annual crop yield observations in the region. The calibrated and validated tool facilitates analyses of effects of cover-crops on annual crop yields, P accumulation and loads, as well as water quality improvements for a baseline period (1982-2016) at NRB. The findings of adopting targeted cover-crop farming in comparison with conventional cropping systems would be significant for both producers and policy makers in achieving regional soil, water, and food security goals in snow-dominated exporting regions.

Keywords: Soil and Water Quality; Crop Yield; Cold Exporting Regions; Ecological Agriculture; SWAT; Nelson River Basin (NRB)

Long-term benefits of soil amendments in reducing phosphorus losses from soils during simulated snowmelt flooding

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In the Canadian prairies, snowmelt runoff is the dominant pathway of nutrient transport from agricultural lands to freshwater systems. Spring snowmelt occurs rapidly and causes flooding in low lying areas, inducing anaerobic soil conditions, which may lead to an enhanced phosphorus (P) release from the soil into porewater and floodwater. Previous studies have shown that additions of soil amendments, such as gypsum, alum, and magnesium-sulphate were effective in decreasing P release from soils to porewater and floodwater. However, little is known on their long-term benefits. This study investigated the effects of gypsum, alum, and magnesium-sulphate in reducing P losses, one year after amendment application, in a simulated snowmelt flooding experiment. Dissolved reactive P (DRP) concentrations in both porewater and floodwater were determined and compared to identify any long-term benefits of these soil amendments. Sixteen intact soil columns were collected in the fall of 2021 from field plots which were amended with gypsum, alum, and magnesium-sulphate in the fall of 2020, as well as an unamended control. Soil columns were flooded at +4 ℃ for 49 days to simulate spring snowmelt flooding. Weekly, redox potential measurements were taken, and samples of porewater and floodwater were extracted and analyzed for DRP, and pH. For all treatments, pH ranged from neutral to slightly alkaline throughout the flooding period. In addition, all treatments saw a decrease in redox potential with a lesser decrease observed in the alum-amendment. Soil columns taken from alum-amended field plots had significantly lower DRP concentrations in porewater when compared to all other treatments, including the unamended control. However, this effect of alum in reducing DRP concentrations was not observed for floodwater. The mechanisms responsible for the decrease in DRP with the alum-amendment, which was observed in porewater but not in floodwater, requires further investigation.

Keywords: Amendments, Snowmelt, Phosphorus, Flooding

Quantifying the transport potential of antibiotics and their degradation products in spring-thaw snowmelt runoff from manure-amended cropland

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Veterinary antibiotics are used to maintain animal health by reducing the spread of diseases among herds. However, there are concerns about antibiotic runoff in manure amended fields because up to 90% of the initial antibiotic dosage can be excreted from the animal in its original form. Liquid swine manure is widely used as fertilizer on the Canadian Prairies, leading to a high risk of soil and freshwater contamination. In this region, an average of 75% of annual runoff occurs during the brief snowmelt period, when soils are frozen. Controls on the transport of antibiotics and their degradation products during this important hydrological period are not well understood but are critical to understand the fate of these contaminants. Our study aims to quantify the dissolved sulfamethoxazole (SMX) and its metabolites in spring-thaw snowmelt runoff in an agricultural field in Manitoba, following two different manure application methods: surface applied and sub-surface applied. We will be collecting snowmelt runoff and pre-concentrating SMX and its metabolites through solid-phase extraction, then quantifying the concentrations and loads of SMX and its metabolites using liquid chromatography-tandem mass spectrometry. In addition, we will perform a lab incubation experiment to assess the partitioning of SMX and its metabolites in snowmelt floodwater and soil porewater under controlled conditions using intact soil columns collected from manure-amended fields. Understanding antibiotic transport via snowmelt from manure application will help minimize antibiotic loss into the environment during land application. Additionally, with the large agricultural industries in the prairie provinces, this study will be critical in guiding policies for sustainable manure management.

Keywords: Manure, Antibiotics, Transport, Snowmelt, Runoff

Phosphorus release from manured soils under simulated snowmelt conditions

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Canadian prairies are prone to temporary flooding conditions during the spring snowmelt period, inducing anaerobic conditions. Phosphorus (P) accumulated in manured, agricultural soils can be released into the environment via snowmelt runoff, which may lead to eutrophication in freshwater bodies degrading the aquatic ecosystem. Liquid swine manure (LSM) is applied to agricultural lands as either surface or subsurface applications. The subsurface application of manure is considered one of the successful management practices to increase yields and decrease the nutrient losses from soils. This study was focused on comparing the P release from intact soil columns collected from field plots treated with LSM subsurface-applied, LSM surface-applied and unamended, under simulated snowmelt flooding conditions. The field plots with three treatments were arranged in a randomized block design with four replicates. An intact soil column was taken from each plot two weeks after manure application. Ultrapure water was added to a 10-cm depth and columns were incubated at +4 °C to simulate snowmelt conditions. Sampling was carried out for 7 consecutive weeks. Soil redox potential was measured weekly. Soil porewater and floodwater samples were collected and analyzed for dissolved reactive phosphorus (DRP) and pH. The average pH values were around 8 initially and decreased with flooding time towards neutral values. Redox potential decreased with time of flooding as well. Soils with surface-applied manure had DRP concentrations of 0.07-0.95 for floodwater and 2.08-2.90 mg L-1 for porewater. In general, soils with subsurface-applied manure showed comparatively lower DRP values of 0.13-0.82 for floodwater and 1.48- 2.29 mg L-1 for porewater. The DRP concentrations in all treatments significantly increased with the time of flooding, suggesting the high potential for P losses with snowmelt runoff.

Keywords: Phosphorus; snowmelt runoff; water quality; soil chemistry; manure

Impact of fertilizer P source, rate, and placement strategy on wheat yield and P uptake across variable topographies in Saskatchewan

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Phosphorus (P) management strategies aim to maintain or increase crop yields and fertilizer P recovery while mitigating against potential P losses in surface run-off water. Various existing and new fertilizer P sources are present in the market, but few studies have compared their agronomic and environmental performance under Canadian prairie conditions. Determining the appropriate fertilizer P application rate and placement for different P fertilizer forms is of benefit. To address this gap, a three-year field study was initiated in spring of 2021 to evaluate the agronomic (crop yield, P and nitrogen uptake and recovery) and environmental (P losses in simulated snowmelt run-off water) performance of eight fertilizer P sources applied in a broadcast or side-band placement strategy at a low and high (20 vs 40 kg P_2O_5 ha^{-1}) rate. Recognizing the influence of topography on hydrology and nutrient transport mechanisms, the study was conducted at three sites within the Brown and Dark Brown soil zones of Saskatchewan, each representing a unique landform complex position (upslope, midslope, and lowslope) and differing baseline soil properties. Under severe drought conditions of 2021, grain yield was significantly impacted by the interaction effect of fertilizer P source and rate at the midslope and lowslope sites ($p < 0.10$) while fertilizer P source significantly impacted grain yield at the upslope site ($p < 0.05$). Across all sites, P uptake was significantly impacted by fertilizer P source and placement method ($p < 0.001$). Fertilizer P forms containing ammonium phosphate that were placed in-soil as side band resulted in higher recovery in wheat compared to surface placement.

Keywords: P Use Efficiency; 4R Stewardship; Snowmelt Run-off

Targeting Soil Phosphorus Management for Improving Water Quality

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Phosphorus (P) critically affects both crop production and water quality. Due to variabilities of landscape positions, soil properties and management practices (e.g. different types of crops and tillage operations), concentration of soil test P often varies widely within a watershed. Such variations should be better quantified and understood to improve soil P management in order to achieve overall better soil productivity and water quality. To address this, we have conducted detailed soil sampling in 12 fields and four ditches in the South Tobacco Creek watershed, Manitoba. The samples, totaling nearly 300, were collected to represent scenarios with various levels of soil P inputs, a range of landscape positions with varying potentials of soil and water loss and crop yield, and different extents of soil P stratification resulting from management. Among all samples, Olsen P ranged from 4 mg/kg to 105 mg/kg, with a median value of 20 mg/kg. In the presentation, we will present the causes and potential consequences of the large variability of the Olsen P (i.e. the relationship of management and landscape variability – Olsen P concentration and stratification – P loss potential), and explore potential solutions to manage the P in order to reduce the risk of P loss from the fields through modeling.

Keywords: Soil test phosphorus; runoff; landscape variability; management practices; modelling

Optimizing crop production while minimizing environmental phosphorus losses using struvite: A case study

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Non-point source pollution from agricultural fields remains a global issue. Recent research under controlled environments has shown that struvite may be a viable phosphorus (P) supplement for readily soluble chemical fertilizers that enhance crop P efficiency while reducing P losses to soil water. However, field studies that assessed the agronomic and environmental potential of struvite are lacking. A field study was established in Elora, Ontario, to study corn yield response, surface runoff and subsurface leaching under struvite application in 2021. The four treatments are struvite (CG100), chemical fertilizer (MAP100), a struvite-chemical fertilizer mixture (CGMAP, a composition of 25% struvite and 75% MAP) and a control. The control treatment did not receive P supplementation. Corn grain and aboveground biomass yields were significantly greater ($p< 0.05$) for CGMAP treatment (10 486 and 26 195 kg ha^{-1}, respectively) relative to the control (8 599 and 23 744 kg ha^{-1}, respectively). Grain yields did not significantly differ between the CG100 (9 852 kg ha^{-1}) and MAP100 (9 419 kg ha^{-1}) treatments ($p> 0.05$). Although the growing season (May to October) surface runoff and soil water P concentrations from the CGMAP treatment (180 and 55 mg L^{-1}, respectively) were greater than the control (72 and 39 mg L^{-1}, respectively), they were statistically similar to the CG100 treatment (99 and 54 mg L^{-1}, respectively). However, surface runoff and soil water soluble reactive P (SRP) concentrations were significantly greater for the MAP100 treatment (353 and 72 mg L^{-1}, respectively) than for the CG100 and control treatment. Growing season soil water SRP concentration was also significantly greater for the MAP100 treatment than for the CGMAP treatment. This study demonstrated the potential of struvite-chemical fertilizer mixtures to improve crop yields while reducing P losses in runoff in the Great Lakes region.

Keywords: Struvite, phosphorus leaching, corn, runoff, Great Lakes

Session 18

Fostering Soil Carbon Sequestration and Protection: Advances in Our Understanding and the Practical Implications

(Room: Aurora)

Elevation Gradient Drives Distribution of Soil Carbon and Plant Communities in a Semiarid Grassland in British Columbia

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A sequence of Brown, Dark Brown and Black Chernozems and associated plant communities over a 600 m elevation gradient was first described in 1961 by van Ryswyk et al. (1966) near Kamloops, British Columbia. Soil organic carbon (SOC) stocks and plant communities among these great groups were once again evaluated in 2019-2021, along the gradient from similar topographic positions as in 1961, and evaluations were done at every 25 m gain in elevation (n=24; 391-987 m). Since mid 1970s, livestock grazing in the area has been managed under a deferred-rotation grazing regime, where spring grazing occurs in one of two pastures every other year before moving to the next pasture located at higher elevations. The objective of this study was to describe current plant communities among the three Chernozemic great groups and their associated SOC stocks along the elevation gradient. There has been litttle change to the plant community on Brown Chernozems, but the Dark Brown and Black Chernozems have experienced significant recovery as indicated from a shift in plant community representative of low ecological succession status to one that reflects the Potential Natural Community. Soil organic carbon stocks (kg m^{-2}; 0-30 cm) increased from 3.64±1.0 in Brown to 3.95±0.73 and 6.77±1.4 in the Dark Brown, and Black Chernozems, respectively. Increasing (5.5±0.7 to 10.0±2.4 kg m^{-2}) SOC stocks from the 0-60 cm were also measured across the three Chernozemic great groups, but as much as 33-50% of the soil C below the 30 cm depth was soil inorganic carbon (SIC). Soil pH increased with soil depth from 6.7 (0-15 cm) to 7.9 (45-60 cm) over all three zones. Soil pH is a key varible when interpreting SOC stocks as the proportion of organic and inorganic C was strongly controlled by soil pH. Different equations for SOC stock calculations produced either no change in soil C stock or a 30-50% reduction from the Dark Brown and Black Chernozems when compared to the original measurements (van Ryswyk et al., 1966). This study has improved our understanding of the SOC inventory among the Brown, Dark Brown, and Black Chernozems of BC's Southern Interior, but changes to the intensity of livestock grazing over the last 60 years and the subsequent improvements to the native plant community did not increase SOC stocks. Information about soil coarse fragments and the distribution of SIC and SOC within the soil profile is crucial for accurate comparisons across studies or resampling events.

Keywords: soil organic carbon, soil inorganic carbon, Chernozem, topography, soil depth

Long-term effects of tillage and crop rotation on soil C and N storage in a temperate humid climate

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The effects of conservation tillage and diversification of crop rotations on surface soil organic C (SOC) and total N storage have been previously studied. Yet little is known about the influence of these practices on C and N storage in the deeper soil profile. Therefore, we used a long-term experiment established in 1995 at Ridgetown, Ontario, Canada to evaluate the effect of seven crop rotations and two tillage practices on SOC and total N storage in 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm, and 100-120 cm depth. Crop rotations were continuous corn, corn-soybean, corn-soybean-wheat, corn-soybean-wheat undersown with red clover, continuous soybean, soybean-wheat, and soybean-wheat undersown with red clover. Tillage treatments were conventional moldboard plough and no/zone-tillage. Results suggested that SOC and total N content were different between tillage treatments (P=0.0014 for SOC and P=0.0002 for total N) and soil depth increments (P<0.0001 for SOC and total N), whereas crop rotation differences were not observed in SOC and total N storage. Among the soil depths, SOC (125 Mg ha^{-1}) was surprisingly greatest in the 100-120 cm depth increment whereas total N (10.4 Mg ha^{-1}) was greatest in 0-20 cm depth. Furthermore, a significant three-way interaction between tillage, crop rotation, and soil depth was detected for SOC and total N storage. Within no-tillage system, all tested crop rotations had significantly greater SOC storage in 0-20 cm and 100-120 cm depth than the remaining depths. Within conventional tillage system, all crop rotations had significantly greater SOC content in 100-120 cm depth than the remaining depths. Across all the soil depths and crop rotations, no-tillage had greater SOC (95.5 Mg ha^{-1}) and total N (6.8 Mg ha^{-1}) storage than conventional tillage. The results confirm that long-term adoption of no-tillage production practices might increase the SOC and total N storage in the soil profile.

Keywords: Conventional tillage; Corn; No-tillage; Soil depth; Soil health; Soybean; Winter wheat

Looking Deeper at Soil Organic Carbon Storage in Prairie Potholes

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Soil organic carbon estimates often rely on measurements from the upper 30 cm of the soil profile. This depth range is expected to be most responsive to land management changes, yet it overlooks deeper soil carbon that should be considered for soil carbon accounting across ecosystems. Prairie potholes are a type of depressional wetland found throughout the Canadian Prairies and Upper Midwest United States that are known to sequester up to two-times the amount of carbon relative to the surrounding landscape. This study aims to quantify soil organic carbon for prairie potholes in Saskatchewan to a depth of 1 m and evaluate how it is stored in soil organic matter fractions. In 2021, soil samples were collected from prairie potholes at three landscape positions and divided into four depth increments (0-15, 15-30, 30-60, 60-100 cm). The soil samples were assessed for organic carbon and divided into organic matter fractions. The change in organic carbon and the proportion of organic carbon in each of the organic matter fractions with depth will be presented. Considering how the carbon is stored in different organic matter fractions will be valuable for inferring the carbon's stability and how this varies with depth as well as the carbon sequestration potential of these wetlands. The findings from this study contribute to refining prairie pothole carbon storage estimates which are needed to inform wetland policy and environmental carbon management strategies.

Keywords: Soil organic matter, soil carbon, soil depth, water extractable organic matter

Molecular characterization of soil organic matter (SOM) under different land uses by DRIFT and ^{13}C DP-MAS NMR spectroscopy

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We applied Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectroscopy and ^{13}C Direct Polarization Magic Angle Spinning nuclear magnetic resonance (DP-MAS NMR) spectroscopy to elucidate the molecular-level differences in SOM in a range of soils and land-use regimes. We studied surface soils from muck soil from Muck Crops Research Station, Bradford, cultivated and forest Luvisolic soils from the Elora Research Station and Podzolic forest soil from Huntsville. DRIFT spectra showed intense aliphatic carboxylic and aromatic bands in forest Luvisols, followed by forest Podzols, muck soil, and cultivated Luvisolic soil. Further, it was evident that agricultural management affects the amount of aliphatic C-H. ^{13}C DP-MAS NMR gave better resolution in identifying aromatics, especially clustered aromatics in soils, that was not feasible to detect clearly with DRIFT spectroscopy. ^{13}C DP-MAS NMR spectroscopy showed that aromatic and aliphatic C were higher in the forest and organic soils than in the cultivated and Podzolic soils. The presence of clustered non-protonated aromatics in the forest and organic soils were revealed in the NMR spectra. The overall distribution of O,N-alkyl C and alkyl C in the cultivated soil indicates a low level of humification, whereas the relatively high presence of aromatics in forest soils indicates high degree of humification. These observations suggest that combining DRIFT and ^{13}C DP-MAS NMR spectroscopy techniques can provide a congruent accurate fingerprint of SOM and a better understanding of the degree of humification under different land uses.

Keywords: DRIFT spectroscopy, ^{13}C DP-MAS NMR, molecular fingerprint, humification

Forage quality improvement and soil carbon and nitrogen dynamics in grazed pastures: the role of non-bloat legumes

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Including different forage legumes in grass pastures can improve forage quality and potentially influence soil carbon (C) and nitrogen (N) forms, amounts, and cycling. This research evaluated the effects of alfalfa and sod-seeded cicer milkvetch and sainfoin on soil C and N in a Black Chernozemic soil in east-central Saskatchewan, Canada. Four years after introducing cicer milkvetch and sainfoin into degraded alfalfa/meadow bromegrass pasture, soil nitrate concentrations were increased, but no other soil C and N pools were significantly affected. Seasonal variations in moisture, temperature, and substrate quality controlled water-soluble and microbial biomass soil C and N fractions. Under controlled conditions, alfalfa, cicer milkvetch, and sainfoin contributed 200, 128, and 65 kg N ha^{-1} yr^{-1} respectively through biological nitrogen fixation. In forage legume/meadow bromegrass mixtures, legume rhizodeposition constituted about 18% of total legume C and 27% of total legume N over four weeks. Nitrogen transfer from the legumes to meadow bromegrass was in the order sainfoin (11.1%) > alfalfa (9.7%) > cicer milkvetch (3.7%), suggesting greater N transfer rates to non-legume partner by sainfoin despite having the lowest total N_2 fixation. The forage legumes contributed 2–9% of soil C, significantly contributing to soil C storage. The findings suggest that including forage legumes in grass pastures can contribute substantially to pasture N economy and soil C and N storage and turnover. Compared to alfalfa, sod-seeding non-bloat cicer milkvetch and sainfoin is a viable way to rejuvenate degraded pastures without greatly affecting soil C and N stocks. A complete life cycle assessment (LCA) under grazed cicer milkvetch and sainfoin is suggested to understand the implications of replacing alfalfa with non-bloat legumes.

Keywords: pasture rejuvenation, rhizodeposition, non-bloat legumes, soil C and N

Agroforestry Perennials Reduce Nitrous Oxide Emissions and Their Live and Dead Trees Increase Ecosystem Carbon Storage

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Agroforestry systems (AFS) contribute to carbon (C) sequestration and reduce greenhouse gas emissions from agricultural lands. However, previously understudied differences among AFS may affect their climate change mitigation potential. In this 3-y field study, we assessed greenhouse gas emissions and various C stocks across two common AFS (hedgerows and shelterbelts) and their component land uses: perennial vegetated areas with and without trees (woodland and grassland, respectively), newly planted saplings in grassland, and adjacent annual cropland in central Alberta, Canada. Between 2018 and 2020 (~April–October), nitrous oxide emissions were 89% lower under perennial vegetation, while methane uptake was 4.28 times greater under hedgerow perennial vegetation relative to the cropland. In 2020, heterotrophic respiration was 53% lower in the shelterbelt woodland relative to the hedgerow woodland (279 and 600 g C m^{-2} y^{-1}, respectively). Within the woodland, deadwood C stock was positively correlated with annual heterotrophic respiration and total (to ~100 cm depth) soil organic C, water-soluble organic C, and microbial biomass C. Deadwood C stock was particularly important in the hedgerow woodland (35 Mg C ha^{-1} or 7% of ecosystem C) relative to the shelterbelt woodland (2 Mg C ha^{-1} or < 1% of ecosystem C), and likely affected C cycling differences between the woodlands by enhancing soil labile C and microbial biomass in hedgerows. Total ecosystem C was 1.90–2.55 times greater within the woodland relative to all other land uses, with 176, 234, 237, and 449 Mg C ha^{-1} found in the cropland, grassland, planted saplings, and woodland, respectively. Shelterbelt and hedgerow woodlands contained 2.09 and 3.03 times more C, respectively, than adjacent cropland. Our findings emphasize the importance of AFS for reducing greenhouse gas emissions and fostering C sequestration, particularly retaining hedgerows (legacy woodland) and their associated deadwood as a means of mitigating climate change across temperate agroecosystems.

Keywords: Agroforestry systems; Climate change mitigation; Ecosystem carbon sequestration; Greenhouse gas emissions; Soil organic carbon

Field demonstrations in Sourthern Ontario of silicate mineral amendment effect on soil carbon sequestration (inorganic and organic)

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The amendment of silicate minerals to soils is considered a feasible means to sequester atmospheric carbon in soils through reaction mechanisms termed “enhanced rock weathering”, “pedogenic carbonate formation”, and “carbon drawdown”, which transport inorganic (bi)carbonates via the subsoil and aquifers to marine carbon sinks. Our research group has demonstrated in the last years that at lab-, microplot-, and field-scales, over timeframes of weeks to several years, pedogenic carbonate formation is detactable in topsoils (≤0.30 m) when wollastonite ($CaSiO_3$) mineral is used in Sourthern Ontario’s brunisolic and luvisolic soils (pH > 5.9), with minimal to no impact on the organic carbon pool.

In the Spring of 2021, a new set of field demonstration trials began at two commercial farm locations: Dawn Euphemia (ON) over 58 ha, and Thorndale (ON) over 18 ha. A wollastonite amendment rate of 4 tonnes·ha^{-1} was selected. The aim of these trials is to correlate changes in soil inorganic carbon (SIC) and soil organic carbon (SOC) between sampling analysis and modelling prediction, accounting for expected spatial (areal and depth-wise) heterogeneity, temporal variability, and hydraulic (infiltration and run-off) conditions. Of particular interest is to verify the gradual transport of pedogenic carbonates and soluble bicarbonates from surface to subsoil, through mass and isotope balances, and to assess the long-term effect of mineral amendments on the SOC pool down to the watertable. Other plant, produce and soil health parameters are also being tracked, since wollastonite is primarily marketed in agriculture for its agronomic benefits, which are commercially and scientifically verified.

Collected soils are chemically analyzed for elemental composition by X-ray fluorescence, pH, organic matter content by dry combustion, and carbonate content by calcimetry, mineralogically analyzed by X-ray diffraction, and morphologically analyzed by electron microscopy. Reactive transport modeling is performed using The Geochemist’s Workbench. The results are aimed to inform scientific advancement of enhanced weathering efforts ongoing around the world, and the creation of policies and carbon credits to incentivize adoption of this climate change mitigation and agriculture-benefitting practice.

Keywords: Soil carbon sequestration; Enhanced rock weathering; Total soil carbon; Mineral amendments; Carbon credits

Tracing pyrogenic organic matter stocks and fluxes using CO_2 flux tracing, three-part partitioning, and nanoSIMS

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Pyrogenic organic matter (PyOM) is produced naturally during fires and can also be produced intentionally for C management or as a soil amendment, in which case it is often referred to as "biochar". In both of these contexts, tracing PyOM as it cycles in the environment is necessary for understanding its net impact on soil C stocks and, hence, climate change. Stable isotopes – particularly ^{13}C – offer a key tool for tracing PyOM. I propose to discuss three facets of this approach. First, I will discuss PyOM-specific considerations for stable isotope tracing. These include low expected flux rates requiring higher labelling than for equivalent non-pyrogenic organic matter cycling experiments, shifts in isotopic composition during pyrolysis, and which proxies (end-members) are most suitable for PyOM ^{13}C tracing. Second, I will present an approach for three-part partitioning using only two stable isotopes (^{12}C and ^{13}C), as illustrated for soil, PyOM, and plants as the three C sources. Third, I will describe an application of nano-scale secondary ion mass spectrometry (nanoSIMS) to image PyOM and soil C in a soil-PyOM incubation study. Together, these three elements will offer insights and examples of the use of stable isotopes for PyOM (and other C source) tracing in natural and managed ecosystems.

Keywords: Three-part partitioning; pyrogenic organic matter (PyOM); biochar; soil carbon; nanoSIMS

Quantifying past, current, and future forest carbon stocks within agroforestry systems in central Alberta, Canada

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Information about regional-level carbon (C) stocks in agroforestry systems, as well as the annual loss of agroforests and associated C stocks, is scarce, limiting our capacity for increasing C sequestration through establishing, retaining, and enhancing these systems. This study quantified regional-level C stocks and the associated incremental economic value in the forest land-use component of three common agroforestry systems (hedgerows, shelterbelts and silvopastures), estimated the annual loss of hedgerow and silvopastural forests and the associated C, and assessed the potential to enhance C storage through the expansion of shelterbelts in central Alberta, Canada, using publicly available satellite imagery, previously collected field data and the Google Earth Engine platform. Results showed that forests in the three agroforestry systems stored 699.9 Mt C across 9.5 M ha of land in central Alberta and were valued at $102.7 billion based on the 2021 Canadian C tax rate of $40 t^{-1} CO_2-equivalent. Silvopastural forests in the studied region had the highest C stocks, which were 14.2 and 67.2 times that found in hedgerow and shelterbelt forests, respectively. Between 2001 and 2020, forests in hedgerows and silvopastures declined at rates of 468.1 and 1957.1 ha yr^{-1}, respectively, leading to an 8.4 Mt decline in total C storage over the 20 years. However, there is potential to establish new shelterbelts at many road/field margins, which could increase C stocks by 2.3 times of the current C stocks in shelterbelt forests. These results highlight the importance of retaining existing and establishing new agroforestry systems for increasing C sequestration, emphasizing the impact of agroforest loss on reducing C storage within agroecosystems. The development of policies that assist or reward landowners for providing the ecosystem service of C storage by retaining, establishing, and enhancing agroforests as part of existing agroecosystem management should be encouraged for mitigating climate change.

Keywords: Agroforestry systems; Carbon sequestration; Carbon storage; Carbon tax; Forest loss; Google Earth Engine

Session 9

General Land Reclamation Session

(Room: Aurora)

Reclamation Certification Achieved using Remote Sensing Technology

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The first Reclamation Certificates ever issued by the Alberta Energy Regulator for assessing sites using remote sensing technology as the primary technique were granted to Wood PLC in early 2021. This presentation showcases the results of this reclamation achievement and the creation of an innovative remote sensing model for assessing the reclamation status of the Oil Sands Exploration (OSE) programs located in remote areas in Northern Alberta.

Due to the remote nature of OSE programs, reclaimed sites are typically assessed using the human eye from a helicopter. To overcome this, a remote sensing model was developed in this study to eliminate the need for helicopters while facilitating a safer, less expensive, and more accurate means for assessing reclaimed sites. This presentation will discuss the types of field data and remote sensing imagery used to build the machine learning algorithms. It will also outline how the outputs of the algorithms were used to produce quantitative data such as the number of black spruce per a given area, types of land covers, and the areas and heights of woody species; and generate aerial maps for interpretation by reclamation scientists. A summary will be provided of the assessment parameters generated to meet the expectations of the regulatory criteria, with a description of them, and a discussion on methods and level of accuracy for each.

Keywords: Land Reclamation; Remote Sensing; Boreal Forest; Reclamation Certification; Northern Alberta

Methanogenic Degradation of PAHs in Oil Sands Tailings

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Management of oil sands tailings is a component of the broader concept of land reclamation after surface mining. Bitumen extraction from oil sands ore using hot water generates huge volumes of fluid fine tailings (FFT) that are deposited in oil sands tailings ponds (OSTP) pending reclamation. Methane (CH_4) emissions from OSTP and end-pit lakes (EPL) occur as a result of microbial metabolism of entrained hydrocarbons in FFT deposited in OSTP or reclaimed in EPL. Methanogenesis also restrain the progression of EPL into natural aquatic ecosystem, therefore it is important to predict the intensity and longevity of CH_4 emissions from OSTP and EPL. Our kinetic model predicts CH_4 production taking into account the microbial metabolism of labile hydrocarbons such as alkanes and monoaromatics. Polycyclic aromatic hydrocarbons (PAHs) had been reported to be found in FFT but no research has been done to assess their biodegradability under methanogenic conditions. Therefore, we investigate the biodegradation of the most abundant PAHs in OSTP by indigenous microbial communities under methanogenic conditions. Our preliminary experiments have shown that 4 PAHs (Fluorene, Dibenzofuran, Dibenzothiophene, and Carbazole) were biodegradable under methanogenic conditions. Members of *Synergistaceae* and *Syntrophaceae* among Bacteria, and *Methanoregulaceae* among Archaea were the key taxa involved in the 4 PAHs' biodegradation. In the current experiment, FFT collected from Syncrude and CNRL tailings ponds were amended with 8 PAHs (Fluorene, Dibenzofuran, Dibenzothiophene, Carbazole, Naphthalene, Anthracene, Phenanthrene, and Pyrene), with appropriate baseline and abiotic controls. The experiment is in progress to investigate the range of PAHs biodegradability under methanogenic conditions. The results have great application not only for biodegrading recalcitrant hydrocarbons under anaerobic environments but also help improve our existing kinetic model to predict CH_4 production and emissions from OSTP and EPL.

Keywords: Oil Sands Tailings Ponds Reclamation; Mature Fine Tailings; Polycyclic Aromatic Hydrocarbons; Methanogenic Degradation

Buried wood effects on nutrient supply and microbial activity in oil sands reclamation soils in northern Alberta

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Buried wood is an important, yet understudied component of natural and anthropogenic soils. Nutrient immobilization as a response to wood addition during oil sands reclamation practices may be a concern, since surface wood resulting from clear and grub procedures is salvaged with the soil thereby becoming buried wood in the reclamation cover soil. This project aimed to investigate the impact of buried wood on the nutrient supply and microbial communities in different soils used in oil sands reclamation. A 60-day incubation was performed with different rates and types of wood (0%-50%, aspen and pine wood), and four different soils (fine and coarse forest floor-mineral mix: fFFMM and cFFMM, peat-mineral mix: PMM, and Peat). Analyses on soil nutrient supply rates using Plant Root Simulator (PRS) probes, C and N microbial biomass, and Community-Level Physiological Profiling (CLPP) were performed at the end of the incubation period; soil respiration was measured throughout the incubation. Responses varied by soil type, but buried wood caused nitrogen immobilization in three out of the four soils due to an increase in the C:N ratio. Soils with lower C:N ratios like fFFMM and PMM were more susceptible to nitrogen immobilization and had a decrease in available nitrogen by up to 95% after the smallest buried wood addition of 10%. Phosphorus immobilization was observed in cFFMM and potassium supply increased in three soils at buried wood rates of 20% and above. Microbial activity increased but no significant changes in the soil metabolic profiles were observed. The findings of this study suggest that buried wood increases the soil C:N ratio and can potentially cause nitrogen immobilization when added by 10% of volume or more, and similar responses between fFFMM and PMM emphasize the high use of these soils in upland reclamation.

Keywords: Buried wood, nitrogen immobilization, reclamation soils, CLPP, microbial activity.

Investigating the role of tree microbiome in sustaining the growth of pioneering pines in an unreclaimed aggregate mining ecosystem

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Aggregate mining is prevalent in forest landscapes across Canada, typically resulting in complete loss of vegetation and topsoil. Despite such disturbance, lodgepole pine (*Pinus contorta* var. *latifolia*) trees consistently show vigorous growth on bare gravel substrate of unreclaimed aggregate mining pits in parts of Canadian sub-boreal forests, possibly owing to, at least in part, the association of pine trees with their microbial partners. To test this possibility, we aimed to investigate the bacterial microbiome of lodgepole pine growing at a gravel pit in central British Columbia and suggest their potential role in tree growth and survival following mining activity. We characterized the diversity, taxonomic composition, and abundance of bacterial communities in rhizosphere and endosphere (needle, stem and root) niches of pine trees regenerating at the gravel pit along with comparing them with a nearby undisturbed forested site using 16S rRNA high-throughput sequencing. Additionally, the soil and plant nutrient contents at both sites were also analyzed. Although soil N-content at the gravel pit was drastically lower than the forest site, pine tissue N-levels at both sites were identical. Beta-diversity was affected by site and niche-type, signifying that the diversity of bacterial communities harboured by pine trees was different between both sites and among various plant-niches. Bacterial alpha-diversity was comparable at both sites but differed significantly between belowground and aboveground plant-niches. In terms of composition, pine trees predominantly associated with taxa that appear plant-beneficial including phylotypes of *Rhizobiaceae*, *Acetobacteraceae*, and *Beijerinckiaceae* at the gravel pit and *Xanthobacteraceae*, *Acetobacteraceae*, *Beijerinckiaceae* and *Acidobacteriaceae* at the forest site. Our results suggest that, following mining activity, regenerating pine trees recruit bacterial communities that appear beneficial in supporting pine growth, with a potential role in N-nutrition, in an otherwise severely N-limited disturbed environment.

Keywords: Aggregate mining; Bacterial microbiome; Lodgepole pine; Nitrogen; Tree regeneration

Session 20

General Land Reclamation Session

(Room: Prairie)

Drivers of soil bacterial community composition and co-currence in agricultural systems of Alberta

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Soil health implies the capacity of soil to providing ecological services, which makes ecosystems sustainable in the long term. The intensification of land management in agricultural systems represents stress to the soil environment and can lead to soil degradation. Therefore, the assessment of soil health could provide insights about the impact of the different agricultural practices on soil and is crucial for the sustainability of both agriculture and soil. Microorganisms play a crucial role in biogeochemical cycling, plant growth, and trophic networks, and are sensitive to changes in the soil environment. The Soil Quality Monitoring Program (SQMP) conducted from 1997 to 2007 aimed to characterize soil quality from benchmark sites across Alberta by evaluating soil physico-chemical parameters. However, no biological indicators of the soil quality were included at the time. Given that agricultural practices could affect the soil environment and microbial communities are sensitive to environmental changes, we revisited the SQMP benchmark sites and evaluated soil bacterial communities from soils undergoing different agricultural practices (i.e., tillage intensity, crop type, herbicide use, and fertilization method). We aimed to assess the effect of agricultural practices on soil bacterial composition and co-occurrence, and identify the drivers of bacterial community composition via high-throughput sequencing of the 16S rRNA marker gene. Results indicate that bacterial community composition is insensitive to different agricultural practices. Instead, pH and ecoregion better explained the variability in bacterial community composition. Co-occurrence network analyses revealed the complexity and behavior of interactions among the members of the soil bacterial community are altered by different agricultural practices. These changes in the community dynamics could indicate changes in microbial functionality, and the capacity of the community to overcome environmental stress, which in turn could influence the functionality of the soil system. Altogether, results indicate co-occurrence network metrics may be promising and better indicators of soil health than bacterial community composition in agricultural systems.

Keywords: Agriculture, bacterial communities, soil health indicators

Optimizing Nitrogen use-efficiency and Arbuscular Mycorrhizae Inoculation Potential in Canadian Cereal Crops

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Demand for greater cereal crop yield often motivates increasing the use of nitrogen-based fertilizers, leading to growing conditions with lower input use-efficiencies. Incorporation of biological inoculants with reduced fertilizer application in cereal crops may be a method to increase input use-efficiencies without risking reductions in crop productivity. Specifically, encouraging the symbiotic relationship of natural or augmented arbuscular mycorrhizal fungi (AMF) among plants has been shown to supplement plant requirements for phosphorus and nitrogen under limiting conditions; however, there is still a need to quantify the efficacy of AMF augmentation through inoculation in cereal crops. Inoculation of *Rhizoglomus intraradicies* was applied to barley and wheat crops in field trials near Edmonton, Alberta during the 2020 and 2021 growing seasons. Improvements to barley crop productivity and nitrogen uptake were generally found with inoculation, while the response to inoculation in wheat was dependent on background nitrogen and phosphorus concentrations in the soil. Enhancements to wheat productivity occurred at higher inoculation rates (3x nominal), but were not consistently realized under high soil nutrient concentrations. AMF symbiosis and its beneficial impacts were also found to differ between wheat varieties. Additionally, application of fungicides from both the demethylation inhibitor (group 3) and quinone outside inhibitor (group 11) generate contrasting impacts on AMF colonization, where the group 3 fungicide generally reduced AMF colonization potential. On average, a net gain of 1 to 2 bushels per acre in grain yield was realized with successful AMF symbiosis.

Keywords: Wheat; Inoculation, Nitrogen use-efficiency; Productivity; Fungicide

Soil controls on root exudate functions

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Through their influence on microbial processes, the carboxylates exuded by roots are key drivers of nutrient acquisition and organic carbon (C) storage in terrestrial ecosystems. However, the simultaneous interactions between environmental factors controlling the production and fates of carboxylates lead to uncertainty in understanding their role in terrestrial ecosystems.

Here we suggest a more integrative view which points out that carboxylate-related functions (nutrient acquisition and C storage) can vary according to soil physicochemical context. We show that a set of variation in soil properties can substantially influence plant production of C surplus and discharge as root exudates. In addition, the magnitude of soil processes involved in the control of carboxylate fates in soils (adsorption, complexation, leaching and biodegradation) is strongly governed by the physicochemical context.

To illustrate this, the first soil scenario we present is characterized by fine-textured and nutrient-rich soils, which leads to a relatively low root exudation rate but high rate of carboxylate associations with minerals. This soil context is more inclined to contribute to the soil C storage function. In the second scenario, the coarse-textured and nutrient-poor soils lead to a higher rates of carboxylate production and higher carboxylate ability to mobilize nutrients. In this case, the carboxylate-related nutrient acquisition function is maximized.

We wish to emphasize the need to integrate the diversity of soil properties when it comes to build on the carboxylate-related ecological functions to promote regenerative agricultural practices, whose potential benefits must be evaluated on a case-by-case basis according to the soil physicochemical context.

Keywords: Pedology, soil physicochemical properties, root exudation, carboxylate fates, ecological functions

No-till and variable P- and N-fertilization levels led to contrasting soil bacterial, fungal and nematodes communities in a 29-years long-term experimental site

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Increasing crop productivity and profitability, while keeping production environmentally sustainable, is a challenge for agriculture worldwide. As a result of agriculture intensification, many soils are highly degraded and depend on the massive use of chemical inputs. Agricultural systems have significantly contributed to the perturbation of natural habitats and losses of biodiversity in addition to being a major contributor to global anthropogenic greenhouse gas emissions. Economic and environmental costs of fertilizers and pesticides are increasing, while yields have reached a plateau, warranting a transition to more sustainable practices. Here we took advantage of long-term (29 years) corn (Zea mays L.)-soybean (Glycine max L. Merr.) rotation to measure impacts of two regenerative agriculture practices – no-till and variable P- and N-fertilization levels – on soil bacterial, fungal and nematodes. While no-till led to no change in bacterial and fungal diversity, it did greatly shift the structure of the communities with potential impacts on soil functions. Although less pronounced, different levels of N-fertilization led to changes in both soil microbial biodiversity and structure while different levels of P-fertilization did not have any impacts on soil microbial communities. The effects on nematodes were more subtle but specific families were affected, revealing a change in the structure of the micro-food web. This was further supported by co-occurrence correlation network analyses. Because microbial communities are carrying a plethora of functions in soils, assessing long-term impacts of regenerative practices on these communities is key to evaluate the impacts of those practices on agroecosystems functions.

Keywords: soil microbiome, regenerative agriculture, reduced tillage, variable fertilization, long-term experimental plots

Influence of Chemical Fumigation on Soil N and C Cycling, and the Soil Microbial Diversity

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Chemical fumigation and biofumigation are used to reduce soil-borne diseases; however, non-targeted microorganisms involved in essential soil processes, such as the soil nitrogen (N) cycle, may also be affected. The objective of this study was to investigate the effects of chemical fumigation with either chloropicrin or metam sodium compared to non-fumigated soil amended with substrates of contrasting C availability (young vs. mature barley plant residues) on the soil bacterial and fungal community diversity using amplicon-based next-generation sequencing. This study consisted of a 3 x 3 factorial arrangement of three fumigant treatments (fumigation with chloropicrin, metam sodium, or no fumigation) and three soil amendment treatments (amendment with young barley, mature barley, or no amendment). In soils amended with young barley, chemical fumigation delayed the maximum rate of soil respiration and N_2O production by five days compared to the amended non-fumigated soil. Additionally, chloropicrin fumigation decreased cumulative soil respiration in amended soils, regardless of substrate C availability, compared to non-fumigated soil. Chemical fumigation used alone or combined with young barley amendments significantly inhibited nitrification compared to non-fumigated soil, whereas amendment with mature barley resulted in N immobilization, regardless of chemical fumigation. After 128 days of incubation, fumigation with chloropicrin and meta sodium had a stronger effect on microbial communities compared to plant residue amendments resulting in different beta-diversity of the fungal and bacterial community compared to the non-fumigated soil. This study demonstrated that chemical fumigation significantly affected soil C and N dynamics and microbial community diversity in soils amended with labile and recalcitrant C substrates, indicating decreased microbial activity and significant implications for soil function.

Keywords: fumigation, N and C cycling, soil microbial diversity

Assessing soil storage strategies for microbial community characterization of long-term agricultural plots

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Soil samples are commonly air-dried and ground for storage and preservation, however these techniques have yet to be deemed appropriate for the storage and preservation of soil microorganisms. Air-dried soil archives at the Lethbridge Research and Development Centre date back to 1906 and could provide valuable insights into the impacts of long-term agricultural practices within the soil microbiome. Are long-term standards in soil preservation applicable for microbial characterization? To answer this question, samples were collected in 2017 from soils that had remained underneath a plastic cover since 1954 as well as from adjacent uncovered soils. Would trends in microbial community composition across covered and uncovered soils be replicated with differing storage? These soil samples were stored for two years at -80°C or room temperature air-dried formats. We conducted physico-chemical analyses on air-dried soils as well as high-throughput sequencing and cell culturing of the bacterial and fungal community from soils frozen at -80°C or air-dried at room temperature. Fungal community composition differed across covered and uncovered plots, showing higher relative abundances of Chytridiomycota in uncovered plots and higher relative abundances of Basidiomycota in covered plots. Fungal richness and diversity were correlated with organic carbon content and depth of the A-soil-horizon. While air-drying was sufficient to recreate general trends between plots, fungal communities differed between the air-dried and frozen soils within covered plots. The covered air-dried soils were driven by a higher relative abundance of Ascomycota and 36.9% of all sequences corresponded to Onygenales sp. Colony forming unit counts were significantly higher in uncovered frozen soils than in other soils. Air-drying had a mixed impact on the reconstruction of soil microbial communities. While general trends may be recreated within air-dried soils, reanimation of biotechnologically valuable microbiota may be compromised.

Keywords: Fungal community; Soil storage; High-throughput Sequencing

Arbuscular mycorrhizal fungi in oat-pea intercropping

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Arbuscular mycorrhizal fungal diversity can be altered by intercropping plant species, as well as N fertilizer applications. This study examined the effects of oat-pea intercropping and N fertilizer addition on the richness and diversity of mycorrhizal species, as well as identified the most common arbuscular mycorrhizal fungi (AMF) genera recruited for oats and peas in two growing seasons (2019 and 2020). The AMF diversity was higher in an intercropped system compared to their respective monocropping system. Under drier conditions in 2019, arbuscular mycorrhizal richness decreased with N fertilizer addition in sole peas and increased with N fertilizer addition in sole oats, but no significant change in richness was observed in oat-pea intercropping. During the wetter growing season 2020, arbuscular mycorrhizal diversity increased when oat and pea were intercropped, compared to either sole oat or sole pea. *Diversispora* in sole pea was a significant indicator differentiating the root associated AMF community from sole oat. *Claroideoglomus* richness increased in peas in 2020, thus this genus could be moisture dependent. *Paraglomus* richness in oat-pea intercropping was similar to sole oat in 2019, and similar to sole pea in 2020. This can suggest that *Paraglomus* is an indicator of plant stress under intercropping, as based on the premise that stressed plants release more exudates, and the subsequent mycorrhizal associations favor these plants with higher exudation. Future investigations can further reveal the functions and benefits of these mycorrhizal genera in annual monocrop and intercropping systems.

Keywords: CSSS-ASSW2022; Soil science; Edmonton

Legacy effects of disturbances on above ground pine metabolites

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Canadian boreal forests are projected to experience increased pressure from various disturbances (wildfires, insect outbreaks, etc.) that threaten the regenerative capacity of forests in the coming decades. These disturbances can alter physical, chemical, and biological properties of forest soils including the abundance and richness of soil fungi. Soil fungi are increasingly recognized as a critical component of forest regeneration for their pivotal roles in nutrient cycling and improving soil conditions for establishment, growth, and survival of forest tree seedlings. Currently, we have little knowledge on how changes in soil fungal communities, particularly mycorrhizal fungi, affect plant metabolites and particularly their defensive capacity. Overall, plant secondary compounds reduce herbivore damage, lessen plant attractiveness to herbivores, and prevent pathogen infection. Overall, there is a close interaction between mycorrhizal fungi and plant defenses. We conducted a series of studies to determine whether soil and root-associated fungal communities differ in lodgepole pine stands disturbed by four common disturbances occurring in the Canadian boreal forests, including wildfire, mountain pine beetle (MPB) outbreak, clear-cut logging, or post-outbreak salvage logging. Each disturbance type was paired with nearest undisturbed, late-successional forest stands. We collected soils from both disturbed vs. undisturbed stand, and characterized their fungal communities. Using the same soils, we grew pine seedlings to determine whether soils collected from disturbed stands affect seedling establishment and performance in a greenhouse and measured the primary and secondary metabolites of the pine seedlings. In this presentation, we will focus on the primary and secondary metabolites of the pine seedlings. Seedlings received one of three treatments: application with methyl-salicylate or with methyl-jasmonate, or untreated, and ten days later all seedlings were harvested. We quantified fatty acids, non-structural carbohydrates, and terpenes of above-ground tissues. We found that disturbance-induced changes in the soil altered constitutive and induced metabolites of above ground tissues of pine seedlings. However, the effects of disturbances on plant metabolites varied. Particularly, clear-cut and salvage logging reduced both constitutive and induced metabolites while wildfire and MPB outbreak had no effect. Changes in soil mycorrhizal fungal communities are likely drivers of changes in plant fitness. Interestingly, MPB outbreaks and wildfire, did not have measurable fitness consequences for the pine seedlings, suggesting that the effects of disturbances on the regenerative capacity of forests depend on the disturbance type. Overall, our study demonstrates that the legacy of disturbances in western Canada extends to pine regenerations through disrupted belowground mutualists, emphasizing interconnectedness of above and below ground stand dynamics.

Keywords: *Pinus contorta*, disturbances, soil mycorrhizal fungal communities, plant defense chemistry

A pull-pull model to describe nitrogen transformations in soil-plant systems

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Soil-plant systems require nitrogen (N) for optimal growth and survival. This is why soil biota and plants have adapted to rapidly acquire and retain N in their biomass. However, the short lifespan of microorganisms leads to N turnover, which will also be triggered by fluctuations in the soil moisture, substrate availability, plant root-induced priming and other factors. This talk will discuss how plant-available N is 'pulled' into microbial biomass and subsequently 'pulled' to plant roots. The pull-pull model is affected by soil water dynamics, which directly control microbial metabolism, growth and cellular lysis caused by abiotic (wetting-drying) and biotic (phages, predator) processes. Selective absorption of N compounds by microorganisms will be discussed in relation to the principles of catabolic repression. The pull of dissolved organic nitrogen, NH_4^+ and NO_3^- to lateral roots and fine root hair, as well as active transportation processes, is evaluated. Coupled C-N cycling has important implications for N transformations in agroecosystems that receive exogenous N fertilizers, and will be discussed from the perspective of managing N fertilizers on farms.

Keywords: microbial metabolism, coupled C-N cycling, catabolic repression

Session 22

Special Graduate Student Session

(Room: Prairie)

Activation Methods Increase Biochar's Potential for Heavy-Metal Adsorption: A Global Meta-Analysis

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Removal of heavy metals by adsorption on biochar's surface has shown promising results in the remediation of contaminated sites. The adsorption capacity of biochar can be increased by modification/activation (pre- or post-pyrolysis) through various physical, chemical, and biological processes that substantially change biochar's physical and chemical characteristics. However, the effect of activation methods on biochar's adsorption capacity for heavy metals has been shown to be variable. Thus, we conducted a meta-analysis to assess the effects of biochar modification and the resulting properties on the adsorption of heavy metals based on 321 paired observations from 50 published articles. We found that the activation/modification of biochar significantly improves adsorption capacity and removal efficiency by 86, and 59%, respectively. We also observed that pre-pyrolysis activation was more effective than post-pyrolysis activation in enhancing the adsorption capacity. and removal efficiency. Chemical activation increased the adsorption capacity by 94%, whereas physical activation enhanced the adsorption capacity by 32% compared to the unmodified biochar. The study also showed that feedstock and pyrolysis temperature affected biochar's adsorption of heavy metals. Moreover, biochars produced from agricultural wastes and pyrolyzed at 350-550 ^{o}C had a greater capacity for heavy metal adsorption. Biochar's characteristics such as a moderate particle size (0.25-0.80 mm), low N/C ratio (<0.01) and H/C ratio (<0.03), high surface area (> 100 m^2 g^{-1}) and pore volume (0.1 cm^3 g^{-1}) were found to be the most desirable characteristics for heavy metal adsorption. We conclude that modification/activation of biochar enhances its potential for heavy metal adsorption and removal, but the process of modification/activation should be chosen to yield desirable characteristics of biochar for enhancing heavy metal removal efficiency.

Keywords: Biochar; Meta-analysis; Heavy metals; Modification; Adsorption

Physical-based hydrological modelling to predict soil moisture in the vadose zone in a mesoscale catchment

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Soil moisture (SM) is a vital protagonist in the development of climate patterns and creation of precipitation. Climate change is expected to produce more fluctuations in precipitation across the globe and cause more frequent extremes in soil moisture, including floods and drought which have major impacts on agriculture and infrastructure. Forecasting can help mitigate the impacts of soil moisture extremes by providing warnings about upcoming extreme events and prompt mitigation measures. This study constructed a physical-based groundwater-surface water three-dimensional model using HydroGeoSphere (HGS) for an agriculturally dominated watershed at Red River Valley, Manitoba, to determine the soil moisture variability in the vadose zone. The sensitivity analysis of soil hydraulic parameters that influenced moisture at different depths was performed. Historically available soil moisture data from Real-time In-site Soil Moisture Monitoring for Agriculture (RISMA) stations present inside the study area and manual installation of Sentek probes in the observational fields were used as observed SM data. Statistical analysis was performed by comparing the simulated and measured soil moisture at the surface and volumetric average of the top 100 cm soil column. At the surface (5 cm), the sand and clay series of the three-dimensional model produced a good correlation with Pearson's R-value averaging greater than 0.5 during calibration and forecasting. The model results of the deeper layers showed a good fit for the clayey soil series with Pearson's R-value averaging greater than 0.5 during calibration and forecasting while the sand series showed poor correlation at lower depths due to certain limitations. The modelling framework in this study assists to provide valuable insights into different hydrological processes. The results obtained from this research will provide valuable support to various systems which can utilize present and future soil moisture data as prime input.

Keywords: Soil Moisture, vadose zone, forecasting, climate change, hydrological modeling

Electro-coagulation modified microalgal biochar for enhancing struvite crystallization

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Phosphorus depletion due to population burst and intensive agriculture have provoked the necessity for developing a sustainable material for the recovery and recycling of this non-renewable nutrient from wastewater. Struvite crystallization is emerging as a promising strategy for phosphorus recovery from phosphorus-rich wastewater. Struvite crystallization can be enhanced with seeding with microalgal biochar. In this study, an integrated electro-coagulation-flotation (ECF) process was used to modify the algal surface and at the same time recover the microalgae with a magnesium anode. Magnesium impregnation of 28% and harvesting efficiency of 98% was achieved with 15 minutes of ECF at a current density of 40.78 mA cm^{-2}, at 0.5 cm inter-electrode distance and an energy consumption of 4.03 kWh kg^{-1}. Phosphorus recovery and struvite yield of 93.7% and 2.66 g L^{-1}, respectively, were obtained from dosing 1.5 g L^{-1} of Mg-laden microalgal biochar. This novel approach can help attaining a circular bioeconomy by encompassing nutrient recovery and waste management in an integrated process.

Keywords: Microalgae; Electro-coagulation-flotation; Microalgal biochar; Phosphorus recovery; Struvite

Reclamation materials from an oil and gas industry as adsorbents of naphthenic acids from oil sands process water: preliminary experiments

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The fourth largest oil reserves in the world is located in Alberta in the form of oil sands with proven reserves in the number of 165.4 billion barrels. The oil sands are a mixture of 10% bitumen, 5% water and 85% mineral solids (sand, clay and silt) and require the application of a Clark caustic hot water extraction process to extract the bitumen. This process demands 0.2 to 2.6 barrels of fresh water per barrel of bitumen and generates high volume of oil sands process water (OSPW) that is stored in on-site tailings ponds as a requirement of the Alberta's zero discharge policy. One of the most significant contributors of acute toxicity of OSPW is the presence of naphthenic acids (NAs), which accounts for more than 50% of all organic compounds in OSPW. Adsorption is an attractive technique for remediation of NAs because of its simple procedure, efficiency at low and high pollutant concentrations, improved selectivity for specific pollutants depending on the adsorbent characteristics, regeneration ability of spent adsorbents, and possibility to apply low-cost adsorbents that require minimal processing and could be available on-site. Natural soils or reclamation materials obtained from the mining activities could be studied with the purpose of evaluating not only the adsorption characteristics aiming at a low-cost adsorbent, but also the leaching capacity and groundwater contamination potential. The main purpose of this project is to apply three types of reclamation materials (an organic material named PEAT-1 and Pleistocene fluvial sands collected from different mines named PF-1 and PF-2) obtained from the oil and gas industry as adsorbents of NAs from real OSPW. Initially, the reclamation materials were air dried at room temperature for 7 days followed by crushing and sieving to pass through a 2 mm mesh. Preliminary adsorption experiments were performed in batch system using raw OSPW at adsorbent concentration of 200 g L^{-1} for PF-1 and PF-2 and 100 g L^{-1} for PEAT-1 at contact time of 48 h. Qualitative measurement of fluorophore organic compounds and quantitative measurement of classical NAs from OSPW before and after adsorption were performed using synchronous fluorescence spectroscopy and ultra-performance liquid chromatography (UPLC), respectively. Qualitative results indicated that PEAT-1 was successful in remediating one, two and three-ring compounds while PF-1 and PF-2 presented some removal of those compounds. This was confirmed later with the measurement of classical NAs using UPLC, in which 38.8, 7.6 and 89.5% of classical NAs were removed by PF-1, PF-2 and PEAT-1, respectively. The studied reclamation materials present as an alternative adsorbent for adsorption of NAs from OSPW. Further studies will be conducted to determine the adsorption mechanisms and the relationship between removal rates and characteristics of reclamation materials.

Keywords: Adsorption; Naphthenic acids; Reclamation materials; Oil and gas industry

The impact of reclamation and vegetation removal on compositional and functional attributes of soil microbial communities in the Athabasca Oil Sand Region

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Large-scale mining for oil extraction in the boreal forests of Northern Alberta has led to a disturbance footprint of ~ 900 km^2 of land; which must be reclaimed to equivalent land capabilities using soil materials salvaged and conserved during land clearing. Microorganisms play pivotal roles in soil nutrient cycling and plant growth, and are sensitive to anthropogenic disturbances, making them potential markers of ecosystem health. Thus, the objective of this study was to determine the impact of reclamation and vegetation removal on the composition and function of soil microbial communities in the Athabasca Oil Sands Region (AOSR). The concept of equivalent land capability is ambiguous; thus, we evaluated bacterial community composition via high throughput sequencing of 16S rRNA genes and functional diversity by community-level physiological profiling (CLPP). The ranges of variability for these factors observed in soils with vegetation removed and soils reclaimed with either peat-mineral mix (PMM), forest floor-mineral mix (FFM) or FFM diluted with sand (Sand-FFM), were compared to that of undisturbed reference soils. Vegetation removal changed the structure of the soil microbial community, and increased the overall diversity, within-community interactions, and heterogeneity. Reclamation shifted the microbial community structure to a greater extent, placing it outside the range of natural variability. Different reclamation substrates resulted in distinct microbial communities, with FFM showing the highest level of similarity to the range of natural variability and PMM showing the least. Bacterial community composition, functional diversity, and soil edaphic parameters all had similar results, but bacterial community composition showed the greatest ability to resolve differences between treatments. Altogether, results suggest both reclamation and vegetation removal alter compositional and functional attributes of the microbial communities of the natural boreal forest soils. Furthermore, bacterial community composition provided the greatest information about the impacts of mining practices; such that it holds promise as a marker of reclamation efficacy and trajectory.

Keywords: Land reclamation; Microbial community; Soil disturbance; High-throughput sequencing

Session 5

Advances in Predictive Digital Soil Mapping

(Room: Glacier)

Divergence metrics for Optimizing Sample Design in Digital Soil Mapping

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A key underlying assumption in digital soil mapping (DSM) is that the variability in the target soil property can be explained by the environmental covariates. Machine learning algorithms (MLAs) are commonly leveraged in DSM and are a data-driven approach to modelling; the resulting model is inextricably linked to the data being used to build the model. Despite the advances in sample site selection algorithms, one critical component of a sampling design which has received considerably less attention is the optimal number of samples, and few techniques have been proposed to address this gap. In this study, we evaluate the use of five techniques: normalized variance approach, the Kullbach-Liebler Divergence (D_{kl}), Kullbach-Leibler Divergence for continuous variables (D_{klc}), the Jenson-Shannon Divergence (D_{js}), and the Jensen-Shannon Distance ($Dist_{js}$) to determine an optimal sample size. We test these techniques for a 26-hectare study site near Guelph, Ontario, across an increasing number of environmental covariates (4, 6, 8, 10 and 12) using the conditioned Latin hypercube sampling algorithm to generate 10 unique sampling designs at 40 different sampling intensities. We also evaluate the effects of data binning, since these techniques require the input data be binned to compare their distributions. Across all techniques and bin sizes, the $Dist_{js}$ consistenly resulted in the largest sample size, while the D_{klc} resulted in the smallest sample size. The number of covariates used to create the sample plan had no effect on the optimal sample size, where sample size increased marginally as the number of covariates increased. On the other hand, the number of bins used to compute the metrics had a significant effect on sample size. For all techniques we saw a strong linear relationship between bins and sample size with regression slopes typically ranging between 2 and 3 sites per additional bin. This comparison of different techniques to determine an optimal sample size provides some new tools that can be added to the DSM toolbox, but also reveals substantial challenges that remain for resolving the issue of optimal sample size. In addition, the conclusions of this work are applicable to field-scale sample design, and these techniques require evaluation at broader scales to determine their usefulness at regional, provincial or national scales.

Keywords: sample design; optimization; divergence metrics; digital soil mapping

Use of LiDAR and machine-learning to predict soil attributes of managed forests in Eastern Nova Scotia

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An understanding of soil properties is fundamental to assessing the character of vegetation that soil will support. By relating field data on soil characteristics to topographic covariates derived from LiDAR datasets, a method was developed that uses LiDAR data to predict the soil moisture regime and soil nutrient regime. A set of topographic covariates was created from a LiDAR derived digital elevation model at multiple spatial resolutions. Random Forest, a decision tree learner, was used to predict soil moisture regime and soil nutrient regime over a region of Eastern Nova Scotia. Tests were processed using covariates based on various filtering window sizes and different data imbalance correction methods, as ground truth data was extremely imbalanced. While variation between results was minimal, there was a trend of smaller filtering windows and less complex data balancing techniques being more effective. Soil moisture and nutrient regime data were used similarly to predict ecosites in the area. Results were heavily distributed at central values in soil moisture and nutrient regime predictions. Results for ecosites showed all extant ecosites in the region.

Mapping maximum peat thickness of cultivated Organic soils in the southwest plain of Montreal

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Large organic deposits in the southwest plain of Montreal have been converted to agricultural land use for production of specialty crops (vegetables) and are economically important for the region. In addition to the variable depth of the organic deposits, these soils commonly have a coprogegous layer between the peat and the underlying mineral substratum which is impermeable and not suitable for agricultural production. Organic soils converted to agricultural use are subject to constant degradation and annual soil loss, which threatens their long-term cultivation. Therefore, five drained and cultivated peatlands were studied to estimate their maximum peat thickness (MPT) — a potential key soil property that can help identify management zones for their conservation. MPT can be defined as the depth to the mineral layer (DML) minus the coprogenous layer thickness (CLT). The objective of this study was to estimate DML, CLT, and MPT at regional scale using environmental covariates derived from remote sensing. To produce a regional MPT map, the DML and CLT were measured as part of two different field projects. Using predictive digital soil mapping, maps of DML and CLT were produced and combined to generate MPT at a spatial resolution of 10 m. Three machine-learning models (Cubist, Random Forest, and k-Nearest Neighbor) were compared. The Cubist model performed the best for predicting both features of interest, yielding Lin's concordance correlation coefficients of 0.43 and 0.07 (DML and CLT respectively) based on a spatial cross-validation procedure. Moreover, the uncertainty associated with the MPT predictions was large due to the propagation of errors. The most important covariates for the prediction of the DML were related to radiometric data, topography, and distance and directional covariates. Interpretation of the drivers of the CLT was limited by the poor predictive power of the final model. Therefore, the main conclusion is that field scale mapping with proximal sensing techniques should be explored. More precise data on MPT is needed to support soil conservation, and field verifications of CLT are required to obtain a higher prediction accuracy. Nonetheless, modern predictive digital soil mapping techniques provided new data to the region with limited fieldwork.

Keywords: Predictive digital soil mapping, Machine-learning, Organic soils, Peat thickness, Coprogenous soil

A comparison of predictive soil map uncertainty metrics and their methodologies

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Digital soil mapping models the relationship between soil and environmental variables to predict the spatial distribution of soil properties. The quality or "performance" of a digital soil map is usually evaluated based on the accuracy/error of the underlying soil-environmental model used to generate the map. This accuracy/error metric is a single numeric value (e.g, 70%, 0.7 RMSE) and more descriptive metrics of uncertainty can be generated that represent error as a function of the predicted soil value or as a function of environmental variation across the landscape. There are multiple approaches that can be taken to quantify prediction uncertainty and it is unclear if some are more reliable than others. In the Ottawa region of Ontario, Canada a digital soil mapping project was undertaken to map various continuous soil properties. We estimated a 90% prediction interval range through 1) model bootstrapping; 2) model bootstrapping + variation in bootstrapped map outputs; 3) nested cross validation estimates of model error. We highlight similarities and differences in uncertainty outputs. We end with a discussion on the rationale behind each methodology and how prediction uncertainty should be conceptualized in practice.

Keywords: Soil Map Uncertainty; Prediciton Error; Bootstrapping; Machine Learning; Validation

Application of Radiometric Data to Predictive Digital Soil Mapping in Ontario

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Predictive digital soil mapping (PDSM) is a data-driven process that relies on data derived from several sources as input for both designing soil sampling programs and to calibrate and validate predictive models of soil properties and classes. Inputs include digital elevation data and terrain derivatives; data from legacy soil maps; crop and forestry inventory data; imagery covering visible and infrared spectra; and radiometric data. These data can be acquired in a multitude of ways such as through ground-based proximal sensing, drone- or aircraft-, or satellite-based remote sensing. Radiometric signals, most notably γ-ray emissions by ^{40}K, ^{232}Th and ^{238}U from soil, are used for the purposes of estimating mineral content and geological parent materials in soil, and have been used to predict soil properties such as sand, silt, clay and organic matter content. The application of γ-radiometry data to PDSM was first introduced in Australian research adapting methods used in geological exploration. The concept has since expanded globally and has been used in many other areas including Europe, USA, BC and Quebec. Considerably less work has been done in Canada to evaluate the potential of radiometric data for PDSM, especially given the relatively young age of Canadian soils. Two projects, one in Peterborough County and the other in the Regional Municipality of Ottawa, Ontario, were conducted to evaluate the use of γ-radiometric data for PDSM. Airborne γ-radiometric acquisition was complete in Peterborough County, while a ground-based proximal acquisition was completed in Ottawa. In addition to the new data acquisition, these areas are also covered by publically-available radiometric data. We compare the performance of these various datasets for predicting key soil properties. Results for these pilot projects will be presented and discussed with respect to their utility for PDSM.

Keywords: soil mapping, radiomentrics, soil minerals, parent materials

Predictive Digital Soil Mapping with Uncertainty Estimation for British Columbia

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In British Columbia (BC), mitigating the ongoing impacts of climate change necessitates a clear understanding of the distribution of soil organic carbon (SOC) and other soil properties. Methods to identify opportunities for SOC sequestration in BC forested systems are needed. Digital soil mapping can address the need for global SOC information; yet, no such assessment has been performed especially in the forested areas of BC where large regions of the province have remained unmapped. This research aims (1) to map the soil properties such as SOC, soil clay content, coarse fragment content, bulk density, and pH; and (2) to estimate the uncertainty in modeling soil properties. Initial predictions of soil properties were carried out using Random Forest. The preliminary results show higher SOC concentrations on the coastline and lower SOC concentrations in the Interior Plateau. The bulk density map shows lower values along the coast and denser soils in BC's Great Plains and Interior Plateau. In modeling soil pH, a pattern of alkaline soil distribution in BC was revealed. Lastly, 90% prediction interval maps were produced using a novel quantile regression approach. The results show higher uncertainty on the coastline of BC in modeling SOC. Higher uncertainty in modeling soil bulk density was found in the Interior Plateau and Great Plains. Likewise, in modeling soil pH, the uncertainty in modeling was highest in the Interior Plateau.

Keywords: Soil Organic Carbon; Digital Soil Mapping; Quantile Regression; British Columbia

Improved Parent Material Map Disaggregation Methods in the Saskatchewan Prairies Using Historical Bare Soil Composite Imagery

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There is increasing demand for more detailed soil maps to support land use planning, soil carbon management, and precision agriculture in Saskatchewan. As parent material is an important soil forming factor and can vary at scales finer than existing maps, there is a need to generate finer-scale parent material maps. As spatially referenced soil point data are lacking in Saskatchewan, predictive soil mapping methods that disaggregate existing soil parent material maps are required. This study focused on investigating important environmental covariates to use in parent material disaggregation; particularly bare soil composite imagery. Synthetic point observations were generated using an area-proportional approach based on existing soil survey polygons and a random forest model was trained with those synthetic observations to predict parent material classes. Models were independently validated using the National Pedon Database. Including bare soil composite imagery as environmental covariates increased model accuracy from 0.33 to 0.51 and the model Kappa score from 0.15 to 0.34 compared with models where it was not included, which overpredicted glacial till. Models that included training points from all locations, regardless of whether bare soil composite imagery was available, and included bare soil composite imagery as environmental covariates had similar results to the bare soil composite imagery model with an accuracy of 0.48 and a Kappa value of 0.31. Based on these results, bare soil composite imagery is an important covariate for parent material disaggregation in the Saskatchewan Prairies.

Keywords: CSSS-ASSW2022; Soil science; Edmonton

Disaggregating Organic Matter Map of Agricultural Soils, Québec, Canada

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Soil Organic Matter (SOM) has been identified as a major soil health indicator as it improves soil fertility, minimizes soil degradation, and enhances food production. Climate change and intensive farming practices may result in the accelerated decline of SOM, which will hinder achieving a sustainable and low-carbon agricultural economy. Hence, it is important to anticipate the nature and extent of SOM in the agricultural field. In response to that, IRDA (agricultural research and development institute of the Province of Québec) has accumulated 315 000 SOM observations, sampled between 2007-2018 and was assembled in 2019, at the postal code level from the Québec private labs. Most postal codes centroids in Québec rural regions are less than 15 km apart. However, producers' administrative addresses could be more distant from related sampled fields and soil analysis reported by a private lab. It creates difficulties to perform digital soil mapping techniques using this dataset as multiple units at the postal code level have more than one sampling point without precise georeferenced information. The objective of this study is to disaggregate the SOM observations at the postal code level into a point-based raster to produce a predictive SOM map of Québec agricultural soils. A reformed version of DSMART (cLHS as sampling approach and random forest as modelling algorithm) was used to disaggregate this dataset. Typically, DSMART is applied to categorical data (e.g., soil class). To fit this SOM dataset into DSMART, the observations were divided into 10 classes. These classes were built on an equivalent number of samples found in each class at the provincial scale. 1km Digital Terrain Model and the last 30 years of climate and cropping data were used as environmental covariates in the model. The final disaggregated map has been produced and a separate dataset is now being processed to validate the outputs. At the conference, this presentation will focus on showcasing the validation results and the disaggregated SOM map of Québec agricultural soils. Also, the drawback of this method and its potential will be further discussed through this oral presentation.

Keywords: Disaggregation, Soil Organic Matter, Digital Soil Mapping, DSMART

Session 6

Digital Agriculture

(Room: Glacier)

Introducing GLOBAL-LOCAL: A new approach to predict soil organic carbon at the local field scale from large soil spectral libraries

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There is much interest in the use of large visible near infrared soil spectral libraries for rapid soil analysis and to further soils research. However, the use of such large and diverse spectral libraries often provide inaccurate predictions at local scales. Here, we present a new approach, GLOBAL-LOCAL, which aims to develop one calibration for all unknown samples from the local site by selecting their most common spectral neighbours. The GLOBAL-LOCAL requires the prior selection of a small representative set (*lab*) from the local site. The approach is based on a combination of *k*-nearest neighbours and principal components that produce with the smallest root mean square error (RMSE) when predicting the *lab* set with partial least squares regression. We evaluated this approach by predicting the soil organic carbon (SOC) content in two different fields, one in Canada (Lévis, QC) and the other in Finland (Maaninka). The soil spectral library used was a combination of that developed by the World Agroforestry Center (N = 3875) and that developed at the Quebec Research and Development Centre (N = 1051). We selected 25 representative *lab* samples from each site using the conditioned Latin hypercube sampling. Our results showed that GLOBAL-LOCAL predictions for Lévis and Maaninka (RMSE = 1.59 and 4.97 g kg^{-1}, RPIQ = 5.2 and 2.5, respectively) were better than using the entire library (RMSE = 20.3 and 23.6 g kg^{-1}, RPIQ = 0.41 and 0.53, respectively), and better or similar to models with site-specific samples (RMSE = 2.38 and 4.68 g kg^{-1}, RPIQ = 3.5 and 2.7, respectively). In addition, the GLOBAL-LOCAL outperformed two other published algorithms for local predictions, the spectrum-based learner and the LOCAL method. Since only 25 *lab* samples would require conventional laboratory analysis, the GLOBAL-LOCAL can substantially reduce analytical cost and greatly improve predictions at local scales using large and diverse soil spectral libraries.

Keywords: Local modelling; Local regression; Soil spectral library; Nearest neighbour; Soil organic carbon

Evaluation of topsoil Magnetic Susceptibility as a criteria for distinguishing soils in Ontario

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As a physical property of soil, magnetic susceptibility (MS) is utilized to distinguish different soil types in southern Ontario. Soil MS depends on soil heating temperature such that heating the soil samples commonly increases MS. This enhanced MS is due to the conversion of iron oxides in the soil from the weakly ferrimagnetic form, hematite, to a strongly ferrimagnetic form, magnetite, when the soil is heated, followed by re-oxidation of magnetite to maghemite, due to re-oxidation during cool-down. Since soil is composed of constituents with different grain sizes, like sand, silt and clay, soil MS is also frequency dependent. At low frequencies, almost all magnetic particles follow the direction of the applied alternating magnetic field, while at higher frequencies, the superparamagnetic (SP) grains, which are typically less than ~20 nm in diameter, cannot be fully aligned with the alternating magnetic field and result in lower MS readings. Frequency dependence (FD) MS, usually expressed as percent of the difference of the MS measured at lower and higher frequencies with respect to the value taken with the lower frequency, continuously increases by heating soil samples, which is attributed to the formation of fine-grained SP particles with high thermal stability from destruction of coarse-grained minerals. This approach is a sensitive tool for identifying the magnetic, and some other iron bearing, minerals which contain information about the origin and diagenesis of soils.

In this study, which is a part of "Ontario Topsoil Project", the MS and FD of 557 soil samples, collected over a variety of soil types in southern Ontario, were measured at room temperature using Bartington MS2B sensor operated in both low and high frequencies. Samples then heated to the temperatures 300, 400 and 700˚C, and MS and FD were measured in the same way. The main objective of this study was to determine which of these parameters is useful for characterizing soil types. Results show that 1) in most of cases, MS at room temperature is lower than the higher temperatures, meaning that most samples, more or less, contain chemically-reduced iron minerals; 2) MS at 400˚C is the highest in most samples, meaning that iron minerals are not dominated by stable single domain magnetite; 3) while MS and its FD of coarse sandy soils do not significantly change in different temperatures, they significantly change for fine clayey soils, meaning that MS and FD could be useful for indicating different soil types; 4) discriminant analysis could help to distinguish various soil types.

Keywords: Soil Magnetic Susceptibility; Frequency Dependence; Heating; Superparamagnetic graines

Standardizing Optical Sensor Canopy Reflectance to Improve Grain Corn Yield Predictions

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Optical sensors are tools that measure optical (visible/near-infrared) reflectance and can be used to assess crop canopy condition. Active optical sensors have their own light source while passive sensors rely on sunlight as a sources of electromagnetic radiation and, thus their reflectance measurements are subject to changing sunlight conditions. As a crop's canopy grows, the additional biomass affects the total reflectance at different wavelengths. A common approach taken to standardize sensor at different growth stages uses heat accumulation index (GDD and CHU). Variations in available soil nitrogen also affects biomass accumulation, especially in high nitrogen use crops such as grain corn. A high nitrogen area (high-N) has been used as a baseline to determine locations in a field where nitrogen may be a limiting factor. While the concept of using a high-N area to make in-season N recommendations is well accepted, the approach of using a high reflectance area to account for variations in light conditions between measurement dates has not been done for active or passive sensors. We used raw and standardized optical sensor measurements for Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Red-Edge index (NDRE) for two active sensors (GreenSeeker (NDVI only), Crop Circle) and one passive sensors (Red-Edge multi-spectral camera) at three target growth stages (V4, V8 and V12) for grain corn. The objective was to determine if standardizing optical sensos data using a high reflectance reference area provides a stronger relationship to grain corn yield than the unstandardized sensor data. Canopy reflectance and grain corn yield measurements were made in Manitoba using four years of nitrogen rate trials on a different commercial corn fields each year from 2018 to 2021. At V4, NDVI was more highly correlated to grain corn yield using standardized data for both active and passive sensors but only for the passive sensor at V8 and for none of the sensos at V12. Similarly for NDRE, The relationship to grain corn yield improved using standardized data at V4 for both active and passive sensors but only for the passive sensor at V8 and for neither sensor at V12. From these results, it appears that standardizing reflectance values between measurement dates using a high reflectance area results in better grain corn predictions at earlier growth stages.

Keywords: optical sensors, grain corn yield, canopy reflectance, data standarized

Multi-Frequency Electromagnetic Induction Soil Moisture Characterization Under Different Land Uses in Western Newfoundland

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Identifying spatial patterns in soil moisture variability under different land uses is crucial for delineating site-specific zones essential to support an economically viable agriculture while minimizing its environmental footprint. Here we present the multi-frequency (MF) electromagnetic induction technique (MF−EMI) as a fast and efficient means to map soil moisture variability under different land uses (natural, agricultural and field road) in boreal podzolic soils. We tested the potential of MF−EMI instrument (GEM-2) to map soil moisture by (i) comparing multiple frequencies for shallow estimation of volumetric soil moisture content (θ_v) with measured data to assess the suitability of apparent electrical conductivity (ECa) to represent θv variations under different land use conditions and (ii) developing a relationship between ECa from GEM-2 and measured θ_v at 0–20 cm depth using a time domain reflectometer. The means of ECa measurements were calculated for the exact sampling location (ground truth data) in each land use condition at Pynn's Brook Research Station, Pasadena, western Newfoundland, Canada. Linear regression models were generated between θv and ECa for the different land use conditions using four frequencies (2.85, 18.33, 38.3 and 80.01 kHz frequencies). Only 38.3 kHz frequency was statistically significant and used for further analysis. Further statistical analysis revealed that although factors other than θv contributed to the spatial variation of the ECa across the different land use conditions, ECa was primarily controlled by θv for all three land use conditions, with the natural land possessing the highest mean ECa and θv. Linear regression between ECa and θv in natural land produced the highest coefficient of determination (R^2) of 0.78 and the lowest root mean square error (RMSE) of 1.19%. These results showed that the georeferenced MF−EMI technique is an efficient and cost-effective way to represent θv variations under different land use conditions, including agricultural fields to support precision agriculture, in boreal podzolic soils.

Key words: Apparent electrical conductivity; GEM-2; podzols; volumetric soil moisture content

Deficit irrigation effect on almond yield and water consumption

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To achieve high yields in almond orchards, growers must irrigate to compensate a water deficit of over 1000 mm each year. This amount of water must however be reduced due to climate change decreasing winter precipitation, which results in less available water for irrigation during the growing season. The current recommendation based on tensiometer readings is to initiate irrigation when soil water potential reaches -40 kPa to prevent yield losses. However, these results are based on traditional tensiometers having technological limitations that can result in inaccurate data when soil water potential reaches -80 kPa. The recent development of a new type of tensiometer with a measurement range of 0 to -1000 kPa has shown that soil water potentials in commercial orchards are much lower than -80 kPa during most of the growing season and has led to the development of an artificial intelligence (AI) algorithm for irrigation threshold detection. This algorithm analyses in situ soil water potential curves to automatically detect irrigation threshold meeting plant needs. This new knowledge suggests that current irrigation recommendations for almond must be reassessed. We hypothesize that using this algorithm will help to increase water use efficiency compared to current guidelines. Hence, the objective of this 2-year study is to establish the best irrigation strategy to maximize yield and water usage. The experimental site (~1 ha) is located on an almond orchard in Kern County, California (USA) where seven automated irrigation treatments monitored using tensiometers (0 to -1000 kPa) are compared (four blocks; 28 plots of 5 trees each). Irrigation treatments include a control treatment based on current recommendations (-40 kPa), a treatment reflecting the grower usual strategies, three treatments based on regulated deficit irrigation (RDI-Advisor: based on a weekly schedule made by a professional irrigation advisor; RDI-ETc: based on estimates of crop evapotranspiration; and RDI-AI: based on an algorithm for threshold detection) and two on sustainable deficit irrigation (SDI-AI: based on an algorithm for threshold detection, and SDI-Dry: -500 kPa). Furthermore, to detect possible water stress in almond, foliage temperature, stem water potential and sap flow are measured on selected trees using respectively infrared thermometers, FloraPulse sensors and thermal dissipation probes. Preliminary results from the first of two years of study indicate no significant differences in yield between RDI treatments and the control, but significantly higher water use efficiencies (RDI-AI: 29%, RDI-ETc: 36%, RDI-Advisor: 41%, $p < 0.01$) compared to current recommendations (-40 kPa). Surprisingly, there were no significant differences in water use efficiency among RDI treatments, despite large differences in soil matric potential when irrigation was triggered (mean values: -162 kPa for RDI-AI, -356 kPa for RDI-ETc and -348 kPa for RDI-Advisor). On the other hand, control treatment showed a significant higher yield with no significant difference in water use efficiency when compared to the grower treatment. Although water stress variables (leaf temperature, stem water potential and sap flow) during the preharvest period were well correlated with each other (r^2 between 0.5 and 0.95, $p < 0.01$), infrared data appears to be a good indicator of crop water stress. Results from the second experimental year will allow us to confirm the best irrigation strategy to apply in almond orchards to decrease water consumption while maintaining high yields.

Keywords: Almond; Soil water potential; Water stress indicators; Deficit irrigation

Session 12

Soil Fertility and Nutrient Management for Sustainable Crop Production

(Room: Maple Leaf)

Assessing Acidification of Cultivated Soils in the Southern Prairies

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The incidence of pockets of acidified soils is increasing in cultivated soils in the Western Canadian Prairies. Many of these soils were neutral to alkaline in soil reaction before annual applications of ammonium based N-fertilizers became commonly used over the past 40 years. Liming is needed in portions of fields, but not blanket applications over the whole fields. Research at three field sitesnear Skiff, AB; Shaunavon, SK; and Strathmore, AB in the southern prairies will be discussed. Grid soil sampling to locate acidified portions, and different methods to apply agricultural lime are being evaluated and monitored.

Keywords: soil acidification, grid sampling, liming

Carbon emission, soil properties, intercropping of cucumber-tomato and carrot-cabbage crops performance affected by application of biochar, urea, and rock phosphate

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Application of biochar soil amendment is a good practice to store carbon in the soil to mitigate against climate change, rock phosphate is an organic phosphorus fertilizer and urea is a chemical nitrogen fertilizer used to enhance soil fertility and food production. The nutrient management system and carbon sequestration were tested in cucumber-tomato and cabbage-carrot intercropped. This greenhouse experiment aimed to evaluate the effect of biochar, rock phosphate, and urea on cucumber-tomato intercrop and to evaluate the carbon emission in the soil-grown with cabbage-carrot intercrop. The two experiments were carried out using rock phosphate (P) applied at a rate of 25Kg/ha for low and 50Kg/ha for high levels, biochar (C) applied at a rate of 25, 50, 100Kg/ha for low, medium, and high levels, respectively, and urea (N) applied at a rate of 30 and 60Kg/ha for low and high levels, respectively. The treatment combinations were no fertilizer application (control), Low N + Low C, High N, Low P + Medium C, High P, Low N + Low P+ High C, and High N + High P using cucumber – tomato as test crops. These treatments were replicated three times resulting in twenty-one experimental pots. The second experiment involved the application of biochar at a rate of 25kg/ha, 50kg/ha, and 100kg/ha (Low, Medium, and High, respectively), all the pots across the experiment received an equal application of urea (N) and rock phosphate (P) at a rate of 60kg/ha and 50 Kg/ha, respectively. The treatment combinations were no fertilizer application (control), Low C, Medium C, High C using cabbage-carrot as test crops. The highest C application at the rate of 120Kg/ha was applied to the cabbage test crop only. The treatments were subjected to analysis of variance (ANOVA) using Duncan's Multiple range test for separation of treatment means. Results showed that High N+P including Low P + MC, Low N+P+HC, and Low N + LC supported height of cucumber while Low N + LC and High N positively influenced height of tomato. It was observed no significant difference in the number of Cucumber fruits produced since the control and High N treatments significantly got the same number of cucumber fruits, whereas Low N + LC treated to tomato crop got the highest number of tomato fruits. In the second experiment, Highest C including High C and Low C favoured the height of cabbage while no significant effort in the treatments to support carrot height. It was estimated that the High C treatment gave the highest carbon emission while the Highest C treatment stored carbon in the soil. The soil sample collected in each of the treatments significantly influenced soil properties. This experiment revealed the potential of biochar fortified with urea and rock phosphate to support food production, as well as fight against climate change.

Keywords: food security, climate change, biochar, rock phosphate, urea, intercropping

Nutrient availability of management practices to advance farm profitability and sustainability

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Soil health is the continued capability of soils to sustain plants, animals and humans. Soil component analysis and management are important parts of soil health and are critical for the efficient and profitable functioning of farms. For this project, over 400 soil cores of up to 1m in length were collected from eight high performance farming clusters across Alberta using Latin Hypercube Sampling to improve the representation of the soil landscape. The sampled farms have adopted regenerative practices, defined in this study as minimized tillage, maintenance of soil cover, increased diversity, minimized inputs, animal integration and living root/green growing. Plant available nitrogen, phosphorus and a range of micronutrients will be analysed to determine soil health and its relationship to nutrient and carbon cycling. Initial analyses indicate that farms that have adopted a full suite of regenerative management practices perform better at soil carbon sequestration in comparison to more conventional management, independent of climate variation. Analysis of soil nutrients is currently underway. This study feeds into a larger project of predictive soil health mapping across Alberta to inform producers and policy makers on regenerative management practices, soil carbon sequestration, nutrient cycling and soil microbiomes.

Keywords: Soil health, nutrients, farm management, profitability, sustainability

Size fractionation of trace elements in soil solutions recovered from soils under contrasting long-term agricultural management

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Long-term agricultural management interacting with inherent soil properties plays a key role in the speciation and transformation of trace elements (TE) in soil solutions. In this study we characterized the distribution of TE species in soil solutions into particulate (> 0.45 μm), dissolved (< 0.45 μm), colloidal (1 kDa to 0.45 μm) and mainly ionic (< 1 kDa) fractions to examine the impacts of manure, inorganic fertilizer and crop rotations. Asymmetrical flow field-flow fractionation (AF4) coupled to UV-Visible absorption (UV) and ICP-MS was used to measure the distribution of dissolved TEs among primarily ionic and small species < 1 nm, organic-dominated colloids and primarily inorganic colloids. Eight soil treatments were chosen from the University of Alberta Breton Plots and associated Bentley Forest Preserve, including the control, NPKS inorganic fertilizer, and manure treatments, applied under different crop rotations (2-year of wheat-fallow rotation and 5-year of cereal-forage rotation), and forested (never cultivated). Soil solutions were collected under vacuum using surgical (316) stainless steel lysimeters (5 micron pore size), after irrigating with high purity water (deionized, Milli-Q). The collected soil solutions were analyzed in the metal-free, ultraclean SWAMP lab. The acid-cleaned lysimeters yielded excellent blank values for most of trace elements of environmental interest. Silver, Al, As, Ba, Li, Pb, Th, Tl, U and V were mainly present in particulate forms in lysimeter soil solutions, while Cd, Co, Cu, Mn and Mo showed greater dissolved fractions under some agricultural managements. Among dissolved fractions of TEs, As, Ba, Co, Li, Mn, Mo and V were mainly present as ionic species, but higher proportions of V were associated with inorganic colloids from uncultivated soils and unfertilized soils under the wheat-fallow rotation compared to other cultivated and fertilized soils. Organophilic Cu was primarily associated with organic matter in soil solutions from treatments with manure. Significantly higher proportions of dissolved Al, Pb, Th and U were associated with inorganic colloids in soil solutions than other TEs, but their ionic species were predominant from treatments with NKS and (or) NPKS fertilizers. Using the new lysimeter combined with AF4-UV-ICPMS, we provide a new perspective on TE speciation in soil solutions, with a view towards understanding the effect of long-term fertilization on the bioavailability of micronutrients and potentially toxic trace elements.

Keywords: Trace elements, Fractionation, Soil solution, Fertilizer, Crop rotation

Soil nitrate, soil properties and potato yield responses to different preceding forage crops

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Understanding the effects of different forage crops on soil nitrate leaching potential, soil properties and on potato yield is important to achieve the environmental sustainability and to sustain soil and potato productivities. Two cycles of a 3yr (barley underseeded with forage-forage-potato) rotation were implemented between 2013 and 2018.The tested forages included a legume (red clover), a grass (timothy) and a red clover-timothy mixture. Soil fertilization (N,P, K inputs) was performed so satisfy barley requirements but no nutrient inputs was supplied in the second year of the forage growth. Measured parameters included C and N contents, aggregate stability, active carbon, protein index, soil respiration, soil water content and potato yields. In addition, suction lysimeters were installed at 30 cm and 50 cm and stainless steel lysimeter installed at 85 cm to measure mineral nitrate concentrations in leachate during the growing season and in fall. Monthly soil sampling were also performed during potato growth to measure soil nitrate at 2 depths (0-15 cm; 15-30 cm). Dry matter biomass, C and N returned to the soils were higher with RC and M than with timothy and timothy returned around half of N in comparison to RC and M. Trends toward lower values of soil nitrate were observed with timothy than red clover or red-clover-timothy mixture. All treatments were associated with comparable potato yields. After 6 years, timothy was associated with lower aggregate stability and protein index in comparison to red clover treatment. In addition, timothy treatment had 13 and 18% lower active carbon than red clover or red clover-timothy mixture. The study suggests that there may be a trade-off between selecting cover crops to reduce nitrate leaching and enhance soil quality

Types and Diversity of Pulses for Wheat Nitrogen Utilization in Two 4-Year Pulse-Wheat Rotation Cycles

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Inclusion of pulses crop in crop production systems has been identified as a means of reducing the dependency on industrial nitrogen (N) fertilizers within the agroecosystem. However, studies are limited on how pulse types and diversity affect subsequent wheat N utilization on the semi-arid Canadian Prairies. The objective of this study was to evaluate the effect of pulse type [chickpea (C), lentil (L), and pea (P)] and pulse diversity (one or two pulse types in a rotation cycle) on grain N removal, N uptake and fertilizer use efficiency (FUE) of wheat (W) in two 4-year pulse-W-pulse-W rotation cycles. The study was carried out at three locations on the Canadian Prairies (one location at Brooks, AB, and two locations at Swift Current, SK) from 2010 to 2019. The rotations were C-W-C-W, L-W-L-W, P-W-P-W, L-W-C-W, P-W-L-W, and W-W-W-W. The wheat phase in the 2nd and 4th year in each rotation cycle received 55 kg N ha^{-1}. Results showed that there were significant effects of rotation type and wheat phase year on N removal, N uptake and FUE. Over the two 4-year rotation cycles, wheat (in 2nd and 4th year) grain N removal in L-W-L-W (64 kg N ha^{-1}), P-W-P-W (66 kg N ha^{-1}), P-W-L-W (67 kg N ha^{-1}) were significantly greater than N removal in W-W-W-W (55 kg N ha^{-1}). Similarly, wheat phase N uptake was significantly greater in L-W-L-W, P-W-P-W, and P-W-L-W than in W-W-W-W by 19-25%. The wheat phase FUE was 14% each significantly greater in P-W-P-W and P-W-L-W than C-W-C-W and 13% each greater in P-W-P-W and P-W-L-W than W-W-W-W. Wheat phase N removal, N uptake and FUE were not significantly different between C-W-C-W and W-W-W-W. Overall, lentil and pea are better than chickpea for wheat N utilization in pulse-wheat system and diversifying pulse phases to include more than one pulse type can improve N utilization relative to continuous wheat in wheat production system.

Keywords: Pulses, rotation cycle, N removal, N uptake, fertilizer use efficiency.

Session 10

The Good, the Bad, and the Ugly: Integrating Technology in the Field, Lab and/or Classroom

(Room: Maple Leaf)

Introducing Mobile Technology in a Field-based Course – Student and Instructor Perceptions

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RRM 301.9 is a field-based course in Renewable Resource Management with learning outcomes that include soil description/classification, plant identification, ecosite and soil mapping, and related relevant field skills and knowledge. Over the duration of the course, students spend time in various landscapes and regions of Saskatchewan, collecting spatially referenced data and information. Until this last fall, use of mobile technology was limited to hand a held GPS. In addition to field notebooks, collection of spatial data was supported by paper copies of geo-referenced air imagery and as stored coordinates on the GPS. Students might augment their observations with images collected on personal devices. Current industry practice includes use of field grade laptops or tablets with subscription to geomatics software and access to georeferenced digital air imagery. Navigation and geo-referenced data collection can happen in real-time. With interface to Arc GIS, these systems can be configured to more efficiently generate maps. After years of hardcopy teaching, it was decided to include iPads, Avenza Mapping Software and QGIS to introduce students to industry practice. As this required a significant investment in hardware and software, it was important to learn what impact this 'upgrade' would have on the both the student and instructor experience and the successful delivery of learning outcomes. Based on in-field discussions with students, a student survey, and instructor reflections, it was clear that students found the mobile technology productive for spatial data collection, and navigation, and subsequent map creation, but not for taking field notes or completing/submitting assignments. At the same time, few students expressed any desire to have the course materials or deliverables mediated entirely through paper. The instructor saw an increased engagement with the final mapping project and reduced time needed in the field, but did note an increase in difficulty implementing the concept of the 'map unit' in completing the final report. These mixed results support continued use of mobile technology, with particular attention to those specific learning outcomes that may be negatively affected.

Keywords: Teaching, Field-course; Soil mapping; Mobile technology, Student experience

Question banks in teaching and learning basic soil science concepts

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Disciplines such as Soil Science, which involve concepts not included in the high-school curriculum, are very challenging for many university students. These concepts are particularly difficult for students accustomed to learning strategies that involve memorization and recall of facts, without emphasis on a deeper understanding of the relationship between concepts. One way to help students master soil sceine concepts is through regular assessments that are well-aligned with specific course learning outcomes. Recent advancements in online educational tools allowed the development of question banks that can be used for assessments and exams. In this presentation we will describe the development of a series of question banks focused on learning outcomes of the Introduction to Soil Science course offered at the University of British Columbia, Vancouver. The question banks were developed during 2020-2022 when this course was offered online. The question banks are housed within the learning management system (i.e., Canvas) and they include several types of questions that are organized by topics and levels of difficulty. Types of questions in our question banks include short answer and data interpretation, calculations, and quiz type questions (e.g. true/false, fill-in-the blank, multiple-choice, and multiple answers). Even though, we initially used these question banks for the online exams in our course, we are currently using them to structure assignments, and provide online practice exams in addition to an online midterm exam.

Keywords: Soil science eduction; introductory soil science course; assessments; exams

What students want versus what is effective: lessons learned for the post-COVID classroom

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As instructors return to in-person teaching and learning following online teaching during the COVID-19 pandemic, we can build from the experiences gained and integrate online resources into our campus-based classes. Drawing from student evaluations of teaching, a post-course student survey and learning management system (LMS) analytics, we documented students' perspectives of online teaching and learning in a large introductory soil science course (with about 300 students) offered as a flipped classroom, and reflect on student and instructor perspectives as we return to campus-based teaching and learning. Results suggest that what students liked and what they perceived as effective often did not align, and that instructors need to consider good pedagogical practice when evaluating student comments. We identified strategies that we can carry forward to enhance our large introductory soil science course including a weekly course structure, synchronous classes and laboratories supported by asynchronous content, and taking advantage of recent advancements in online teaching and learning tools for discussion forums, practice exams and assessment.

Keywords: Soil science eduction, student perspectives, instructor perspectives, introductory soil science course

Using Apps to Support Teaching of Soils Skills and Knowledge – Round Table Discussion

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Mobile websites or applications (apps) are common-place in many aspects of day to day activities. Several apps have been developed in recent years that directly or indirectly address the professional practice of soil science. Navigation, mapping, soil classification, and plant identification are a few of the activities that can be supported by apps. These and similar apps are being used by instructors of soil skills and knowedge to support their teaching. The purpose of this round-table discussion is to bring instructors together to share their knowledge and experiences using apps for teaching, both in the classroom and the field. The discussion may also foster collaboration on future projects to examine the use and impact of apps in the teaching of soil skills and knowledge.

Keywords: Mobile website; Apps; Soils; Teaching; Mobile technology

Session 17

Canada's National Inventory Reporting of Greenhouse Gases: Meeting Target Reductions Rests on Sound Emission Estimates

(Room: Aurora)

Revisions to GHG estimates from Canadian agricultural soils: Emission factor updates and alignment of carbon and nitrogen methods

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A revision of agricultural emission methodology was completed and published in the 2022 National Inventory Report. Recent publications carried out by Agriculture and Agrifood Canada scientists, in collaboration with scientists from Environment and Climate Change Canada suggested that important trends in emissions were not captured by the methodology developed in the early 2000's and revisions were required based on more recent research findings. The national weighted N_2O emission factor was revised through a change in the correction of emissions for climate variation by replacing a linear relationship based on the ratio of precipitation to evapotranspiration to an exponential relationship with precipitation. Further revisions included the addition of an N source and crop type modifier as well as revisions to soil texture and the non-growing season emission modifier. Further, a yield driven calculation of changes in soil organic carbon (SOC) under annual cropping systems was introduced in place of the area-based calculation of changes in SOC resulting from reductions in summerfallow, as well as carbon transfers to soils from the application of manure on annual crop production systems. These methodological changes resulted in important changes in emissions and removals. Emissions from the application of nitrogen to agricultural soils decreased by 5.5 MtCO2e nationally, with the majority of these reductions in the Canadian prairies (4.2 $MtCO_2e$). Removals of CO_2 and sequestration in soils increased on average between 1990 and 2005 by 7.1 $MtCO_2e$ and on average 13 $MtCO_2e$ between 2006 and 2019. Interannual variability is high, highlighting the influence of annual weather on crop yields and feedbacks to SOC in soils. These improvements represent a first step in the development of improved inventory methods built on consistent national C and N data and an improved representation of soil management practices and processes.

Keywords: Emission Factors, IPCC, N_2O, Tier 2, Trends

National inventory reporting of nitrous oxide emissions from agricultural soils in the USA

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The DayCent ecosystem model is used to estimate direct soil N_2O emissions, NO_3 leaching, and nitrogen gas volatilization from most (~85%) US cropland and grazed land areas, including mineral soils on non-federal lands that are used to produce alfalfa hay, barley, corn, cotton, grass hay, grass-clover hay, oats, peanuts, potatoes, rice, sorghum, soybeans, sugar beets, sunflowers, tobacco and wheat. Default Tier 1 emission factors from IPCC are used to estimate direct and indirect emissions from federally managed grazed lands and crops (e.g., vineyards) and soil types (e.g., histosols) that are not included in the DayCent simulations. Default Tier 1 factors were also used to estimate indirect N_2O emissions from DayCent outputs for leaching and volatilization losses of N. Model inputs files are derived from government surveys and databases, remotely sensed products, PRISM weather, and SSURGO soils. The sampling importance resampling algorithm is used for Bayesian calibration of parameters controlling nitrification and denitrification. DayCent model results imbed three types of uncertainty: management input uncertainty, model structural uncertainty, and land-area scaling uncertainty. Uncertainty in management inputs was addressed using Monte Carlo analysis with 1000 iterations. Model structural error and associated parameterization uncertainty are quantified by comparing N_2O emissions generated by DayCent with emissions measured at various research sites. The uncertainty associated with scaling the DayCent results for each land use survey location to the entire land base is determined by computing the variances from a set of replicated weights for the expansion factor.

Keywords: DayCent, IPCC, Modelling, N_2O

Nitrous oxide emission reductions reflected in the German greenhouse gas inventory

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Agricultural soils account for 63% of German N_2O emissions. The main agricultural N_2O sources are mineral and organic fertilizers, drained organic soils and nitrate leaching. Germany uses a Tier 2 methodology for the main agricultural N_2O sources. It was developed by statistical models based on a database of N_2O field studies in the country. Unlike the revised IPCC Guidelines 2019, mineral and organic fertilizers have the same emission factor. There are no clear effects of fertilizer management. In contrast, clear regional emission patterns are driven by soil and climate factors. They reflect the susceptibility to wet or dry conditions and freeze-thaw events. Germany thus developed regional emission factors for N_2O emissions from fertilizers and crop residues for mineral soils and based on four ecological zones. They were applied for the first time in the 2022 GHG national inventory report.

Nitrous oxide emissions have declined by 18% since 1990 due to lower animal numbers and less use of synthetic nitrogen fertilizers. Germany has no dedicated policy to reduce N_2O from agricultural soils but does have strong policies to reduce nitrate leaching and ammonia emissions. These policies are included in changes to the Fertilizer Act. Market trends towards lower cattle numbers (at higher productivity), nitrogen legislation and the trend towards organic farming have clearly reduced total nitrogen input to agriculture. This is thus reflected in the lower N_2O emissions in the GHG inventory.

Keywords: Emission Factors, IPCC, N_2O, Tier 2

CongrUpdating non-growing season:annual N_2O emission ratio from Canadian croplands

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Nitrous oxide (N_2O) is a potent greenhouse gas (GHG) whose atmospheric concentration is increasing primarily due to nitrogen (N) fertilizer application to agricultural soils. Due to the difficulty in measuring emissions during winter Canada and many other regions with cold winters and an accumulated snowpack have typically focussed measurements on the growing season. However, research has shown that emissions continue throughout the winter with pulses during thawing that can account for a large proportion of annual emissions. We collected the data from all available Canadian studies (n = 17; 256 treatment years) that measured soil N_2O emissions from agricultural systems for the entire year and determined the proportion of total annual emissions that occurred during the non-growing season and examined these proportions for differences between various management and pedo-climatic variables. The proportion of annual N_2O emissions that occurred during the non-growing season was 36.6% ± 23.0% (mean ± 1 SD). Due to the high variability, few significant differences were observed between the climatic, soil and management variables, including spring versus fall N applications. There was a significant interaction between soil texture and fertilizer type. No detectable differences were observed between fertilizer type on the fine textured soils, whereas the enhanced and regular synthetic N fertilizer had a lower proportion of winter emissions compared to the control and the organic fertilizers on medium and coarse textured soils. The dataset however is limited and thus our analyses rely heavily on a few sites. Overcoming potential site related bias will require additional studies on multiple sites across the country.

Keywords: Agriculture, winter, N_2O

Changes in Reactive Nitrogen Losses from Canadian Agricultural Land over 36 years

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Agriculture produces food, fiber and biofuels for the world's growing population, however agriculture is also a major contributor of nitrogen (N) losses to the air and water through ammonia (NH_3) volatilization, nitrous oxide (N_2O) emissions, and nitrate (NO_3^-) leaching. ***The objective*** of this presentation is to changes in reactive N losses from Canadian agricultural land over 36 years from 1981 to 2016. ***Methodology:*** A Canadian Agricultural Nitrogen Budget- for Reactive N (CANBNr) model was developed to estimate the reactive N (Nr) balance in soils. The model estimates N inputs, N removals (crop and soil organic N) and N losses over 36 years (from 1981 to 2016) in 3480 agricultural polygons which represents almost all of the agricultural land in Canada. Annual N inputs to farmland include fertilizer N, manure N, biological N fixation and atmosphere N deposition. Annual N outputs from agricultural include N removal by food and feed crops, NH_3 and N_2O emissions and NO_3^- leaching. The CANBNr model integrates NH_3 emissions from applied fertilizers, stored and applied manures, direct and indirect N_2O emissions from fertilizers, stored and applied manures, crop residues and change of soil SOM pool. The nitrate leaching was estimated based on improved drainage simulations by the DNDC model for SLC polygons. The landscape polygon results were scaled up to the provincial and national scales. ***Keyfindings:*** at a national scale, N input increased 1.86 times from 1981 to 2016 in Canadian agricultural systems and this was mainly contributed by the increased uses of inorganic fertilizer (from 938 Gg N in 1981 versus 2557 Gg N in 2016). The higher national percentage of N removal by crops was strongly affected by the farmland weighting because the prairie provinces has 84% of total farmland. ***Conclusion:*** The total annual N input for Canadian farmland was 5528 Gg N in 2016 whereas N removal by crops and Nr accounted for 4009 Gg N (72.5%) and 1519 Gg N (27.5.%), respectively. The Nr losses from N_2O emissions, NH_3 volatilization and NO_3^- leaching account for 64, 331 and 347 Gg N (1.1, 6.0 and 6.3% of total N input) as well as a total of 777 Gg N (14.1% of total N input) left as surplus residual soil N in soil which could be available to the subsequent crop.

Keywords: Reactive N, Nitrous oxide emission, Ammonia emission, Nitrate leaching, Residual soil N

Changes in pulse type and frequency in rotations affect CO_2 and N_2O emissions on the semi-arid Canadian prairies

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Pulse crops have been adopted on the Canadian prairies to achieve a more sustainable agriculture system by diversifying and intensifying the dominant cereal-oilseed cropping systems. Although pulses in the cereal-based cropping system have been found to reduce greenhouse gas (GHG) emissions, the impacts of pulse type and frequency in crop rotations on GHG emissions remain unclear. A 4-year pulse-cereal rotation study was established in 2010 at Swift Current, SK. Four-year (2018-2021) cumulative carbon dioxide (CO_2) emissions and nitrous oxide (N_2O) emissions were examined. The inclusion of a 2-year pea rotation (pea-wheat-pea-wheat (PWPW)) tended to have a greater decrease in cumulative CO_2 and N_2O emissions than the 2-year chickpea (chickpea-wheat-chickpea-wheat (CWCW)) and lentil (lentil-wheat-lentil-wheat (LWLW)) rotation. Compared to the control treatment (WWWW), PWPW, CWCW and LWLW decreased or had minimal impact on CO_2 emissions by 13, -1 and 3 %, respectively; and decreased N_2O emissions by 51, 46, and 35%, respectively. Regardless of pulse type, increased pulse frequency in 4-year crop rotations generally decreased both CO_2 and N_2O emissions. Increased pulse frequency reduced N_2O emissions considerably more than CO_2 emissions (i.e., 34-51% decrease in N_2O vs. 0-19% decrease in CO_2 compared to the control). This was likely due to the reduced nitrogen fertilizer inputs in higher frequency pulse rotations. In conclusion, increased pulse frequency and the appropriate choice pulse type could mitigate greenhouse gas emissions in crop rotations in the semiarid Canadian prairies.

Keywords: pulse; rotation; carbon dioxide; nitrous oxide; greenhouse gas emissions

Session 11

Soil Properties in Nutrient and Water Transport in the Vadose Zone

(Room: Aurora)

The Ecohydrology of deep soil water

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Deep soil water is defined as soil water at the bottom of the root zone and this “hidden” water is often ignored for soil water balance and root water uptake. Recently, deep soil water has been found to be important in some regions. However, a systematic understanding of the roles of deep soil water is still lacking. The objective of this study is to investigate how deep soil water interacts with deep roots, the heart of ecohydrology in the deep soil. Specifically, we will examine how rooting depth affects groundwater recharge and how deep soil water contents dictate the roles of deep roots in helping plants to combat droughts. Capitalizing on historical tracers, we determined groundwater recharge rates in the Canadian Prairies and the Chinese Loess Plateau. We found the deep soil has a long residence time in the scale of decades. And the recharge rates to groundwater is less than 1% and 10% of the precipitation at the Canadian Prairies and CLP, respectively. Moreover, the groundwater recharge rate is inversely correlated to root depth. Deep soil water also affects plant hydraulic traits, and the roles of deep roots depends on deep soil water contents. Deep roots suppress transpiration when the deep soil water content is low, and promotes transpiration when the deep soil water content is high. There is also a water-for-carbon trade-off in deep soil, which is often forgotten in accounting for carbon storage in soil.

Keywords: Deep soil water; plant root zone, groundwater recharge; transpiration; ecohydrology

Seasonal release of historical nitrate from vadose zone delays underlying groundwater quality response to BMPs

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Excessive nitrate leaching from crop production has been linked to elevated nitrate levels in groundwater. Beneficial Management Practices (BMPs) have been implemented to reduce nitrate leaching to protect groundwater quality, but monitoring rarely detected groundwater nitrate reduction after implementing BMPs for years and the processes responsible for this lack of response were poorly understood. A study was conducted to understand the processes in a 7-ha potato-grain-forages rotation field in Prince Edward Island, Canada, from 2011 to 2016. The field consists of fine sandy loam soil and is underlain by 7–9 m of glacial till, which overlies the regional fractured ‘‘red-bed” sandstone aquifer. The water table fluctuated seasonally about 2 to 6 m below ground surface near the till/bedrock interface. Field treatments included one field zone (Zone D) taken out of production in 2011 with the remaining zones (Zones A–C) kept under a conventional potato rotation. Taking Zone D out of production simulated an extreme scenario of N input reduction so that the effects of soil, weather and geology on nitrate transport can be demonstrated without adding confounding effects related to infield practices. Soil and rock core collection and high resolution sampling for nitrate and other parameters, tile-drain and high-frequency hybrid multilevel monitoring were performed to trace nitrate in the soil–vadose zone–bedrock aquifer continuum. Soil sampling detected a significant amount of nitrate after potato harvest in fall 2011, which could be conceptualized as a nitrate maker. The combination of rock coring, tile-drain and multilevel monitoring demonstrated that it took about 2.5 years for the nitrate marker to travel through the 6-m thick vadose zone down to the water table; seasonal recharge and associated nitrate load were derived from “old” drainage/nitrate stored in the vadose zone and were being pushed downward to the water table by “new” drainage/nitrate added on the top of the vadose zone column via hydraulic pressure propagation. This would act like a piston movement, creating an instant water table response but a delayed nitrate concentration response in the aquifer to current nitrate leaching events. This study not only demonstrated the vadose zone processes responsible for the delayed response of groundwater quality improvements to BMPs but also implied that agricultural vadose zones can store a significant amount of historical nitrate with a substantial delay in release to the underlying groundwater.

The contentious size range terminology of soil pores

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Soil pores are where the action is when it comes to soil carbon and moisture, and the change of state of carbon into CO_2. As a regulatory body, soil pores are silent, yet their collective action constitutes the difference between carbon gain and loss and moisture retention and drainage from the micro scale to terrestrial biomes. In an attempt to understand the changes in soil properties that justify tile drainage in agriculture, I struggled to untangle the varied use of terminology for soil pore size in regards to water flow rates. There was a wide range of difference in soil pore size and the functions associated with published size ranges, possibly stemming from the development of measurement methods over time. As I began to aggregate the literature based on function, I was better able to determine appropriate size ranges. Moreover, the most difficult aspect was to determine a division between aggregate formed pores and void spaces which were both termed “macropores”. To readers not associated with soil carbon processes, the water flow rates for all macropores were deemed equal, whereas the physiological and biological processes associated with soil aggregate formation are not comparable to clay cracks, root channels or soil fauna burrows in water flow function. I will demonstrate the data interpretations from past to present. The goal of this presentation is to engage the audience in a discussion from which to decide optimum pore size classifications. A consensus is needed to create a paper to promote a better understanding of soil pore size, which is needed to improve interpretation of soil processes among papers. The understanding of the smallest functioning soil pores may be critical in optimizing soil moisture in challenging times.

Keywords: Soil pores; Soil carbon; Water flow; Pore size terminology

Session 3

Soil Data Curation

(Room: Prairie)

Introducing the Canadian Soil Data Portal: The path towards renewing our digital soil information system

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During the establishment of the Global Soil Partnership of the FAO, the scientific community held the wide consensus that, despite the abundance of soil knowledge and data worldwide, soil data is often dispersed, not harmonized, and not accessible to stakeholders and that there is a need to enhance the wide sharing of data. Comprehensive soil data is the keystone for a realistic and detailed representation of this vital natural resource in global-scale models and is required for establishing soil observational and monitoring networks for model validation. Despite these needs, Canada's soil information remains decentralized—the data is dispersed amongst academic institutions, government agencies, and industry. We are not well equipped to fully contribute to the understanding of soil ecosystem services, threats to the delivery of these services, as well as to national global soil initiatives. To address this, members of the Canadian Digital Soil Mapping Working Group are developing the Canadian Soil Data Portal—an open access repository of soil information. The objectives are: (1) to establish a network of data contributors from academia, government, and industry; (2) to develop protocols for data structuring, harmonization, cleaning, and documentation; and (3) to leverage the advances in modelling and geovisualization for analyzing and communicating soil data. This presentation highlights the progress to date and identifies key challenges that must be addressed. The democratization of soil data is required for providing accurate and precise information about our soils from local- to global scales and the data can then be leveraged to help address pressing issues, such food security and climate change.

Keywords: Soil information system; data management; data harmonization

Legacy Soil Survey Data Recovery in Ontario: cards to computers

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After the International Union of Soil Sciences World Congress in 1978, hosted in Edmonton, Alberta, soil survey and mapping programs saw renewed interest and funding from federal and provincial governments across Canada. In Ontario, this resulted in the revitalization of a tri-agency partnership between the federal government, provincial government and academia (University of Guelph) known as the Ontario Institute of Pedology (OIP). Under this partnership, numerous soil surveys were completed through the 1980s and 1990s until the dismantling of the federal and provincial soil survey units in the mid to late 1990s. Through termination of the soil survey programs and physical office relocations and reduction in storage space, much of the information collected through the field programs was lost. In 2016, the Ontario Ministry of Agriculture, Food and Rural Affairs launched a digital soil mapping (DSM) program. DSM is a rapidly developing, data intensive discipline which merges predictive modelling, geographic information systems and pedology, and can be used to renew soil maps using spatially-referenced legacy soil data. Old digital media were located and thousands of paper records were recovered from the soil surveys completed by the OIP. Over 12,000 soil inspection points were extracted from the legacy material.

This presentation will focus on the approach to recover data for three legacy soil surveys in Ontario: Middlesex County, Elgin County and the Regional Municipality of Niagara, and the unique challenges encountered. Some key steps in data recovery to be highlighted include georeferencing of airphotos and large-format scans, digitizing of information from air photos and scans, data entry, soil correlation, data interpretation and harmonization, accuracy assessment and data dissemination. The value of these datasets was less apparent at the time of data collection, since the major deliverable for these projects were the soil maps and their reports. These datasets not only represent a significant scientific recovery, but also represent a significant financial recovery for the soil survey program. Using an average cost of acquisition for a soil inspection of $500CAD, data recovery efforts thus far are valued at over $6.4 million. These datasets can now be used to develop updated, high resolution digital soil maps using new DSM approaches and techniques, and new projects are already underway to leverage the recovered data.

Keywords: legacy soil survey; georeferencing; data entry; spatial accuracy; data recovery

Evaluating the reliability of soil pit locations within the BC Soil Information System

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The BC Soil Information System (BCSIS) was developed over a period of several years beginning in about 1980. BCSIS is a computerized system to store records from soil pits that were established during soil inventory projects throughout BC. The BCSIS point data is a valuable data catalogue, but the geographic positioning of many points is suspect because in the 1980's, there were no GPS systems available and field locations were often approximated from maps. With the advent of GPS systems in the 1990's, point location errors were less common, but most soil inventory projects had been completed by that time. This project used an automated process to evaluate the spatial positioning of the 26,750 soil pit locations in the BCSIS inventory. A seven step process was developed to determine whether the point location could be considered accurate with high confidence, low confidence, or some intermediate level of confidence. The process then allows a user to select points for spatial modeling, based on specified confidence levels. More than 10.9% of the 26,750 soil pit locations were found to have serious accuracy concerns, likely making them unsuitable for spatial modeling. Identification of spatial errors and improved spatial accuracy will make the dataset more suitable for use as an input for the creation of digital soil maps.

Keywords: Soil Database Management; Quality Assurance; Quality Control; Data Curation; Spatial Accuracy Assessment

Building an enhanced soil information database for British Columbia

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Existing soil datasets provide knowledge and information to facilitate soil-related research projects, test theories, and develop models. Many of these datasets are preserved by governmental agencies, academics, and industry. Individually, each data system has its own data structure, data formats, workflow, and quality control system. Although there is an abundance of data available, the lack of integration between systems makes it difficult to fully explore and realize the potential of the information. In building the BC SOIL 2020 repository, we achieved two objectives. First, we developed a reproducible and scalable system to host observation and analytical data. Second, we designed a semi-automated workflow that takes raw soil data and redelivers it in a fully harmonized and integrated form and with a common data structure. The semi-automated workflow is carried out using the R statistical language, which can be expanded with additional data contributions and adapted for datasets beyond BC. Moreover, the BC SOIL 2020 repository provides a centralized storage system with standardized data descriptions and summaries. Furthermore, the non-harmonized and harmonized data will support current and future soil mapping and monitoring projects in BC at various scales and across diverse ecosystems and landscapes. This data management framework provides the foundation for a national soil database.

Keywords: Soil Database; BC SOIL 2020

BC Soil Survey Data Curation – Challenges and Successes

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This presentation will provide a reflection on the challenges and successes of curating Soil Survey Data for the Province of British Columbia. Soils data is needed across the natural resource ministries in British Columbia yet the responsibility for soil data curation is not clearly addressed in the mandate of any one ministry. Soil data is also needed across Federal, Provincial, Local and First Nations Governments. Yet intergovernmental coordination is driven by funding opportunities rarely focussed on soils or data curation. This provides challenges for resourcing data custodianship for soils information. Inter-ministry and inter-governmental collaborations and agreements have aided in provincial efforts to compile, convert, manage and provide access to soils data, as well as partnerships with NGOs and academic partners. The Province has stitched together a "data quilt" of BC Soil Survey polygons using scripted processes to harmonize data sourced from different mapping projects, multiple scales and different data structures. Project are brought together into a harmonized data model; then overlaps are eliminated to provide the best available data for a given area. Project footprints provide access to reports, project metadata and original project data. This allows more user friendly data access through applications like the Soils Information Finder Tool (SIFT). The harmonized data highlights where data gaps and deficiencies exist. The need for province wide detailed soil surveys is not filled by the quilted product. Too often data needs do not match data availability or the original survey purpose. In addition, soil surveys date from 1938 through 1990 and reflect data needs of the past. Of note is the lack of inclusion of First Nations data needs. Data requests, application usage, analysis challenges and biases in the data, highlight the need for improved soils data and data curation.

Keywords: CSSS-ASSW2022; Soil Survey, British Columbia; soil data curation; Soils Information Finder Tool; soils information system

Session 8

Advances in Material Synthesis for Soil Remediation

(Room: Prairie)

Hydrothermal carbonization produces more recalcitrant soil conditioners from a given feedstock than pyrolysis

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Hydrothermal carbonization and pyrolysis are techniques for valorizing waste biomass to high value products such as hydrochars and biochars, respectively, that can be used as adsorbents or soil conditioners to remediate contaminated soil and water. However, we do not fully understand how process parameters and feedstock types interactively affect the properties of derived hydrochars and biochars. Such effects were studied for hydrochars and biochars produced from four feedstocks at three temperatures typically used for both processes. Thermogravimetric analysis was performed to evaluate oxidative recalcitrance, a measure of the ability of a carbon-based material to resist abiotic and biotic degradation. Regardless of feedstock type, increasing production temperature decreased hydrochar and biochar yield and oxygen content due to loss of volatile matter. The yield decreased non-linearly as temperature increased for both conversion processes due to multi-step degradation of the feedstocks. Increasing production temperature increased elemental carbon content for lignocellulosic feedstock biochars but had little impact on the non-lignocellulosic counterpart due to high ash content that inhibited thermal degradation. Production temperature had little impact on oxidative recalcitrance of the biochars while increasing temperature increased that of the hydrochars regardless of feedstock type. For a given feedstock, mineral contents were higher for the biochars than the hydrochars due to mineral dissolution into the liquid phase of the hydrothermal carbonization process. The results showed that biomass conversion method, in addition to feedstock type and production temperature, plays an important role in the properties of derived chars, with hydrothermal carbonization producing more recalcitrant soil conditioners from a given feedstock than pyrolysis.

Keywords: Biochar; hydrochar; hydrothermal carbonization; oxidative recalcitrance; pyrolysis

Effect of Combining Biostimulation using Compost and Rhizoremediation using Grass and Dandelion for Bioremediating an Oil-contaminated Soil

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Contamination by oil is a common problem in many parts of the world. Because of the intrusive nature of the physico-chemical methods and being expensive to implemnt people have been looking for alternative methods for remediating oil contaminated soil. Bioremediation uses microbes for converting hydrocarbons into non-toxic compounds and less harmful to the environment. The oil contaminated fields normally lack nutrients needed for the microbes to perform their task. Biostimulation refers to the addition of nutrients to severely polluted sites to stimulate the existing bacteria to degrade the toxic contaminants. Adding compost to soil can provide the nutrients needed for bioremediation. Plant rhizosphere is a location of intense microbial activity because of the ample degradable substances exudated by the roots. Rhizoremediation is the term referring to the bioremediation carried out by the microbes in the rhizosphere. Dandelion is a weed that can grow in nutrient poor soil environment. The aim of this research is to determine the combined effect of biostimulation by compost and rhizoremediation of dandelion and grass on bioremediating of a hydrocarbon-contaminated soil.

A lab experiment was conducted with six treatments and three replicates. The soil was contaminated with motor oil at 3% on a dry mass basis. The treatments were control, compost, grass, dandelion, grass and compost, and dandelion and compost combined. The compost were added at 15% dry mass basis. The samples were collected at the end of every month for three months and thereafter at the end of one year. Oil contents of the soil samples were determined using a a Soxtec® extraction apparatus. Results showed that at the end of the three month only compost treatment was successful in removing oil by 41% compared to control. At the end of the year dandelion combined with compost gave the best results removing 83% of the oil followed by compost treatment at 66%. Rhizoremediation alone with grass and grass combined with compost did not remove oil. The results suggest that using compost is a good way of remediating oil contaminated soil. Adding dandelions to compost treated plots may enhance oil remediation but takes long time to show the results.

Keywords: Bioremediation, Biostmulation, Compost, Rhizoremediation

Biochar effectively remediates Cd contamination in acidic or coarse- and medium-textured soils: A global meta-analysis

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Soil cadmium (Cd) contamination is one of the most serious environmental problems on a global scale. Biochar has a great potential to reduce Cd bioavailability in contaminated soils even though biochar effects on soil Cd bioavailability has been inconsistent among different studies. Here, we used 802 paired observations from 84 peer-reviewed articles to evaluate the effect of biochar application on Cd bioavailability among different soil types and to elucidate the factors governing that effect. Biochar application reduced Cd bioavailability across various biochar and soil types, with reductions of 41.1% in acidic soils (pH < 6.5), 70% in urban/anthropogenically contaminated soils, and 42.3 and 30.2% in coarse- and medium-textured soils, respectively. However, biochar increased Cd bioavailability in fine-textured soils by 16.2%. For acidic soils, biochars produced from rice straw, pyrolyzed at 450-550 °C, with a heating rate of 1-5 °C min^{-1} and a residence time of <60 min were most effective; whereas in alkaline soils, biochars produced from sewage sludge, pyrolyzed at <350 °C, with a residence time >60 min were more effective in reducing Cd bioavailability. The effect of biochar on soil Cd bioavailability was mainly governed by the induced changes in soil pH and dissolved organic C, and by the surface area, ash content, H/C and abundance of O-containing functional groups of biochars. We conclude that biochar application to acidic or coarse- and medium-textured soils is effective for remediating Cd contamination, but application to fine-textured soils should be avoided.

Keywords: Biowaste; pyrolysis; soil contamination; remediation; toxic element

The feasibility of using municipal compost cover over Cu-Ni tailings as a growth medium for biofuel crops

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Utilization of residual organic materials as covers to mine tailings is an innovative form of recycling, employing one industry's waste to remediate that of another's, while providing a growth medium to produce biomass for biofuel production. The main objective of this project is to determine the feasibility of using a municipal compost cover over Cu-Ni tailings as a growth medium to grow biofuel crops over two growing seasons. A 0.5 ha demonstration plot was constructed on the low sulphur slimes at the Sudbury Integrated Nickel Operations Strathcona tailings facility in Onaping, Ontario. The plot was constructed with GroBark municipal compost over a woody compost construction material approximately 1 m thick. An agricultural reference site in Azilda, Ontario was established and monitored to provide a control comparison. Both sites were seeded with a short rotation dwarf corn (*Zea mays*), a northern variety of canola (*Brassica napus*), and two varieties of switchgrass (*Panicum virgatum*). Development of the vegetation, crop yield, uptake of metals and nutrients by plants, and compost/soil compaction were monitored at both the mine and agricultural reference site. Crops from the 1st field season showed deficiency symptoms and stunted growth early in the season, and biomass yield were very low in comparison to the agricultural reference. In the 2nd field season, a modified experimental design with variable fertilizer rates (134, 203, and 518 kg ha^{-1}) and compaction level treatments was implemented to alleviate the low inherent fertility and subsoil compaction of the compost material, being suspected to have impeded crop growth suggested from the 1st field season. Crops grown on the lower nutrient application treatment displayed initial nitrogen deficiencies, which were corrected with mid-season fertilizer applications. While alleviating compaction can improve crop growth, biomass yields were generally similar between the compaction treatments but different between the fertilizer treatments, indicating that compost fertility was the main cause of reduced growth in the 1st field season. With the addition of conventional agricultural fertilizers at appropriate rates, the development of mature agronomic crops on the municipal cover on the Cu-Ni tailings site was shown to be successful.

Keywords: Mine tailings, Remediation, Biofuels, Muncipial Compost, Fertilizer

Poster Session

(Room: Wild Rose)

The effectiveness of plant material-based amendment with differing particle sizes in acid soil reclamation

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There is a growing concern that acidification of arable soil is threatening efforts to increase crop production. This is further exacerbated by the scarcity of arable land, which means that farmers inevitably have to rely on acidic arable soil for cultivation. Due to the low pH of acid soil (pH < 5.5), major nutrient such as phosphorus (P) becomes unavailable and form an important limiting factor for crop growth and production. As a cost-effective and environmentally-friendly alternative to liming, the incorporation of plant materials such as crop residue or underutilized wild species has received increasing attention in acid soil reclamation for their effectiveness in increasing soil pH and P availability. However, the impact of differing particle sizes of plant materials on pH and P of acid soil is poorly characterized. Therefore, this work will focus on the effects of plant materials differing in particle sizes towards pH, available phosphorus (Bray-P) and inorganic phosphorus of arable acid soil.

Keywords: Amelioration of soil acidity, Bray-P, inorganic phosphorus, soil pH, plant material

Mobility of arsenic, selenium and vanadium from manured and non-manured fields during snowmelt flooding after addition of soil amendments

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Application of soil amendments to agricultural soils could change geochemical properties of soils altering the mobility of As, Se and V. Mobility of As, Se and V with snowmelt flooding due to the addition of amendments in the previous fall season were rarely investigated. This experiment was conducted (a) to compare loadings of As, Se and V to spring snowmelt from manured and unmanured soils and (b) to compare loadings of As, Se and V in snowmelt of unamended, gypsum-, $MgSO_4$- and alum-amended soils. In the fall of 2020, field plots were laid out in a randomized complete block design in two agricultural fields (manured and non-manured), and amendments were surface applied at a rate of 2.5 Mg ha^{-1}. Runoff boxes were installed at the edge of plots in the fall of 2020 to collect snow during the winter. In the spring of 2021, snowmelt in each box was pumped out, and volume was recorded until the end of the snowmelt period. The As, Se and V concentrations of sampled snowmelt were measured. The measured Se and V loadings in the manured field were higher than in the non-manured field while As showed no difference. In manured soil, fall amendment with $MgSO_4$ reduced Se, V and As loadings in snowmelt floodwater by 75%, 44% and 40%, respectively, compared to unamended. In non-manured soil, the amendment effect was non-significant. Our results with one season showed that the effect of amendments on As, V and Se loadings varied depending on the amendment, metal, and soil conditions.

Keywords: Vanadium loading; snowmelt flooding; soil amendments

Oxidative stress response of Eisenia fetida after exposure to copper in soil amended with residual fertilizing materials

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Copper is well known for its toxicity to earthworms based on dose-response at the organismal level (i.e., survival, growth, reproduction) and metabolic activities such as respiration. Since copper toxicity is associated with an excess of reactive oxygen species in the affected organisms, the oxidative stress response should be a sensitive indicator of toxicity. The purpose of this work is to understand the oxidative stress of Eisenia fetida after exposure to copper in soil amended with residual fertilizing materials. It is hypothesized that with increasing copper concentrations, the earthworms will undergo oxidative stress resulting from the imbalance between reactive oxygen species (ROS) and antioxidants enzymes, superoxide dismutase (SOD) and catalyst (CAT), because of the accumulation of copper in the metal-binding protein metallothionein. The experimental procedure involves performing survival, growth, and reproduction experiments conducted according to OECD guidelines, and by quantifying the degree of DNA damage, measuring ROS levels, SOD and CAT activities, and by conducting LC/MS analysis on metabolite biomarkers in earthworms' coelomic fluid. The bioassays will be conducted on earthworms exposed to copper in soil amended with papermill biosolids and sludge incinerated ash. We expect that the oxidative stress response will be a robust indicator of contamination, and that this approach will account for the presence of multiple contaminants, which is a limitation in traditional dose-exposure-response studies.

Keywords: Residual fertilizing materials, OECD bioassays; Oxidative stress; DNA damage; Metabolite biomarkers

Influence of Concentration and Speciation of Trace Elements in Soil Solution on Plant Uptake and Accumulation by *Hordeum Jubatum* L.

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Trace elements (TEs) enter plants via two main pathways: root uptake from the soil solution and foliar uptake of material deposited on leaf surfaces. When determining the impact of soil related factors on plant uptake, it is important to account for or eliminate potential uptake via atmospheric deposition. Our study will assess the relationship between plant uptake and TE concentration and speciation in soil solution, in the absence of atmospheric deposition. A pot experiment was designed using soils collected from Lake Miwasin, a demonstration pit lake developed to demonstrate the treatment of tailings, and the re-integration of pit lakes into the surrounding environment. Foxtail Barley (*Hordeum Jubatum* L.) is a naturally abundant plant on the Lake Miwasin landscape and was selected as the indicator plant. Seeds were harvested from plants grown at Lake Miwasin, and the plants were grown inside laminar flow, Class 100, metal-free clean air cabinets. The soils were spiked with three elements (V, Ni and Mo), chosen for their environmental importance and enrichment in bitumen. At the beginning of the experiment, salt solutions were mixed with samples of surface soil to achieve the following soil concentrations: V (15 and 75 mg/kg), Ni (5 and 25 mg/kg), and Mo (1 and 5 mg/kg). The above ground plant biomass was harvested using ceramic scissors, and the soil solutions were collected using silicon carbide (SiC) lysimeters (2 μm pore size) that were modified and specially cleaned to facilitate trace-level measurements, in the metal-free, ultraclean SWAMP lab. These lysimeters provide excellent blank values for most of the TEs of environmental interest including V, Ni and Mo. The TE concentrations in digested plant samples, soils and soil solutions will be analyzed using ICP-MS, and the distribution of TEs amongst major colloidal forms will be analyzed using AF4-ICPMS.

Keywords: Soil solution, Root uptake, SiC lysimeters, Colloids, Bituminous Sands

Impact of Burial Duration on Nutrient Supply to Plant Root Simulator (PRS™) Probes

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Plant Root Simulator (PRS™) probes are ion-exchange membranes in a plastic support that are used globally to monitor soil nutrients *in situ*. A key decision is the duration of probe burial. Temporal patterns of ion adsorption from laboratory and field studies were compared to patterns based on soil processes of diffusion, ion-exchange and mineralization. The duration required for equilibrium to be achieved between ions adsorbed to ion-exchange membranes and those in soil solution varied from less than one day to weeks, depending on ion type and soil conditions. Changes in soil conditions induce changes in ion adsorption on PRS probes when soils were sufficiently moist for ions to diffuse and exchange. In most soils, a burial period of one to four weeks is sufficient to provide a stable measurement that reflects the capacity of a soil to supply nutrients, but shorter or longer periods may be required, depending on objectives and soil conditions.

Keywords: ion exchange membrane; *in situ* nutrient monitoring, moisture

Modelling Nitrogen Release Patterns To Determine If Environmentally Smart Nitrogen Can Increase Nitrogen Use Efficiency

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The use of synthetic nitrogen fertilizer maintains high crop yields, but nitrogen use efficiency (NUE) remains low, resulting in environmental degradation and economic losses. Environmentally Smart Nitrogen (ESN), a polymer-coated urea (44-0-0), releases nitrogen more gradually than conventional urea, potentially allowing for better synchronization between available nitrogen and crop nitrogen uptake, thereby increasing NUE. Properly validated computer models can quantify nitrogen uptake and losses that are difficult to measure in field experiments and could be used to determine the effectiveness of ESN. The potential of ESN to increase NUE depends upon the nitrogen release patterns; therefore, accurate simulation of nitrogen release is necessary to quantify nitrogen uptake and losses. The objective of this study was to validate model parameters for nitrogen release in the process-based model "*ecosys*". An experimental laboratory study was simulated in *ecosys* to validate model parameters for nitrogen release by comparing modelled and measured nitrogen release patterns. Modelled and measured results had a lag in nitrogen release for the ESN, and nitrogen release increased with increasing temperature and moisture. If initial crop nitrogen uptake is low, a delay in the nitrogen release and subsequent hydrolysis could help avoid nitrogen losses. Validated model parameters will be applied in field simulations to determine how different fertilizer formulations, rates, and irrigation affect nitrogen uptake and losses in Southern Alberta. This project could provide information on effective nitrogen management strategies for policymakers and producers.

Keywords: CSSS-ASSW2022; Soil science; Edmonton; Modelling; Nitrogen use efficiency

Machine Learning-Process Modelling Hybrid: A Novel Approach in Predicting Changes in Agricultural Soil Organic Carbon

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Recent rapid advancement of hyper-sensed data and machine learning (ML) has opened up unprecedented opportunities for predicting spatial and temporal variations in agricultural soil organic carbon. ML models are highly capable of deciphering complex patterns in multi-dimensional large datasets. However, lack of large agricultural soil organic carbon training dataset featuring adequate climatic and management effects on carbon stock changes reduces ML models' predictive capacity. Mechanistic process models, once robustly validated against field datasets, can fill some of the gaps by simulating these effects and hence by generating synthetic data for training ML models over large temporal and spatial scales. In this study, I summarize the strength and uncertainties of using ML models in predicting spatial and temporal variations in agricultural soil carbon stocks in both tropical and temperate climate zones by reviewing published scientific literature. I then propose a conceptual model on how the shortfalls of the ML models can be overcome by using hybrid modelling of ML and process-models that simulate soil and vegetation processes. This review outcome will help formulate future studies in predicting changes in soil carbon that has important implications for farmers and policy makers in supporting and promoting climate smart agricultural soil management practices.

Keywords: Machine Learning; process-model; soil carbon; climate smart agriculture

Improving the annual crops mapping accuracy using feature level based fusion of Surface biophysical properties

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Preparing up-to-date land crop maps is one of the most important study directions in achieving food security and sustainable development in agriculture. Therefore, the aim of this study was to evaluate the impact of surface biophysical properties including surface greenness, wetness, imperviousness and reflectivity and feature level based fusion of these properties on the accuracy of annual crops mapping. For this purpose, multi-temporal images of Sentinel 2 and an actual land crop maps prepared by Agriculture and Agri-Food Canada (AAFC) in 2019 were used for 3 site tests in Ontario, Canada. First, surface biophysical properties maps were prepared based on spectral indices including Normalized Difference Vegetation Index (NDVI), Index-based Built-up Index (IBI), Wetness, Albedo, and Brightness for different dates. Then, different datasets including single surface properties and a combination of several surface properties were generated. In the second step, land crop maps were prepared for each dataset based on the Maximum Likelihood Classification (MLC). Finally, accuracy of the land crop maps obtained from each of the datasets was evaluated based on omission and commission errors and overall accuracy metrics. The results showed that the mean temporal variation of NDVI, Wetness and IBI land crop classes was higher than Albedo and Brightness. Among agricultural products, the highest and lowest classification errors were related to wheat and soybeans, respectively. The average overall accuracy of land crop maps obtained from datasets including NDVI, IBI, Wetness, Albedo and Brightness were 66, 68, 63, 60 and 57 %, respectively, which by combining the surface biophysical properties, the overall accuracy of land crop maps increased to 80%. The results of this study indicate that the feature level based fusion of surface biophysical properties the increases the accuracy of annual crops mapping.

Keywords: Crops mapping, surface biophysical properties, fusion, accuracy

Bioremediation of Hydrocarbon-contaminated soil using Various Organic Soil Amedments under Flooded Condition

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Soil contamination by fossil fuel due to anthropogenic activities is a world-wide issue. Bioremediation where contaminant oil is removed using microorganisms is a green technology alternative to using expensive physicochemical methods. Since many of the contaminated sites also are poor in nutrients and microbial biomass, organic amendments can be added to enhance the remediation treatment. Some of these sites also have drainage issues which can cause anaerobic conditions that can reduce contaminant removal. This research study aims at using various organic amendments under flooded conditions to determine their effectiveness in contaminant removal using bioremediation.

An outdoor pot experiment was conducted with five organic amendments as treatments and three replicates. The pots were kept under flooded conditions creating anaerobic conditions most of the time due to heavy rainfall in the summer. Oil not remediated in the soil was measured 60 - 90 days using a Soxtec apparatus. Organic amendment addition in general enhanced removal of oil from 10% oil contaminated soil. When the amendments were balanced on a volume basis the oil removal rates were in the order of vermicompost > manure > grass > sludge > biochar > control. When equal amounts of organic amendments were added to the soil, all the organic amendments helped removal of oil but were not significantly different in their rates. Many contaminated sites have drainage issues and flooded conditions are common occurrence in these areas. Draining these locations for aerobic bioremediation can be a costly exercise. Bioremediation under anaerobic conditions seem an alternative option in place of expensive aerobic bioremediation exercise under flooded conditions.

Keywords: Bioremediation, Organic Amendments, Anaerobic Conditions

Development of soft tailings capping technology – first step towards creating stable and sustainable boreal landscapes

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The production of synthetic crude oil generates large volumes of fluid tailings comprised of process water, sand, silt and clay along with residual bitumen, diluent and other chemical constituents remaining from the extraction process. Given the nature and scale of tailings generated by oil sands mine operations, returning soft tailings deposits back to an ecosystem of equivalent land capability is a complex challenge faced by all operators in the Athabasca oil sands region. This three-year meso-scale greenhouse study used 55-gallon columns to evaluate the survival and growth of boreal upland and wetland communities on centrifuge (CF), co-mix (CM) and thickened tailings (TT) under various capping treatments. Treatments with CF and TT included 0 cm, 10 cm and 30 cm peat-mineral mix (PMM) reclamation cap. The CM tailings included treatments with overburden or till in addition to PMM. After three growing seasons, survival was high for most species amongst all tailings types with a reclamation cap compared to those without. The vegetative cover of forbs and graminoid species, height incremental growth of woody species and root development were greater in treatments with 30 cm PMM. The same trend was observed with increasing till depth for the CM tailings. Of the species planted in CF tailings treatments, *Scirpus microcarpus* and *Salix bebbiana* were less negatively impacted by no reclamation cap (0 cm PMM) in contrast to *Betula pumila* and *Rumex occidentalis*. In CM tailings, *Carex aquatilis* and *Triglochin maritima* had relatively greater vegetative cover and survival compared to *Beckmannia syzigachne* and *S. bebbiana*. We saw high survival of *C. aquatilis*, *S. bebbiana*, *T. maritima* and *Rumex salicifolius* in the TT with no reclamation cap (0 cm PMM), albeit the plants were much smaller in size. Survival of *Elymus trachycaulus* ssp. *trachycaulus* remained high in the 0 cm PMM treatment with similar vegetative cover among all TT treatments, while *Pinus banksiana*, *Cornus stolonifera*, and *Populus tremuloides* survival and growth was limited in no cap (0 cm PMM) treatment. The constituents that may impact plant growth include Na, B and naphthenic acids; monitoring the change of those constituents in tailings, expressed water and plant tissue will be highlighted in this presentation.

Keywords: Oil Sands, Tailings, Reclamation

Spatial distribution of selected geochemical properties in anthropogenic soils on Aldermac site, Quebec, Canada

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The former Aldermac mine located 25 km west of Rouyn-Noranda in Abitibi-Témiscamingue (Quebec, Canada), exploited from1932-to 1943 a volcanogenic sulphide deposit (copper, zinc, gold and silver). Mining operations discharged up to 1.5 Mt of acidic tailings over an area of 76 ha and consequently highly acidic mine drainage is still occurring on site, causing the leaching of heavy metals and other toxic contaminates into the surrounding ecosystem. The objective of this study is to assess the patterns of spatial variability of major geochemical properties in the southwest region (SW) of the Aldermac site. The acquired knowledge can help in planning and realizing phytoremediation works. A total of 173 anthropogenic mine soil (MS) samples were collected from the surface (0–10 cm) over the entire study area (approximately 1 ha) in September 2020. Geochemical parameter maps were obtained by ordinary kriging interpolation approach. The geostatistical analysis highlighted the heterogeneity of the spatial distribution of pH values and total copper (Cu), zinc (Zn) and sulphur (S) contents. Kriging maps allowed the identification of three geographic zones with distinct geochemical properties: E1 (west), E2 (center) and E3 (east). The pH values of MS increased in the following order: E1 (2.83) < E2 (3.07) < E3 (3.62). The average concentrations (mg/kg) of total Cu, Zn and S decreased in the following order: (i) S (36512.3) > Cu (616.92) > Zn (304.42) for E1; (ii) S (7855.87) > Cu (182.12) > Zn (51.69) for E2; (iii) S (1045.15) > Cu (29.51) > Zn (28.38) for E3. Heterogeneity is noteworthy in MS, and pH and Cu, Zn and S, in particular, exhibit high spatial variability. These results could be attributed to : (i) the way in which the layers of mine tailings with different properties were deposited on land at the mine site during different periods; and (ii) the long-term effect of the environmental, geographical and pedoclimatic conditions on the speciation of heavy metals in the study area.

Keywords: Sulfide mine tailing; Anthropogenic mine soil; Zinc, Copper, Sulphur

Amelioration of two acidic soils using chicken eggshell waste

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In the context of sustainable development, chicken eggshell wastes (ESW) may offer opportunities for valorization beyond their traditional disposal. From the viewpoint of accelerating stability of heavy metals in acidic degraded lands and improving plant growth, pH of the sulphide-rich mine tailings, anthropogenic soils containing sulphide mine tailing (AMS) and organic soils (OS) should be controlled. In this study, two sets of liming experiments using three types of ground ESW were conducted to evaluate the effectiveness of ESW in neutralizing soil acidity and maintaining soil pH at an acceptable level for the cultivation of vegetables or energy crops. The soils are: (i) surface layers of OS (mean pH 4.99) from a vegetable farmland site (Sherrington, Quebec) and (ii) AMS (mean pH 2.67) from the abandoned Aldermac mine site (Rouyn-Noranda, Quebec). The ESW rates (Q) are: 0; 0.5 g; 1.0 g; 2.0 g and 4.0 g ESW/5 g of soil (OS or AMS). Three ESW finely ground are used : ESW dried at 60°C and finely ground (ESW1), EWS1 calcined at 500°C for 24 hours (ESW2) and ESW1 calcined at 700°C for 6 hours (ESW3). The pH values of aqueous soil suspensions are measured at several reaction times (t) varying from 2 hours to 1080 hours. In general, the mean values of $pH_{suspension}$ increased with t and Q. At the end of experiment (t = 1080 hours), the pH values of OS amended with the highest rate of ESW increased from 5.79 (without amendment) to 6.31 for ESW1, 6.69 for ESW2, and 6.75 (6.73) for ESW3. At t = 1080 h, the pH values of AMS amended with the highest rate of ESW increased in the following order: Without ESW (2.99) < ESW1 (6.75) < ESW2 (6.97) < ESW3 (7.05). Under our experimental conditions, calcined amendments neutralize more efficiently soil acidity and provided more soluble Ca to the aqueous soil suspensions than non-calcined ESW in the long term. ESW are acid-neutralizing materials and could be used as a lime amendment for the amelioration of acidic soils.

Keywords: Bio-waste; Organic soil; Sulfide mine tailing; Anthropogenic mine soil

Combined application of lime and organic amendment to ameliorate exposed soils for vegetation establishment

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Exposing C horizon soil (parent material) to the surface and subsequent vegetation establishment is challenging. The C horizon generally lacks many of the key properties of the soil layers above it including organic matter, and nitrogen (a key macronutrient) and the overall recovery of these exposed soils could take several decades due in part as a result of exposure of acid- or alkaline-reactive geologic materials, or leaching of organic acids that could limit microbial activity, potentially compromising plant growth and establishment. This field study evaluated whether liming alone or in combination with an organic amendment can ameliorate acidic soils and improve the capacity of the soil to support native vegetation. Three commercially available formulations of agricultural lime (Supercal™, Granulime™ and N-Rich™), organic amendment (alfalfa pellets) and lime plus organic amendment combination (Supercal ™ + alfalfa pellets) were applied in 8m x 15 m strips, divided in two application rates (low: 5,000 kg ha^{-1} and high:11,000 kg ha^{-1}) and native forbs seedlings -*Aster conspcuous* (smooth aster) and *Solidago canadensis* (goldenrod), and woody seedlings -*Betula papyrifera* (paper birch, standard propagation and nutrient loaded seedling with alfalfa pellets comprising 20% of total planting container cavity volume), were planted in year one, while seedlings of *Alnus viridis* (green alder) were planted in the second year. The entire study area was also seeded with 50 kg ha^{-1} of *Elymus trachycaulum* (slender wheatgrass).

Preliminary results after the first growing season found no measurable change in bulk density, pH, electrical conductivity and all measured soil chemical parameters with liming and/or organic amendment incorporation in soil. We expect this was due to the method of incorporation as the amendments were surface applied and it is expected to take more than one growing season to see the effects of amendment.

Key vegetation related findings after two growing seasons include **(a)** total graminoid coverage (natural ingress and seeded slender wheatgrass) and was highest in Supercal™ plus alfalfa or alfalfa-alonetreatment, **(b)** planted native forb survival was higher in high granulime treatments compared with other lime or alfalfa treatments, **(c)** planted native forb cover was highest in Supercal plus alfalfa or alfalfa treatments compared with other lime treatments, **(d)** survival of paper birch (conventional propagated or nutrient loaded) was highest in Supercal™ or Granulime™ treatments, and **(e)** total height and cover of paper birch in year 2 was highest in Supercal plus alfalfa or alfalfa treatments compared to other tested lime applications. Green alder was established one year following the other species, based on year 1 findings it appears to be positively affected by Supercal treatment. In summary – preliminary findings from this ongoing trial suggest the combined incorporation of agricultural lime and alfalfa pellets or alfalfa pellets alone was most effective in improving the growth of planted woody and native forbs species after two growing seasons. Interestingly, nutrient loaded seedlings with alfalfa pellets, also appear better suited to overcome the difficult site conditions of this study area as they grew taller with higher cover compared to conventionally propagated seedlings.

Keywords: Exposed soil; Liming; Amendment; Forbs; Woody

Management Practices For Creating A "Sun-Grown" Organic Amendments In Post-Mining Landscapes

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Coal-mining companies in Alberta are legally obligated to reclaim areas disturbed by resource extraction activities and their urgency to act has become more imperative following the announcement made by the government to phase-out coal by 2030. However, reforestation challenges in these mines are well known and include poor soil quality due to lack of topsoil, aggressive competition from agronomic weeds, and slow establishment of desired native species. The lack of information on best practices to use, combined with the exigency to act is forming a practice where a single treatment is prescribed over a large area with the potential for significant unforeseen negative reclamation outcomes. This study will design an integrated set of best management practices (BMPs), and in the process provide a basis for quantifying the value of this technique for concurrently facilitating soil building, erosion control, and weed management in former mine sites. First, we will test the efficacy of multispecies perennial native grasses, a nitrogen-fixing annual species, and perennial native forbs for soil quality improvement and low-input weed control. Second, we will evaluate a combination of trees and herbaceous species (grasses and forbs) to further increase biomass production and restore biological diversity. The following questions will be specifically evaluated:

- Can we blanket these fresh reclamation areas with a graminoid-dominated cover crop to both reduce initial erosion concerns as well as manage weedy vegetation?
- Do these cover crops facilitate improved soil quality through reduced soil erosion and increases in soil carbon? And does this translate into improved rates of desirable tree growth?
- Does the incorporation of native forbs aid in breaking up the graminoid herbaceous layer and promote the establishment of other desirable species?

We are currently testing these two BMPs at two field studies (0.5–2 ha each) at two different coal mines in central Alberta (Genesee and SunHills). The benefits of this project should be simple and practical BMPs for use by industry practitioners to facilitate faster native plant establishment on industrially disturbed landscapes. Here, we present the rationale of our study design, project setup, and preliminary results after the first growing season.

A comparison of water evaporation rates from ponds, peatlands and soil pores

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The role of tile drainage in streamflow is a small-scale analysis from field to watershed. The major components of the terrestrial water cycle are the transpiration of water from vegetation and evaporation of molecules from surface water collection. While transpiration from peatlands and surface water bodies is relatively easy to estimate, the residence time of water in soil is highly variable depending on soil properties and landscape attributes. Tile drainage results in more surface water becoming ground water, and I wonder about the overall change in atmospheric water recycling time. The subsurface soil influences on soil water infiltration and retention are not considered in the equation. The greater the soil water infiltration and soil water holding capacity, the greater the evapotranspiration from the crop will be along with lower surface water collection. In order to address the significance of this phenomenon, I will use existing data from literature to present comparative scenarios of water ponds, peatlands and good agriculture soils to demonstrate how the change in vegetation and land management can affect the atmospheric and ground water cycles. The computations will be compared to published results from current hydrological models. While tile drainage was initiated to remove excess water, the question now is; “can tile drainage also improve the time stability of atmospheric moisture”?

Keywords: Soil water storage; evapotranspiration; soil pores; water ponding; peatlands

Rebuilding the Fertility and Productivity of Eroded Knoll Soils in South-Central Saskatchewan: Second-Year Results

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Historical erosion (water, wind, and tillage) of upper-slope convex knolls within hummocky fields have typically resulted in native fertile topsoil translocation to lower-slope positions, leaving thin soils remaining at these higher landscape positions with low organic matter content and poor fertility. Few studies have examined the ability of fertilization and amendment strategies to rebuild phosphorus and micronutrient fertility on eroded knolls. The objective of this study was to test the efficacy of numerous conventional and unconventional approaches to build and reclaim the soil fertility and productivity of these upper slope areas of Saskatchewan farm fields. In the spring of 2020, a three-year rotational field study was established to evaluate the productivity of spring wheat, field pea, and canola growing on two eroded knoll locations in south-central Saskatchewan with and without nine different soil fertility treatments: side-banded mono-ammonium phosphate; side-banded zinc sulfate; side-banded copper sulfate; side-banded $ZnSO_4$ + $CuSO_4$; side banded MAP + $ZnSO_4$ + $CuSO_4$; broadcast and incorporated composted solid cattle manure; solid cattle manure + side-banded $ZnSO_4$ + $CuSO_4$; side-banded Zn-containing char; and mechanically transplanting eroded topsoil from an adjacent depressional area back onto the knoll. For the second consecutive year, despite dry conditions that severely inhibited crop growth, restoring eroded topsoil back onto the knoll most effectively increased crop production in our study. The highest canola (grain, straw, and total biomass) and field pea (straw and total biomass) yields following topsoil replacement was attributed to its more favourable edaphic characteristics: organic matter rich; greater water holding capacity; better structure and lower bulk density; faster hydraulic conductivity; along with superior macro and micronutrient fertility compared with the existing thin calcareous soils with a strong P, Cu, and Zn fixation capacity. Residual treatment impacts on crop nutrient uptake and growth will be evaluated in 2022.

Keywords: Canola; Erosion; Field pea; Knoll; Topsoil

Larger root surface area increases plant nitrogen uptake in nitrogen-deficient soil

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Nitrogen (N) uptake by corn depends upon a root system with numerous fine roots that extend into soil pore water containing ammonium (NH_4^+) and nitrate (NO_3^-) ions. Applying a biostimulant with auxin-like activity to corn seedlings is expected to increase the surface area of fine roots, which will enhance uptake of N ions in N-deficient soils. Corn was grown with the recommended N fertilizer rate and less than recommended N fertilizer rate in growth chambers and in the field in southern Quebec. The growth chamber experiment was designed as a factorial with biostimulant application × abiotic stress (i.e., nitrogen and water) treatments, with 5 replicates per treatment. Corn seed was soaked in tap water (control) or biostimulant solution, then grown in pots with N fertilizer rates equivalent to 170 kg N ha^{-1} or 85 kg N ha^{-1} (N deficiency) at 26% or 20% (low water) gravimetric water content. The field experiment had biostimulant application × N stress treatments. The N stress was imposed at the seeding and V6 stage, when N fertilizer rates of 120 kg N ha^{-1} (recommended), 96 kg N ha^{-1} (20% lower than recommended), and 72 kg ha^{-1} (40% lower than recommended) were banded and side-dressed in four replicated blocks. In the growth chamber experiment, there was 50% more N accumulation in biostimulant-treated corn under N-deficient and low water conditions, possibly because a larger surface area of fine roots (<1 mm diameter) had greater access to N ions under low soil water availability. Root surface area explained about 22% of the variation in the corn shoot N content. In the field experiment, total root surface area and fine root surface area were greater in the biostimulant-treated corn in the early vegetative stages (V3 to V5). Greater root surface area did not increase the corn shoot N content, possibly because there was abundant nitrate (30 mg NO_3^--N kg-1 soil) during the early growth stage. Since fine root surface area is related to N uptake by corn experiencing water stress and N limitation, it may be an interesting root trait for corn yield improvement.

Keywords: Nitrogen absorption, Nitrogen limitation, Reduced fertilization, Root morphology, Nitrogen use efficiency

Impact of Including Brassicaceae Oilseed Crops on The Performance of Pulse and Wheat-Based Cropping Systems in Canadian Prairies

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Re-designing agricultural practices are vital to building economically and environmentally sustainable agricultural systems. Incorporation of alternative crops such as pulse and oilseed crops into cropping systems have many on-farm agronomic benefits in the semi-arid prairies. The benefits of pulse crops in cereal-based cropping systems are well-known and mainly attributed to the symbiotic nitrogen fixation. Brassica oilseed crops, such as canola are the cornerstone of Canadian prairie agriculture. However, other specialty brassica crops like mustards and camolina have the potential for expansion in the Canadian economy. The allelopathy effect of brassica crops are mainly due to glucosinolate, a secondary plant metabolite. Glucosinolates have the potential to prevent bacterial, fungal and insect infestation, and nematode invasion, through bio-fumigation. By understanding the role that each crop species plays or could play in a crop rotation, there is a potential to enhance its 'usefulness' in a rotation. One unanswered question is how brassica crops impact biological nitrogen fixation (BNF) in subsequent pulse crops and the overall performance of wheat-based cropping systems. Therefore, a field study and two controlled environment studies are being carried out to fill the knowledge gap on how the Brassicaceae oilseed crops effect BNF capacity of succeeding pulse crops, soil quality and crop productivity in cereal-based cropping systems under different growing environments in semi-arid Canadian prairies. Three major crop groups used in this study are: i.) cereal - spring wheat [*Triticum aestivum* (L.)], ii.) brassica oilseed - Argentine canola (*Brassica napus* L.), camelina [*Camelina staiva* (L.) Crantz], industrial mustard [*Brassica carinata* (A.) Braun], oriental mustard (*Brassica juncea* L.) and yellow mustard (*Sinapis alba* L.), and iii.) pulse crops - yellow pea (*Pisum sativum* L.) and red lentil (*Lens culinaris* Medikus). Development of comprehensive knowledge in selecting the most appropriate oilseed crop species to include in a pulse and wheat-based rotation will result in cost-effective sustainable production under different growing environments.

Keywords: crop rotation, bio-fumigation, biological nitrogen fixation, soil quality, crop productivity

Fall Nitrification Inhibition of Anhydrous Ammonia in Manitoba

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Fall-applied anhydrous ammonia (AA) is prone to nitrification losses in the soil by the time of next growing season. Farmers often apply higher fall nitrogen (N) rates than spring to compensate N losses. In 2020, a preliminary trial was set up on a commercial field at the Silverwinds Farms to determine whether nitrification inhibitors (NIs) with fall-applied AA can slow down the conversion of ammonium (NH_4^+) to nitrate (NO_3^-). Stabilizing fall-applied AA in NH_4^+ form may prevent N losses and cut short the higher fall N rate requirements. Nitrogen (82-0-0) was applied on September 30, at 110 lb N ac^{-1} with Centuro®, N-Serve®, and without any nitrification inhibitor (NH_3 110N), while treatments without N addition as control and with full N rate at 140 lb N ac^{-1} (NH_3 140N) were also included. Extractable NH_4^+ and NO_3^- concentrations (mg N kg^{-1} dry soil) were obtained for the soil sampled (0-12” on band rows) in late fall, early, and late spring. We found that the use of NIs allowed more inorganic N and NH_4^+ persistence, and Centuro tended to show better inhibition than N-Serve. We continued following a similar setup at two different sites this fall to get more detailed patterns.

Keywords: Nitrification inhibitors; Fall nitrogen; Anhydrous ammonia; Ammonium; Nitrate; Manitoba

Variations in Crop Productivity across Western Canadian Wheat Classes and Fertilizer Formulations

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The uptake of nitrogen-based fertilizers in Canadian cereal crops are usually only 50-60%, with losses from spring applied fertilizers ranging from 10 to 40%. Improvements in nitrogen uptake and temporal availability of fertilizers can be achieved when paired with nitrogen stabilizers such as nitrification (DMPSA) or urease (NBPT) inhibitors. Further enhancement of nitrogen-use-efficiency may be accomplished through the incorporation of nitrogen stabilizers with alternative nitrogen-based fertilizer formulations into fertilization regimes. Available alternative nitrogen-based fertilizers such as, calcium ammonium nitrate (CAN) and ammonium sulphate nitrate (ASN), include both nitrate and ammonium species of nitrogen and may offer a suitable substitute to urea. Field trial comparisons at Barrhead and Lethbridge, Alberta in 2017 and 2018 were undertaken to compare nitrogen stabilizers coupled with ASN and CAN against urea fertilizer in multiple wheat classes. The efficacy of the nitrogen stabilizers was heavily influenced by wheat class and location, where the crop productivity response of either DMPSA or NBPT with urea was not significantly different compared to untreated urea. Furthermore, when DMPSA was paired with ASN, it had a net negative effect on crop productivity. However, when DMPSA was added to CAN, a consistent 1 to 2% higher crop yield was observed over untreated urea and constituted the highest yielding treatment at both sites. Untreated ASN and CAN enhanced soil nitrogen uptake when compared with untreated urea, leading to marginal improvements in crop productivity at Lethbridge over urea. Significant differences in crop yield and nitrogen use-efficiency were observed between wheat classes and amongst nitrogen fertilizer rates.

Keywords: Wheat; Fertilizer, Nitrogen use-efficiency; Inhibitor; Nitrification

Revising the Crop Nutrient Uptake and Removal Guidelines for Western Canada

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Yield-based crop nutrient uptake and removal data are critical in making nutrient application rate decisions to achieve a target crop yield of major crops within the Canadian prairies. However, for many years, agronomists have used the Canadian Fertilizer Institute (CFI) Nutrient Uptake and Removal guidelines for estimating fertilizer requirements to match and balance crop requirements with nutrient removal. Despite the CFI guidelines being revised and updated over the years, there is the need to revise them further to reflect current high-yielding crop varieties, fertilizer application rates, and crop and soil management practices. Additionally, there is limited data on micronutrient uptake and removal. Our project aims to revise crop macro- and micronutrient uptake and removal guidelines for the major crops grown in western Canada, based on seed and biomass samples collected from commercial fields across Alberta, Saskatchewan, and Manitoba from 2020–2022 growing seasons. Preliminary nutrient removal values from 2020 seed samples show extreme variability in some crops and less in others. The pattern of nutrient removal in 2020 may reflect the number of available varieties for the different crops. Final nutrient uptake and removal values will be based on seed and biomass yields over three growing seasons (2020–2022).

Keywords: crop nutrient uptake, nutrient removal, soil nutrient supply, Canadian prairies, crop yield

Effects of increasing soil pH to near-neutral using lime on phosphorus saturation index and water extractable phosphorus

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Soil pH influences phosphorus (P) dynamics and agri-environmental indicators used to monitor the risk of P loss from agricultural soils. We studied the effects of liming with calcium carbonate ($CaCO_3$) to increase soil pH from acidic to near-neutral on i) degree of P saturation (DPS), the P saturation index (PSI), Mehlich-3 P (PM3) and water extractable P (Pw). Soils collected from a long-term highbush blueberry experiment were incubated at 22.5 °C for 93 days after $CaCO_3$ amendment to increase initial pH values from 4.1 to 4.8, 5.5 to 6 and from 5.8 to 6.5. We observed a decrease of PM3 of 6, 8 and 10% respectively for each of the $CaCO_3$ amended soils. The PM3 were classed as very high P with critical DPS > 25%, indicating increased risk of P loss with runoff. For soils with initial pH values of 5.8, Pw was 3.65 mg kg^{-1} which is in line with critical DPS > 25%, but decreased to 2.74 mg kg^{-1} with $CaCO_3$. In contrast, $CaCO_3$ decreased Pw from 1.17 to 0.86 and 1.47 to 1.39 mg kg^{-1} for soils with initial pH values of 4.1 and 5.5, respectively, but for soils with initial pH 4.8, $CaCO_3$ increased Pw from 1.00 to 1.21, reflecting low PSI (5.2 to 6.1%). For soils with initial pH 5.5, high Mehlich-3 Al indicated high exchangeable Al which enhanced the fixation of phosphate ions from the solution, thus reducing Pw. Our results suggest using PM3 as an indicator of environmental risk likely underestimate potential P losses compared to Pw.

Keywords: Degree of phosphorus saturation; Liming; Oxy-hydroxide of aluminum and iron; Phosphorus fractionation; Risk of phosphorus loss

Mulch application influences N_2O flux from organic soils under lettuce production

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Cultivated organic soil is a highly valuable non-renewable resource susceptible to rapid erosion. It is hypothesized that the application of mulch could contribute to, conserve, and regenerate those soils. However, the mulch can change physical, chemical, and biological properties of soil, including soil moisture and temperature, with potential impacts on nitrous oxide fluxes. To assess the impact of mulch on N_2O flux, a field study was conducted using a randomized complete block design with five types of mulches (ash, larch, willow, switchgrass, and miscanthus), roller-crimped rye, a bare no-till treatment, and a bare control. A series of gas samples were collected weekly and analysed by gas chromatography. Nitrous oxide flux was calculated using the HMR algorithm of R statistical software and total emissions calculated using Microsoft Excel. Initial results indiate that total nitrous oxide emissions increased in the miscanthus, switchgrass, and roller-crimped rye treatments, and decreased in no-till condition. This project will provide information on the impacts of different types of mulches on greenhouse gases emissions and support producers in their selection of methods to conserve and restore cultivated organic soils.

Keywords: Nitrous oxide flux, organic soil, denitrification, nitrification, mulch

Effect of soil moisture status and non-bloat legume diet on greenhouse gas emissions from the manure patch

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Manure patches excreted by the cattle on pasture represent considerable, highly localized nitrogen applications, subsequent microbial activities favor by these readily energy (carbon) and substrate (nitrogen) could result in high greenhouse gas (GHG) emissions. Yet, not much is known about the extent of these emissions under different soil moisture statuses and possible mitigation options remain unclear as there is considerable uncertainty surrounding the GHG emissions from these patches. An incubation study was conducted to quantify the effect of soil moisture status and non-bloat legume diet on GHG emissions from the manure patches. For this, urine and dung sample excreted by the beef cattle grazed on the Cicer milkvetch (CM; Astragalus Cicer L.), Sainfoin (SF; Onobrychis viciifolia Scop.) and Alfalfa-bromegrass pastures were collected and applied on the soil microcosms under 50% and 70 water-filled pore space (WFPS) soil moisture status. The GHG emissions were measured daily following the manure application and soil properties including soil pH, electrical conductivity, ammonium (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-) were monitored for four to seven times within a 22-day period. Our results will provide information on the fate of nitrogen following the urine and dung application and examined the impact of these non-bloat legume diets on manure patches GHG emissions.

Keywords: Cicer Milkvetch, GHG emissions, Sainfoin, soil moisture

Modelling beneficial management practices in agriculture to analyze effects on greenhouse gas emissions and environmental sustainability

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Reducing greenhouse gas (GHG) emissions and other detrimental environmental effects of agriculture is a goal paramount to societal stability and prosperity. Understanding the advantages and constraints of beneficial management practices (BMPs) to the fullest extent in varying conditions is imperative for effectively selecting the right interventions tailored to specific farming scenarios. Modelling agricultural management practices and scenarios enables comprehensive testing of simulation experiments to be conducted efficiently, conveniently and at low cost while yielding accurate, representative results. The objectives of this research include: 1) To identify and review all existing BMPs for mitigation of GHG emissions within farming systems relevant to the Canadian Prairies, 2) To implement the Holos model software to run simulations of farming scenarios and management practices, and 3) To inform future research recommendations in agricultural sustainability and identify existing knowledge gaps. The scenarios modelled focused on the Canadian Prairies and so the modeled replicates were split evenly across Alberta, Saskatchewan, and Manitoba. Each beneficial management practice was modelled using Holos model software providing that the model had the capability. The greatest reduction in farm GHG emissions occurred when nitrogen fertilizer inputs were reduced. The average reduction in emissions from a regime of high N inputs to conservative inputs was 32.6% CO_2e. Reduced tillage also resulted in a large decrease of emissions relative to intensive tillage. Across a variety of soil types and fertilizer regimes, the average reduction by switching to reduced from intensive tillage was 15.2% CO_2e. This great reduction was attributed to increased soil carbon sequestration and reduced fossil fuel emissions from farm equipment operations. In addition, for livestock, use of a 4% fat and ionophore supplement enabled a reduction of 5.9% CO_2e. Earlier studies have shown that both fat and ionophore supplements directly reduce methane emissions from beef cattle. The GHG emissions estimates from the Holos model suggest that implementation of beneficial management practices can play a large and important role in reducing emissions in agriculture. These results contribute to a comprehensive, valuable synthesis of the current knowledge base in BMPs for agricultural sustainability and provide deployable insights for BMPs implementation.

Keywords: Agriculture; Greenhouse gas; Modelling; BMP (beneficial management practice)

Prediction of subsoil organic C stocks from measurements of topsoil organic C for carbon accounting in a soil in Southern Ontario

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Soil Organic Carbon (SOC) stocks are distributed throughout the soil profile. However, in most SOC inventories, stocks are accounted for only in the top 30 cm and attempts to measure SOC stocks have often failed to consider the full soil profile. Nevertheless, the subsoil contribution to total SOC stocks is becoming increasingly recognized with studies showing that SOC storage in subsoils (below the top 30 cm) can exceed 50% in most ecosystems. Therefore, measuring, modelling, and understanding soil C dynamics based on topsoil dynamics alone can result in incorrect extrapolations as to total soil C stocks. If resources were not limited, studies should be conducted using a full soil profile and sampled to solum depth. In this study of total SOC stocks, entire soil profiles were taken from a level cultivated field and an adjacent native forest located at the Elora research station. A significant relationship between topsoil SOC and subsoil SOC stocks was used to create a pedo-transfer function with a specific coefficient for soil subgroup. Thus, SOC stocks in the solum at this site can be estimated from measurements of the quantity of topsoil SOC.

Keywords: Soil Organic Carbon, Carbon Stocks, Subsoil, Topsoil, Pedo-transfer

Infrared spectra of soil organic matter (SOM) in a muck soil profile

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Muck soils are composed of organic materials that have accumulated under waterlogged conditions and undergoing slow decomposition processes. We analyzed a muck soil profile by Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectroscopy which is a rapid method to characterize the nature of organic matter structures at a molecular level. Samples were collected from a depth sequence of a soil profile located at the Muck Crops Research Station, Bradford, Ontario. The soils were air-dried, passed through a 2-mm sieve and ground using a ball-mill grinder. Bands indicative of aliphatic C-H, carboxyl, and carboxylate functional groups, aromatic C=C, and C-O stretch of polysaccharides were very well resolved from the acquired spectra. The spectrum of the soil at 90 cm depth was clearly differentiated from those at other depths, while spectra of 0-20 cm/50 cm and 20-30 cm/70 cm depths looked similar. Carboxylic acids and other hydrophilic compounds such as peptides and carbohydrates were higher in the order of 70 cm > 20-30 cm> 0-20 cm> 50 cm> 90 cm, reflecting the degree of decomposition through the profile. At the 90 cm depth, 1660-1580 cm^{-1} (aromatic group stretching) and 1400-1380 cm^{-1} (aliphatic C-H stretch) were significantly different from other soil depths. This reflects that poorly soluble and nonpolar organic materials are formed and preserved at 90 cm depth. We conclude that using the DRIFT spectroscopy technique in a muck soil profile can be used to study and understand the changes in a soil OM decomposition following its microenvironment at a molecular level.

Keywords: DRIFT spectroscopy, muck soil, organic matter decomposition, microenvironment

Clay Aggregates as the Nucleus of Root-Driven Soil Organic Carbon Priming

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Rhizosphere priming, or the intensified loss of soil organic carbon (SOC) due to the presence of living roots, plays an important role in soil carbon-climate feedbacks. However, the mechanisms of rhizosphere priming, especially across land uses and soil depths, are not well understood. Here we examined priming effects in soils collected from three different land uses (cropland, grassland, and woodland from ten agroforestry sites in central Alberta, Canada) and soil depths (0–10, 10–30, and 30–50 cm) using the stable carbon (C) isotope natural abundance technique. Following a 150-d controlled growth-chamber incubation, paired planted and nonplanted root-free soils were fractioned into particulate organic matter (> 53 μm), coarse and fine silt, non-aggregated clay, and aggregated clay within stable silt-size aggregates. Priming was limited to the aggregated clay fraction, similar across land uses, and greatest in the surface soil (1.28 mg C g^{-1} soil). Clay aggregates appeared to undergo rapid turnover in the presence of living roots, with between 6 and 16% of C in this fraction comprised of rhizodeposit-C (addition of 0.49–0.91 mg C g^{-1} soil). The proportion of clay-associated C in the aggregated clay fraction was greater in the surface soil and the woodland relative to all other depths and the cropland, respectively, and was positively correlated with priming in this fraction. Moreover, priming in the aggregated clay fraction was positively correlated with increases in microbial biomass C and reductions in the proportion of aggregated clay across land uses and soil depths, indicating that clay aggregate disruption is a key mechanism of rhizosphere priming. Here we show that living roots and their effect on the soil microbiome can counteract both physical and mineral protection of SOC, which has important implications for our understanding of SOC persistence and, in turn, soil C models.

Keywords: Clay aggregates; Mineral-associated organic carbon; Particulate organic matter; Rhizosphere priming; Soil organic carbon

Investigating the controls of forest conversion on deep soil carbon dynamics

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As the global climate crisis accelerates, research relating to the flux of greenhouse gases is becoming increasingly important. One of the largest sinks of carbon is found within terrestrial soils. However, soils are being disturbed through human activity, whether it be agricultural, forestry, or through the expansion of towns and cities. In the high precipitation forests of the Coastal Western Hemlock (CWH) zone high ecosystem productivity has led to stands with the highest biomass and some of the highest mineral soil organic carbon (SOC) pool densities in Canada. Investigations into soil carbon dynamics have largely focused on the upper layers of soils, despite a large portion of this carbon being found at greater depths. Little is known about the influence of forest conversion on soil processes that drive C stability in deep soils (>50cm). We propose to study the impact of forestry practices in the temperate rainforests of British Columbia on the dynamics of carbon in deep soils. This project will be done in conjunction with the Mother Tree Project: a study of harvesting practices on the health of Douglas fir stands through BC. We will measure the stocks of organic carbon (OC) and C distribution in size fractions of these deeper soils to study the influence of time following harvest on processes controlling deep C dynamics in two contrasting soil contexts (Luvisol versus Podzol). The soil chemical controls on the pool of organic carbon will be elucidated by a combination of mineralogical analysis (XRD and specific extractions) and NMR characterization to assess how soil typology affects the formation of organo-mineral associations and their dynamics in deep soils. Changes to the microbial community and its functional diversity will also need to be studied. This information will help us determine the soil processes that lead to C stabilization into deeper soils, and what environmental factors drive long term deep soil C storage. Comparison between harvesting methods will allow us to determine the link between aboveground harvest practices and belowground carbon dynamics. We anticipate that forestry management and practices influence the capacity of soils to store and retain carbon. If this is the case, this study may illuminate harvesting methods that could help preserve these vital carbon stocks.

Keywords: Carbon, forestry, climate, soil processes

Does dissolved organic carbon increase biological hydrogen oxidation in agricultural soil?

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Chemical oxidation of hydrogen with hydroxyl radicals reduces the oxidation of atmospheric methane, a potent greenhouse gas. Therefore, hydrogen is an indirect greenhouse gas by insulating methane from oxidation. Soil microbial-mediated oxidation is the main sink of hydrogen and account for ~80% of atmospheric hydrogen loss. However, the effects of soil carbon on hydrogen oxidation in agricultural soil still remains unclear. The general objective of this study is to determine how dissolved organic carbon affects hydrogen uptake activity in agricultural soils. I hypothesize that if dissolved organic carbon was increased in soil, then hydrogen uptake rate would increase because more dissolved organic carbon in soil support a bigger hydrogen oxidizers community. We will test this hypothesis with a lab incubation study where we treat agricultural soils with a series gradient of dissolved organic carbon (glucose) under a hydrogen headspace concentration of 5,000 ppmv. After the 24 h incubation period, we will calculate the hydrogen uptake rate based on the changes in hydrogen concentration of the headspace measured by gas chromotagraphy that equipped with a thermal conductivity detector. In addition, we will assess the abundance of culturable hydrogen oxidizers by counting colony forming units. Since hydrogen oxidation in soil is important to mitigate hydrogen emission from an expected booming hydrogen economy, the results of this study will shed light on how dissolved organic carbon of agricultural soils affects its hydrogen uptake activity.

Keywords: Biological hydrogen oxidation; Soil dissolved carbon; Agricultural soil

Change in Soil Organic Carbon Storage as Influenced by Forestland and Grassland Conversion to Cropland in Canada

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National scale estimates of soil organic carbon (SOC) losses through land-use change are often developed through either the default IPCC Tier 1 approach or modelling. However, model validation with measurements/observations is rarely done. In the present study, we compiled published data on SOC losses in agricultural soils, as a result of conversion from native forestland and grassland in Canada, to identify key soil and climate factors, and management practices that explain their variations. Losses of SOC on an absolute or relative basis from forest conversion varied from 14 to 60 Mg C ha^{-1} and from 18 to 30% for Eastern Canada, and from 0 to 27 Mg C ha^{-1} and from -1 to 25% for Western Canada, respectively. Smaller losses of SOC in absolute C stock and relative percent from forestland conversion were associated with the coarse-textured soil in Eastern and Western Canada, compared with medium- and fine-textured soils. Losses of SOC on an absolute or relative basis from grassland conversion varied from 5 to 27 Mg C ha^{-1} and from 14 to 25% on the Canadian prairies, respectively. Greater losses of SOC in absolute C stock occurred in the medium-textured soil compared with coarse- and fine-textured soils. This meta-analysis of losses of SOC from native forestland and grassland conversion broken down by climatic region and soil texture, will help to develop country specific C factors or model validation data to improve regional and national estimates of SOC changes in Canada. The analysis may also provide improved understanding of key factors that impact the SOC change associated with land-use change in other regions of the world.

Keywords: Native grassland, Forestland, Soil organic carbon, Climate, Soil texture

Soil carbon sequestration does not increase under adaptive multi-paddock grazing

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Grazing lands cover 40% of the earth's ice-free land and constitute nearly one-third of terrestrial soil organic carbon. Managed grazing lands' contribution to mitigating agricultural greenhouse gas emissions has great potential, as they is recognized by carbon crediting programs and soil carbon modeling tools. Adaptive multi-paddock (AMP) grazing has gained popularity in the beef industry for its purported gains in production and environmental sustainability; yet it presents variable results in the academic literature. The purpose of this study is to investigate the impacts of AMP grazing on soil carbon sequestration in southern Ontario at the farm scale. In this matched pair design, 5 beef farms practising AMP grazing were compared to nearby non-AMP grazing sites. Soil cores were taken to a depth of 45 cm and segmented into 15 cm increments. The 15 cm increments were analyzed for bulk density (g cm^{-3}), soil organic matter concentration (g organic matter kg $soil^{-1}$) via loss on ignition, and SOC stocks (Mg C/ha) via dry combustion. Results showed a significant interaction of depth*land use ($p=0.0859$) on SOC stocks when analyzed by 15 cm increments. When SOC stocks were measured for the cumulative 45 cm soil profile, SOC stocks were not significantly different ($p= 0.1444$). Future studies investigating soil organic matter quality will better elucidate the origins and longevity of soil carbon between the contrasting grazing strategies.

Keywords: carbon sequestration; adaptive multi-paddock grazing ; pastures; soil carbon

Carbon Content of Buried A Horizons of Saskatchewan Croplands

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To understand the potential implications of climate change on subsoil C, it is important to understand the nature of C at depth in the soil profile. Buried A horizons are formed when soil eroding from hill-tops due to intensive tillage practices buries the original A horizon in the lower slopes of hills. There is limited research on the nature of C-rich buried A horizons in Saskatchewan which could hold valuable insights into the stability and permanence of sub-soil C. The objective of this study was to determine if buried A horizons formed across different soil zones and different soil textures in Saskatchewan were C-rich. Soils were collected from six different sites in October/November of 2021. Samples were collected from two sites from the Brown soil zone, one with a clay loam soil texture and one with a sandy to silty loam soil texture; two sites from the Dark Brown soil zone, one with loam soil texture and one with a clay loam soil texture; one site from the Black soil zone with a sandy loam soil texture; and one site from the Dark Gray soil zone that had a very fine sandy loam soil texture. It is hypothesized that the organic C content of the buried A horizon will be proportional to the new A horizon that has formed on the deposited soil with Black and Dark Gray greater than Brown and Dark Brown soil zones, regardless of soil texture. It is also likely that within a soil zone, heavier soil textures will have sequestered greater C in the buried A horizon. The organic C concentration, C mass equivalent and soil texture of the A horizon formed on deposited soil, the buried A horizon and original Bm horizon for each site will be presented.

Keywords: Buried A Horizon; Subsoil Carbon; Soil Erosion

Impacts of Short Rotation Canola on Soil Microbial Dynamics and Nutrient Cycling

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Soil organic matter (SOM) is the largest terrestrial C sink on the planet and plays a key role in C storage. The quantity and forms of SOM storage in agricultural soils are an indicator of soil health, function, and fertility in cropping systems. Canola, a staple cash crop in western Canada, has recently been grown with increasing frequency within crop rotations. However, little is known about the impact of short rotation canola on SOM and the formation of different SOM functional pools. The objective of this research is to assess canola frequency impacts on microbial communities through measurement of phospholipid fatty acids (PLFA), on enzyme activities, and on soil C storage in particulate organic matter (POM) and mineral-associated organic matter (MAOM) functional pools. In 2018 and 2019 soil samples were collected at Scott and Swift Current, SK and Lacombe, AB during canola peak flowering from a multi-site AAFC canola frequency rotation study (est. 2008). We measured total C and organic C content of physically fractionated POM and MAOM, PLFA, beta-glucosidase, N-acetyl-glucosaminidase, phosphatase, and arylsulfatase enzyme activities. Initial results of the PLFA analysis indicate canola grown in two- and three-year rotations had an impact on microbial community structure compared to continuous cropped canola. The effect of continuous canola versus canola grown in rotation on microbial activities, abundance, community structure, and POM and MAOM C storage is being further explored and will be presented. This study will deepen our understanding of the effect canola cropping frequency has on soil microbial dynamics, C content, and C storage in multi-year canola dominated crop rotation systems.

Keywords: Crop Rotation, POM, MAOM, Carbon Storage, Microbial Activity

Decomposition dynamic of bare and cultivated organic soils amended with straw and wood chips under greenhouse conditions

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Organic soils typically lose from 2 to 20 t C-CO_2 ha^{-1} yr^{-1}. A laboratory study carried out in glass jars with bare and unfertilized soils showed that depending on the degree of humification of the soil, bringing 2 to 20 t ha^{-1} yr^{-1} of straw and wood chips might compensate for Quebec organic soils decomposition. However, fertilizer application and root activity can stimulate organic matter decomposition, a phenomenon known as the priming effect. The objective of this study was to assess the importance of this phenomenon in the context of organic soils conservation.
The disturbed horizon (Ohp) of three cultivated organic soils (Fibrisol, Mesisol, Humisol) was sampled and placed in cylinders of 25 cm diameter and 35 cm height. The first 20 cm of soil was mixed with the biomasses (miscanthus and wood chips from eastern white pine) at a rate of 15 t ha^{-1}. Half of the cylinders were kept bare, and half were cultivated with three iterations of leafy vegetables and fertilized according to usual field practices. Irrigations with rainwater were performed throughout the experiment to maintain a matric potential of -15 kPa at 10 cm depth. Before seeding and after each harvest, the 0-20 cm horizon of soil (cultivated and uncultivated) was mixed, weighed, and sampled. Soil samples were analyzed for water content, total organic matter (loss on ignition) and microbial activity (Fluorescein diacetate). The cultivated and fertilized soils showed a 10% significant increase in microbial activity compared to the bare and unfertilized soils. However, this dynamic did not appear to reflect on the organic matter stock change. Although the difference is not significant, the cultivated soils lost 38% less organic matter than the bare soils, 2.1 t ha^{-1} compared to 3.4 t ha^{-1}. This apparent absence of priming can notably be explained by (1) the contribution of leafy-vegetable roots to the organic matter input and (2) the suppression of priming with nitrogen addition preventing N mining from microorganisms. The change in organic matter stock with the cultivation and fertilization deserves further investigation since it might considerably impact the estimation of biomass required to compensate for organic soils decomposition and, in turn, the cost for growers.

Keywords: Priming effect, N mining, Stochimetry, Histosol

Soil Biochar Application for Drought Adaptation in Agriculture in British Columbia

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Due to climate change, farmers in British Columbia are experiencing increased fall, winter, and spring precipitation followed by periods of summertime drought. It is anticipated that these climactic conditions will continue to increase in intensity. In addition to growing-season drought, decreased groundwater availability also emphasizes the importance of identifying ways to meet crop water needs and sustain yields. Biochar, as characterized by high porosity, specific surface area, density of carboxylic functional groups, and cation exchange capacity, can potentially increase the water and nutrient holding capacity of drought sensitive soils. This research will focus on understanding the impacts of pristine biochar and activated biochar on soil water and nutrient-use efficiency in sandy soils on Vancouver Island, British Columbia. Pristine biochar will be applied, and will also be "activated" through prolonged contact with nutrient-rich liquid dairy manure. Biochar utilized in this study is sourced from wild-fire affected "waste" timber and applied at a "sustainable rate" of 3 tons/ha. This application rate reflects available (annual) forest waste biomass in British Columbia. Greenhouse trials (spring 2022) will be utilized to examine water and nutrient-use efficiency in a controlled setting. Field trials (2022 and 2023) will be utilized to examine water and nutrient-use efficiency on three operational farms on Vancouver Island, which will also allow for farmer feedback. This study is important to understand if pristine biochar and activated biochar can allow farmers in British Columbia to obtain sustained yield throughout periods of drought and/or decreased irrigation.

Keywords: biochar, water-use efficiency, nutrient retention, charcoal, sandy soil

Biochar and nitrification inhibitor changed soil microbial biomass and ecoenzymatic stoichiometry in a Gray Luvisol

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Agricultural management practices are known to influence microbial and enzymatic activities in soil. However, their effects on microbial biomass and ecoenzymatic stoichiometry, an important tool to understand the relative availability/limitation of carbon (C) and nutrients for microbial metabolism are not well known. In a 2-year field study, we assessed the effects of biochar amendment and nitrapyrin (a commoly used nitrification inhibiror (NI)) application on soil nutrient availability, microbial and ecoenzymatic stoichiometry to understand microbial nutrient limitations in an agricultural land. Two treatments: (i) biochar amendment at three levels: no biochar added (BC0), biochar added at 10 ton/ha (BC10) and biochar added at 20 ton/ha (BC20), and (ii) NI application at two levels: with (NI+) and without NI (NI-) were applied to an agricultural land with a Gray Luvisol in a randomized block design with four replications. Biochar increased N and P availabilities but biochar amendnment at 20 ton/ha did not yield significant increase in nutrient availability as compared to the rate of 10 ton/ha. Biochar increased soil microbial biomass C and phosphorus (P) with no significant difference between the rates of 10 and 20 ton/ha while NI did not change microbial biomass C, nitrogen (N) and P. Biochar increased and NI decreased β-1,4-glucosidase and acid phosphatase activities with a subsequent change in ecoenzymatic stoichiometry. Vector angle of ecoenzymatic stoichiometry showed that microbial metabolism is limited by P limitation in the studied area. Biochar decreased ($P = 0.037$) and NI increased ($P = 0.043$) microbial P limitation with no significant interaction between the treatments. This study shows that soil microbial biomass and ecoenzymatic stoichiometry are responsive to soil amendment and suggests biochar amendment to alleviate microbial P limitation in the Gray Luvisol.

Keywords: enzyme activities, microbial biomass, management practices, nitrapyrin, soil fertility

Do Cover Crops Impact Soil Microbial Communities in the Prairies?

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Cover crops have the potential to confer many benefits to agricultural soils, including reduced soil erosion, increased nutrient and water retention, and increased carbon storage. Many of the ecosystem services derived from cover crops are actually provided through activities associated with soil microorganisms, while the cover crop acts as a sort of catalyst. However, cover crop research is limited in terms of impacts on soil biology, and especially in semi-arid growing environments like the Canadian Prairies. My research aims to address this knowledge gap by evaluating the impact of cover crops on biological soil health across a range of growing environments in Prairie Canada. It is hypothesized that the use of cover crops will support a more active, abundant soil microbial community and impose changes in soil microbial community composition, leading to improved soil health.

A four-year fully phased crop rotation field study was established in 2018 at Carman and Glenlea, Manitoba and Saskatoon, Saskatchewan. Treatments included a four-year crop rotation including cover crops, a four-year crop rotation without cover crops, a two year wheat-canola crop rotation check, and a perennial alfalfa check check for a total of eleven treatments arranged in a randomized complete block design with four replicates at each site. A variety of crops and cover crops were chosen to represent broader groups (ex: brassicas, oilseeds, grains, tubers). Surface soils (0-15 cm) were collected in fall 2020, following cash crop harvest and cover crop establishment, in spring 2021 prior to seeding, and summer 2021 coinciding with cash crop flowering/anthesis. Phospholipid fatty acids (PLFA) were extracted to determine microbial abundance and structure, while activities of extracellular enzymes important for carbon, nitrogen, and phosphorus cycling and soil organic matter quality are being assessed. Preliminary PLFA results from the Saskatoon site indicate a strong seasonal effect for total PLFA abundance without an effect of cover crop. Completed analyses will provide insight into whether this is consistent within all microbial groups and among sites; additonally, ancillary soil data such as pH, soil texture, and nutrient availability will be used to understand site-specific effects. Producers may use this information in creating more efficient management strategies, specifically in deciding whether or not to implement cover cropping practices on their Prairie operations.

Keywords: cover crops; microbiology; agriculture; soil health

Response of microbial communities to long- and short-term coordinated nitrogen and sulfur fertilization

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Nutrient stocks and cycling have been greatly affected by increasingly diverse crop rotations including higher yielding cultivars. If nutrients removed in harvested crops are not replaced, soil health, crop productivity and quality may decline. This research aims to assess the response of crops and microbial communities to N and S fertilizer applications. More specifically, our target is to quantify the effects of long- and short-term N and S fertilizer applications on the efficiency of elemental S oxidation, soil N mineralization, and soil microbial communities and enzymes involved in N and S cycling in agricultural soils with different fertilization histories. The research project takes place at the Breton Classical Plots in Alberta and includes six long- and four short-term treatments where different fertilizer treatments are assigned. The long-term treatments have received consistent N and S fertilizers for at least 40 years and the short-term treatments have received fertilizer for the first time in 90 years. Long-term treatments include manure, NPKS, NS, Control, NPK (-S), and PKS (-N). Short-term treatments include a number of new, granular micronized sulfur fertilizers blended with urea. Soil was sampled at the depths of 0 to 7.5 and 7.5 to 15 cm and analyzed for basic soil properties and microbial communities involved in the N and S cycle using quantitative PCR. The results of these findings will provide information on fertilizer use efficiency with coordinated management of multiple nutrients such as N and S for supporting on-farm nutrient management decisions. Further, this research will contribute to quantifying the link between soil health and nutrient stewardship.

Keywords: Nitrogen, Sulfur, Soil microbial communities, Management practices

Changes in soil microbial community structure and functional potential in response to grazing management practices in a semi-arid agroecosystem

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Agricultural management practices such as different livestock grazing systems are known to have an impact on soil properties, plant productivity, and microbial biodiversity. Microorganisms play a vital role in mediating important agroecosystem services such as nutrient cycling, modulating soil-to-plant nutrient transfer, and regulating greenhouse gas fluxes. Previous studies have shown that grazing management and plant species composition in grasslands can have an influence on soil microbial community structure and function. However, the effects of intertwined linkages between grazing management and plant productivity on microbial community functioning and their resulting influence on soil physicochemical processes are still poorly understood. The impacts of cattle grazing management on microbial community structure and their potential role in carbon and nitrogen cycling were studied using samples collected from a long-term grazing experiment (established. in 2001) conducted at the Agriculture and Agri-Food Canada, Swift Current Research and Development Center. Soil microbial communities were characterized using shotgun metagenomic sequencing and compared between grazed and ungrazed soils from two pastures with either 7 or 12 plant species. Both pastures also included continuous grazing and deferred-rotational grazing systems. We hypothesized that pastures with higher plant species diversity will have higher microbial diversity, and increased functional redundancy. Furthermore, compared to no grazing, continuous and deferred-rotational grazing systems are expected to increase soil microbial diversity and multifunctionality, possibly due to grazing-related changes in plant productivity. In addition, deferred-rotational grazing in pastures with 12 plant species would be expected to have more microbial genes associated with nutrient acquisition, in comparison to pastures with continuous grazing and fewer plant species. The results from this study will provide insight about how grazing management and plant species diversity affects microbial community functional potential and their related ecosystem services. This information may aid in developing more sustainable grazing management practices that can potentially increase long-term carbon storage in the soil.

Keywords: Cattel grazing, soil microbiome, shotgun metagenomic sequencing

Effect of drought stress on nodulation, plant growth, soil enzyme activities, soil nitrogen availability, and nitrogen fixation in alfalfa

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Alfalfa (*Medicago sativa*) is one of Canada's most important forage legumes due to its high yield and nutritional quality. It is commonly grown as monoculture stands or with grasses to improve forage production, nutritional quality, and soil fertility. The symbiotic relationship of alfalfa and rhizobia facilitates nitrogen fixation, an activity supplying bioavailable nitrogen to support plant growth and yield. Recently, drought has been a significant concern in western Canada as it limits plant growth, yield, and symbiotic nitrogen fixation (SNF) in legumes. We hypothesize that drought stress significantly affects the SNF and nitrogen rhizodeposition of alfalfa, thus affecting extracellular enzyme activities, soil microbiome, and nitrogen availability in the soil. A greenhouse pot experiment was conducted with alfalfa to evaluate the effect of drought stress on plant growth, SNF, plant physiological parameters, soil extracellular enzyme activities, soil nitrogen availability, and soil microbiome structure. Alfalfa inoculated with *Sinorhizobium meliloti* Rm1021 were exposed to drought conditions at the flowering stage: 20% field capacity (FC) (severe drought), 40% FC (moderate drought), and 80% FC (well-watered) for three weeks. Results showed that photosynthesis, leaf chlorophyll content, nodulation, root traits (length, volume, surface area), and shoot and root biomass significantly decreased under the severe drought condition compared to the well-watered condition. Similar trends were observed under the moderate drought condition; however, leaf chlorophyll content increased compared to the well-watered condition. Furthermore, extracellular enzymes responsible for cycling carbon (β-Glucosidase, β-D-Cellobiosidase) and phosphorous (Phosphatase) were not affected by drought stress. Conversely, the enzyme activity for nitrogen cycling (N-acetyl-glucosaminidase) decreased under drought conditions. The available soil nitrogen (NO_3^- and NH_4^+) was higher following three weeks of drought stress compared to the well-watered control treatment. In the future, the SNF will be measured using the ^{15}N-isotope dilution method, and soil microbiome analysis will be performed to investigate the effect of drought stress on soil microbial community.

Keywords: alfalfa; drought stress; available soil nitrogen; soil enzyme activity; symbiotic nitrogen fixation

Bacteria's ambivalence to the herbicide clopyralid: a microcosm experiment

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Soil microbial communities can degrade pesticides and reduce pesticide leaching and contamination that can have negative consequences on subsequent crops growth and productivity. Utilizing microbes ability to degrade organic contaminants is increasingly common for bioremediation and the inoculation of degraders is a potential solution for recalcitrant and persistence pesticides. In this study, we focus on clopyralid, a broadleaf herbicide commonly used in the Canadian Prairies that has been found to persist in soils and compost. Our objectives were to: 1) study the effects of clopyralid on soil/biomixture bacteria, and 2) isolate potential degraders of clopyralid. We set up 36 microcosms with three soil types (2 agriculture soils and 1 biomixture from a pesticide rinsate biobed) and four dosing treatments (0x, 1x, 2x, and 10x field rates). Microcosms were spiked with the commercial product Lontrel weekly for 18 weeks. Soil was collected every 3 weeks, extracted for DNA and cultured. Contrary to our hypotheses, bacterial diversity, culturability, and community composition did not change with dosage, regardless of soil type. There was no common community shift over time for all soil types, only distinct community changes within soil types. No changes to diversity with dosage reflect the limited ability of clopyralid degraders to outcompete other bacteria, while no common community shift highlights the role soil matrices play in bacterial responses to pesticides. A single genus, *Azoarcus*, was enriched in the 10x doses treatments of clopyralid, while the genus *Gaiella* was amongst the most abundant amplicon sequence variants associated with clopyralid dosing. Despite no clear winners with clopyralid dosing, we were able sequence three cultured isolates, of which there were two unique species: *Rhodococcus erythropolis* and *Pseudomonas yamanorum*. While bacterial diversity was largely unaffected by the dosage of clopyralid and community changes were largely dependent on time and soil type, there is evidence that potential inoculants can still be present without outcompeting other bacteria.

Keywords: Soil microbiome; herbicides; bacteria

Soil-Plant microbial assemblages associated with regenerating Pinaceae trees at an anthropogenically-disturbed gravel mining site

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Forest ecosystems are commonly affected by anthropogenic disturbances such as gravel mining, leading to poor edaphic conditions for plant growth. However, Pinaceae tree species – Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta var. latifolia*) – have been thriving on an unreclaimed gravel mining site lacking topsoil, organic forest floor and essential plant nutrients in the central interior of British Columbia, Canada. To evaluate the role of soil and plant microbiome in sustaining tree growth, we examined the bacterial and fungal communities inhabiting bulk soil, rhizosphere and endosphere niches of Douglas-fir and lodgepole pine trees at this site. We found that bacterial and fungal community structures differed significantly among various niches, suggesting plant-driven selection of the microbial communities. Overall, Douglas-fir and lodgepole pine harboured distinct fungal communities with *Rhizopogan* dominantly colonizing Douglas-fir rhizosphere (30%) and roots (12%) and *Suillus* dominantly colonizing pine rhizosphere (60%) and roots (30%). Along with enhancing nutrient uptake from the soil, these ectomycorrhizal fungi have been reported to harbour nitrogen-fixing bacteria in their tuberculate structures. No significant differences were observed in the bacterial community composition and diversity of both Pinaceae species. Bacteria in the order *Rhizobiales* and *Acetobacterales* dominated both tree species, particularly the endosphere with a relative abundance of 30% and 10%, respectively. The most abundant phylotypes in both tree species belonged to *Bradyrhizobium*, *Beijerinckia* and *Rhizobium* – genera commonly associated with nitrogen-fixation. The patterns observed for the soil-plant microbiome of Douglas-fir and lodgepole pine suggest that both tree species largely associate with plant-beneficial bacterial and fungal communities that could help explain their growth on severely nutrient-limited gravel substrate. Such understanding of native soil–tree microbiome is important to help comprehend natural revegetation strategies following disturbance events.

Keywords: Soil-plant microbiome; Lodgepole pine; Douglas-fir; Anthropogenic disturbances; Natural regeneration

Effects of soil carbon amendments on H_2-oxidizing bacteria activity and diversity

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Soil represents the most important sink of atmospheric H_2, where nearly 80% of H_2 uptake occur. This is the result of H_2-oxidizing bacteria (HOB) activity, a functional guild including representatives of several phyla. The ability to oxidize H_2 is assumed to provide energy for survival in hostile environments such as cold deserts via atmospheric chemosynthesis, or to confer a higher growth rate by combining organic and inorganic energy sources via mixotrophy. Furthermore, several HOB have been identified as being able to degrade complex organic matter which, overall, emphasizes on the importance of soil carbon availability on the HOB activity. Here we test the hypothesis that carbon amendment will impact HOB activity and diversity, where cellulose and starch amendment will promote HOB establishment, and the addition of sucrose will modulate microbial community by favouring copiotroph species over HOB. To test this hypothesis, 39 microcosms were divided in tree temporal blocs including four doses (0.1, 1, 3, 5%C equivalent) of tree carbon sources (sucrose, cellulose, and starch) and one control (no amendment). Dose-response effects of each carbon sources on H_2 oxidation rate were measured weekly using a gas chromatography system. After 42 days, soil samples were used for PCR amplicon sequencing of taxonomic and functional genes that were related to variation of H_2 oxidation rate with compositional changes of soil microbial communities. Significant changes in community composition occurred in response to the sucrose treatments compared to the others. Sucrose treatment showed the lowest oxidation rate with values decreasing with sucrose concentration. The loss of alpha diversity was consistent with the decrease in median oxidation rate observed in microcosm with the higher percentage of sucrose. Cellulose and starch treatment had little or no impact on the oxidation rate compared to the control. This work allowed the first identification of bacteria and fungi whose ecological niches contrast with those of the HOB guild.

Keywords: Hydrogen; Soil; H_2-oxidizing bacteria; Carbon

How soil microbial diversity with different land management conditions and be used as an indicator of soil health

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The demand for agricultural products withincreasing global population drives the use of intesive cultivationpractices and consequently may affect soil health. However, maintaining soil health can potentially preserve sustainable agriculture, which will increase social resilience and food security. Understanding the linkages between indicators of soil health such as soil aggregate stability, soil organic carbon and soil microbial community structure can help to build useful indicators of sustainable agricultural soil systems. In this study, we examine 1m soil cores split into 4 depth and taken from three contrasting management practices (adaptive multipaddock grazing, rotational grazing, and annual cropping) near Tabor, AB. Bacterial community structure was determined by fungal and bacterial amplicon sequencing and standard techniques were used for wet aggregate stability. Soil organic carbon was determined by combustion. We found changes in aggregate stability with management, but no change in soil carbon stock. Changes to bacterial and fungal communities are discussed. The results will inform land users and agricultural stakeholders for a more sustainable management of their lands in the future.

Keywords: Soil microbial diversity, aggregate stability, climate, soil properties, DNA extraction

Comparison of two methods for calculating soil loss due to wind erosion

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Wind erosion is a problem that affects organic soils in the Montérégie-Ouest. However, little research has been done to measure soil loss due to wind erosion. The purpose of this study is to compare two methods of calculating soil loss due to wind erosion and to define which one is the most appropriate. A measurement site was established to monitor wind erosion since 2019, 32 modified Wilson-Cooke dust collectors (MWAC) were randomly placed on the field to measure the dust flux. A meteorological station was also installed to measure wind speed and direction. Mass transport data from a dust storm recorded between June 10 and 12, 2020 were taken to perform the calculations. The first method consisted of a simple empirical calculation following the gradient from southwest (SW) to northwest (NE) shown by the field measurements. The second method consisted in analyzing the anysotropy from semivariograms and calculating the losses following the directions with the largest effective ranges found by these. The losses calculated by the simple empirical method were 9.68 ton ha-1 (0.32 cm of soil). The anysotropic variograms showed a spatial structure in the south-north direction and in the SW to NE direction, so that when calculated from a weighting of the south and SW winds, the calculated losses were 8.41 ton ha-1 (0.28 cm). The results suggest that the second method of calculation is the most appropriate since it takes into account the prevailing wind directions. However, these calculations need to be improved as other field measurements indicate soil losses greater than 2 cm. Consideration of factors such as the efficiency of the MWAC samplers may help to improve the estimates of soil loss due to wind erosion in Montérégie-Ouest.

Keywords: Wind erosion, Anysotropy, soil losses

Cropping System Impact on Physical Soil Health Properties in Semi-Arid Southern Alberta

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Understanding and identifying cropping systems influence on physical soil health properties is crucial to designing and developing sustainable agriculture that can meet global food demands while also promoting soil and environmental health. A study was initiated in Lethbridge, Alberta in 2018 to investigate the impact of a broad range of cropping systems on productivity, systems resilience, and soil health. Six contrasting 4-yr rotations were assessed: i) conventional cropping system as control (CON): durum wheat (*Triticum durum*) – barley (*Hordeum vulgare*) - durum wheat - fallow, ii) pulse- or oilseed-intensified system (POS): lentils (*Lens culinaris*) - durum wheat - chickpeas (*Cicer arietinum*) - durum wheat, iii) diversified cropping system (DS): durum wheat – lentils – canola (*Brassica napus*) - peas (*Pisum sativum*), iv) market-driven commodity system (MDS): canola - spring wheat (*Triticum aestivum*) - spring wheat - barley, v) high-risk rewarding system (HRRS): durum wheat - soybean (*Glycine max*) - corn (*Zea mays*) - faba bean (*Vicia faba*), and vi) green-manure incorporated system: peas (as green manure) - barley/peas - faba bean/barley - barley (GMS). This presentation will focus soley on physical soil health properties: water stable aggregates (WSA, 0 - 15 cm soil depth), penetration resistance (cone index, 0 - 60 cm soil depth), infiltration rate (Inf.Rate), and field saturated hydraulic conductivity (K_{fsat}) measured after hearvest in 2020. After 3-yrs of rotation, preliminary results showed that DS (82.0%), MDS (83.7%), and POS (88.0%) had significantly more stable aggregates than CON (65.8%); while HRRS had the most unstable aggregation with a slake index of 3.8. Among the cropping systems, DS had the lowest cone index. Inf.Rate across cropping sytems ranked as MDS > CON = DS > POS > GMS > HRRS, while K_{fsat} follows the order of MDS > CON > POS > DS > GMS > HRRS. These preliminary results suggest that choices of cropping systems have significant influence on physical soil health properties, and should be carefully considered.

Keywords: crop rotation; cropping system; agriculture sustainability, soil health

Tensile strength of aggregates and spatial distribution of different rootstocks in Ultisol under citrus production

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Decision making, based on land use, directly reflects changes in the physical properties of the soil, such as density, structure and distribution of the root system. Therefore, since soil quality is fundamental in guaranteeing the sustainability of agroecosystems, tensile strength (TS) stands out, as one of the most significant mechanical properties in the evaluation of management associated with soil quality, with TS being directly influenced by the size and aggregate form. Thus, the present study aimed to evaluate the structural quality of an Ultisol from the tensile strength and spatial distribution of root volume of different citrus rootstocks. The experiment was installed in a citrus farm in the city of Perdões, Minas Gerais, Brazil, in an area of Ultisols. The preparation of the experimental area consisted of opening planting furrows with subsequent subsoiling (0.40 m wide and 0.50 m deep). The rootstocks (RS) studied were: 'Cravo Santa Cruz' (CSC); 'Sunki Tropical' (ST) and 'Citrandarin Índio' (CI). After three years, from the initial soil preparation, intact soil block samples, with preserved soil structure, were collected from the layers (0-0.05; 0.35-0.40; 0.45-0.50m). The aggregates were obtained from 8.00 and 4.76 mm sieves, 10 randomly chosen aggregates were used for the TS test and destined for the bench penetrometer (Marconi®). Each aggregate was subjected to contact with the flat base of the rod with displacement at a constant speed of 0.3 mm s^{-1}. Through a load cell (20 kgf) and computerized system, the force values (kgf) were registered until the moment of rupture of the aggregate. Subsequently, the broken aggregates were sent to the oven for moisture determination, then the effective diameter (D) and TS were calculated for each RS studied. The root system of the rootstocks was evaluated by the cultural profile method, 2D image, with subsequent preparation of volume surface maps analyzed by means of kriging. The data were submitted to analysis of variance, and the means were compared using the Tukey test ($p<0.05$) by R program. As RT is the force necessary to break the point of weakness of the aggregates, it is noteworthy that it is sensitive to assess the structural condition of the soil. Thus, the CSC presented higher D and consequently lower RT. These results are justified by the ease with which these larger diameter aggregates are fragmented, thus exposing their planes of weakness and consequently the areas of lower resistance. In addition, this lower TS contributed to better root development, because for this RS, greater expansion in the volume of roots was verified along the soil profile.

Keywords: Soil structure, Soil quality, Aggregates, Tensil strength, Rootstocks

Does intensive organic farming influence earthworm population?

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Earthworms are identified as soil engineers as they play an important role in soil health as they have an influence on soil structure and on short-term soil organic carbon dynamics. Nonetheless, their dynamics has been less documented especially in organic cropping systems. Our objective is to assess the effect of short rotations - three years cropping - under organic management on earthworm abundance and diversity. A field survey was conducted in the springs of 2019 and 2021 on 11 certified organic farms in Quebec, Canada. On each farm, earthworm population was assessed by physical and chemical extraction in a corn, a soybean, and a cereal rotation phase. An unmanaged benchmark was also sampled on each farm in 2021. The influence of soil properties (soil temperature, texture, bulk density, water content, and soil organic carbon) on earthworm populations was also assessed. Among the earthworm species recovered, species from the endogenic group were the most abundant with *Aporedica turgida* observed in 80% of the fields. Principal component analysis and multivariate analysis of variance showed that the crop at earthworm assessment did not explain the variation in the adult abundance, while year of sampling and soil properties explained together 30% of the variation of adult earthworm abundance. Spring 2019 and 2021 were contrasted with higher soil temperature and lower soil water content in 2021 than in 2019. Difference in soil properties (higher soil temperature and lower soil humidity in 2021 than in 2021) resulted in lower endogenic and juvenile abundance, and in lower species richness in 2021 than in 2019. Despite lower residue and higher tillage intensity during the soybean phase, the earthworm population was sustained at a steady state. The implementation of best management practices such as manure amendments, reduced tillage, and cover cropping may have also influenced the observed earthworm population dynamics on these farms. This component of the study will be further explored based on data from a management practice survey being completed by producers.

Keywords: Earthworm, Soil Health, Organic Agriculture, Soil Structure