WETLANDS
Natural Climate Solutions

Welcome to the Third Annual General Meeting
Wetlands as Natural Climate Solutions

April 9 and 10, 2025

Day 1. Wednesday, April 9 (ET time)

11:00–11:15 AM:	Network Status and Priorities Moving Forward (Irena)
11:15–12:00 PM:	OBJ1. Wetland Mapping (David)
12:00–12:45 PM:	OBJ2. Wetland GHG Fluxes (Pascal)
12:45–1:15 PM:	Lunch Break
1:15–2:00 PM:	OBJ3. Wetland to Watershed Modelling (George)
2:00–2:45 PM:	OBJ4. Wetland Co-benefits (Irena)
2:45-3:00 PM:	OBJ5. Nature Smart Climate solutions (Guillaume)
3:00–3:45 PM:	OBJ5.4. Nature Smart Climate Solutions Fund (Extension projects, John)
3:45–4:00 PM:	Plans for Day 2 (Pascal)

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Land Acknowledgment

Before we begin, I want to take a moment to recognize and honour the Indigenous Peoples across what is now called Canada. From coast to coast to coast, First Nations, Inuit, and Métis Peoples have cared for the lands, waters, and skies since time immemorial.

As someone who is part of a national research network, I feel deep gratitude for the opportunity to live, work, and learn on these traditional territories. I acknowledge the ongoing presence, strength, and contributions of Indigenous Peoples, and the injustices they have faced — and continue to face — due to colonialism.

Let us each reflect on our role in reconciliation and how we can contribute to a future built on respect, equity, and meaningful relationships with Indigenous communities.

Celebrating 3 years as a network

Start
April 1, 2022

Finish
March 31, 2028

Today, April 2025

2023 | 2024 | 2025 | 2026 | 2027 | 2028

CAAF Project:
Wetlands as nature-based climate-change solutions: Quantifying carbon-capture potential while building a stronger green economy.

Five years: April 1, 2022 - March 31, 2027 (plus 1 year no-cost extension)

Prairies Project:
Wetland as Natural Solutions: Baselines and projections for Wetlands on Agricultural Land

Three years: Jan 1, 2023 - March 31, 2025

Great Lakes Project:
Wetlands as Nature-Based Climate Solutions: A Socioeconomic Analysis of the Great Lakes-St. Lawrence River Basin

Four years: Jan 1, 2024 – March 31, 2027

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Irena Creed
University of Toronto Scarborough

Pascal Badiou
Ducks Unlimited Canada

Ali Ameli
University of British Columbia

George Arhonditsis
University of Toronto Scarborough

Matthew Bogard
University of Lethbridge

Gail Chmura
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Jay Famiglietti
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Steven Webb
GIFS, University of Saskatchewan

Lauren Bortolotti
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James Paterson
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Kevin Bishop
Swedish University of Agricultural Sciences

Sheel Bansal
United States Geological Survey

Tim Moore
McGill University

Patrick Lloyd-Smith
University of Saskatchewan

John Pattison - Williams
University of Alberta

Roy Brouwer
University of Waterloo

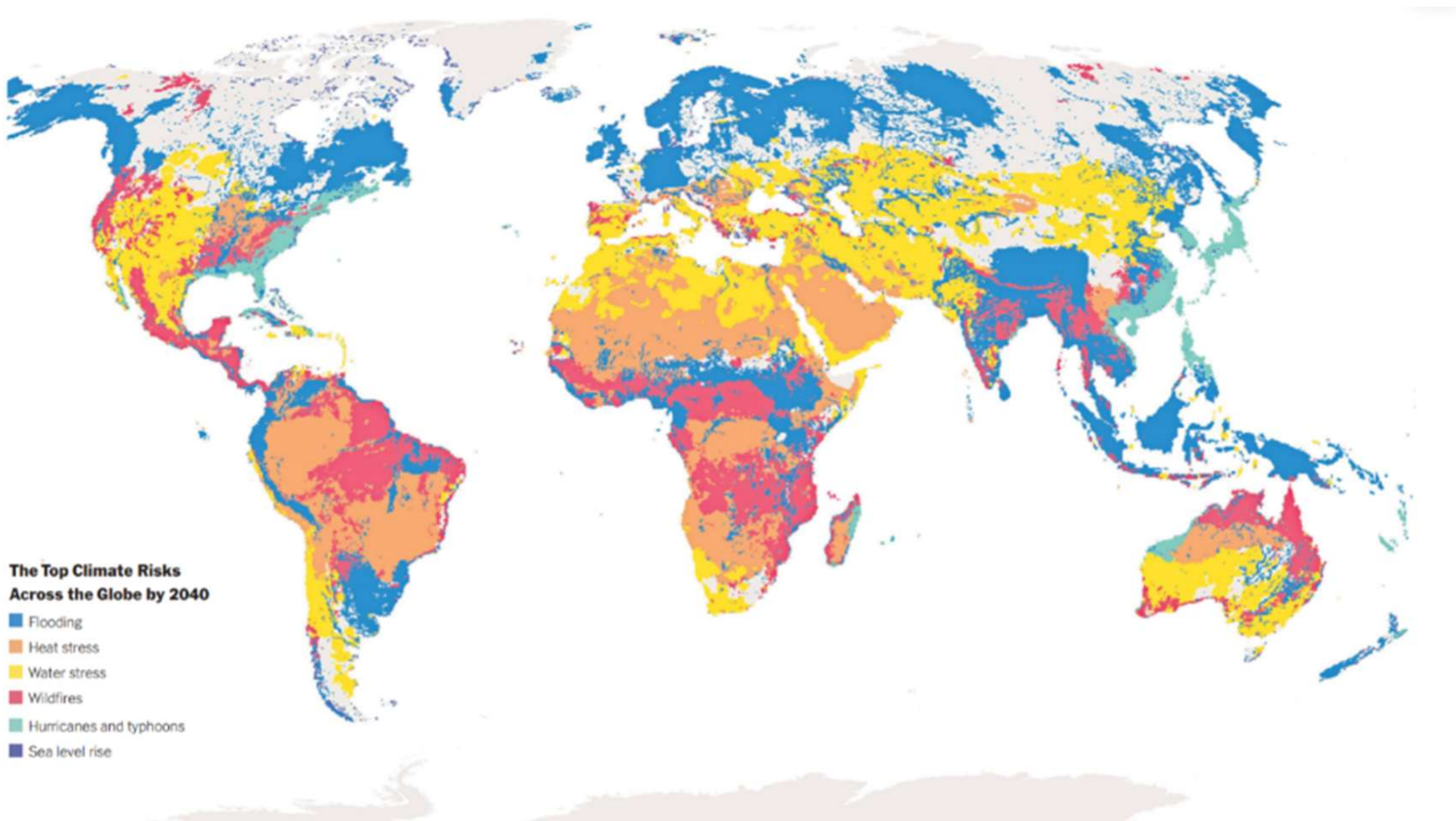
Jie He
University of Sherbrooke

Lota Tamini
University of Laval

Genevieve Ali
McGill University

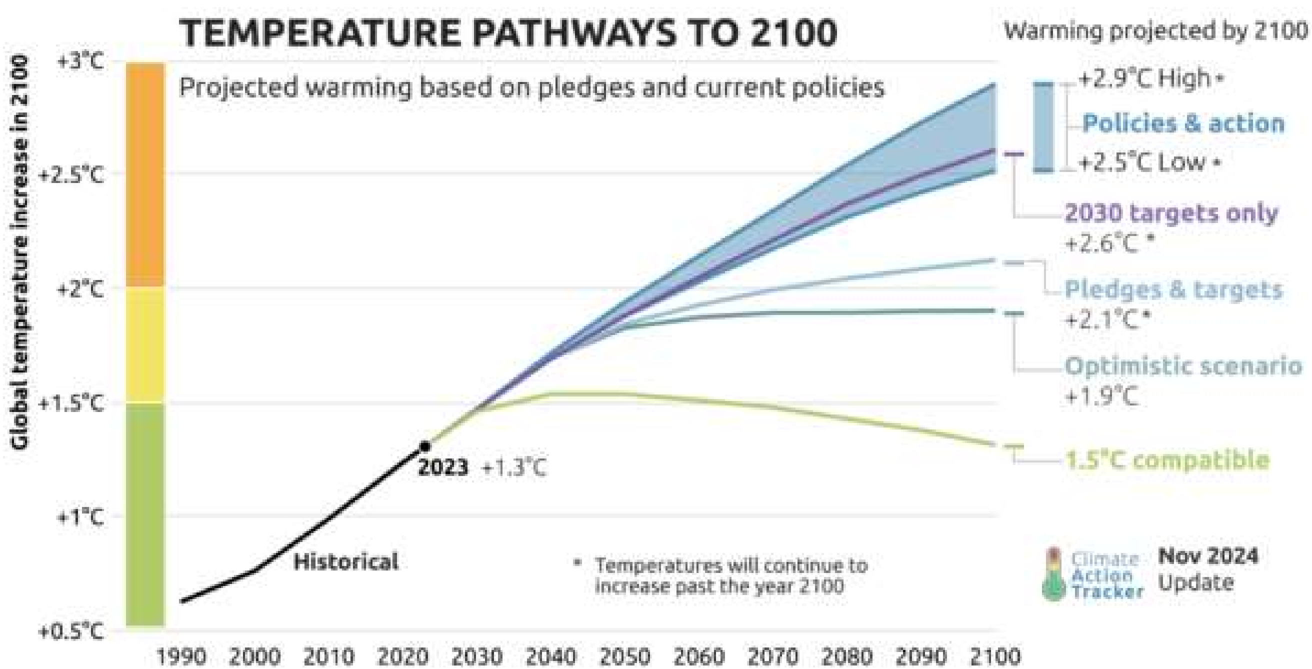
Ben de Vries
University of Guelph

Why the work that we do matters



Source: Four Twenty Seven and The New York Times

Why the work that we do matters



https://newclimate.org/resources/publications/climate-change-performance-index-2024.

Natural climate solutions are actions to protect, conserve, and restore nature in order to store carbon and reduce greenhouse gas emissions.

Nature plays an important role in climate change mitigation

In Canada, 18 to 20% of total commitment can be achieved through natural climate solutions

78.2 Mt CO_2eq in 2030

Drever et al. 2021. Natural climate solutions for Canada. Science Advances 7: DOI: 10.1126/sciadv.abd6034

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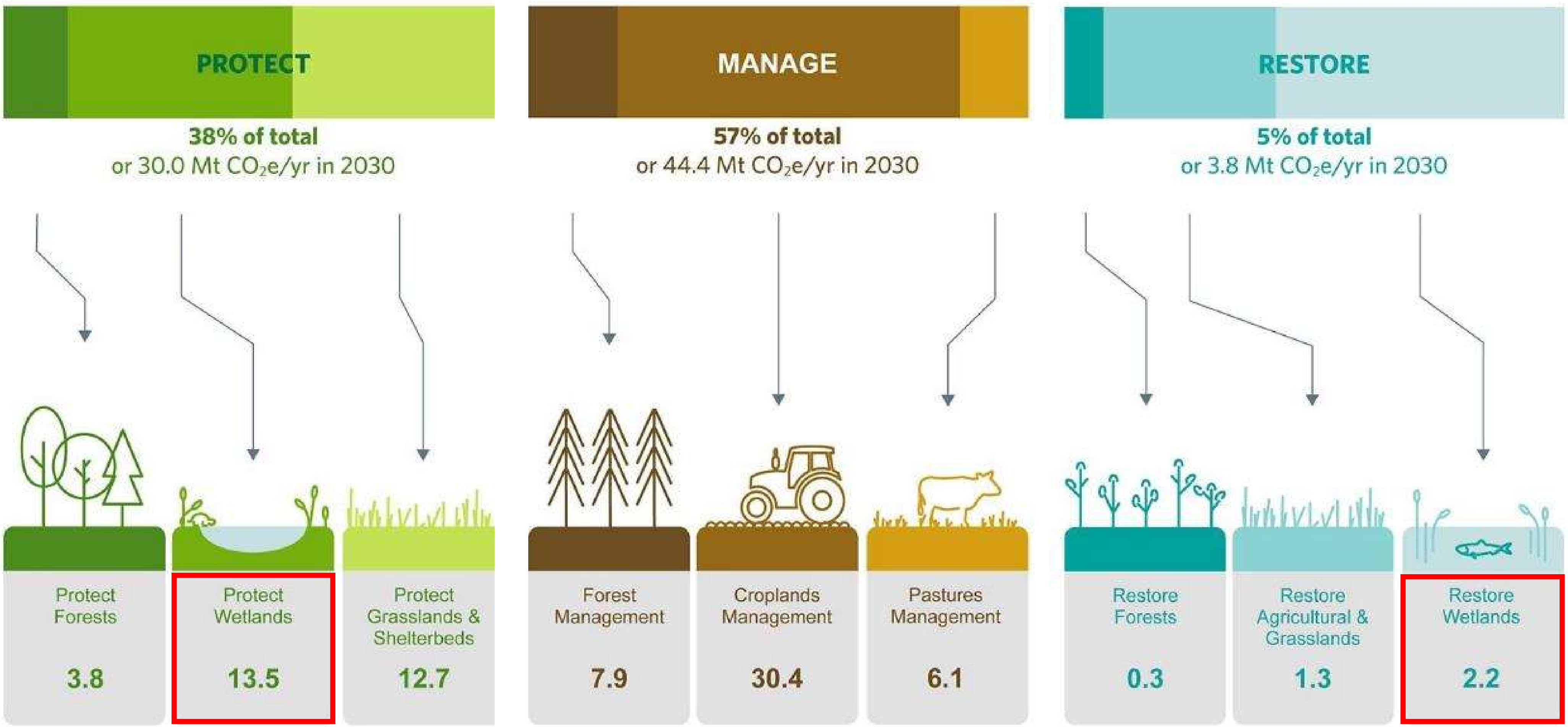

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2025 Meeting Goals

1. **Strengthen Our Community Through Shared Progress**
   To foster a stronger sense of community by sharing our progress—and the challenges we've faced—toward achieving our collective goals, creating space for open dialogue, support, and shared learning.
2. **Enhance Collaboration Within and Across Objectives**
   To respond to the community's request for deeper collaboration by identifying opportunities to connect, align, and co-create across team members and project objectives, both within and between disciplines.
3. **Mobilize Knowledge into Climate Action**
   To amplify our efforts in translating research findings into meaningful actions that inform policy and practice, supporting Canada's commitment to achieving its climate goals.

Our Core Themes (cross-cutting)

1. **Coordinate and engage** the Project Team, International Science Advisory Group, Partner Steering Committee, and stakeholders through workshops to guide strategic direction and implementation.

2. **Support decision-making** in the face of uncertainty by advancing tools, frameworks, and dialogues that help navigate complexity and risk.

3. **Mobilize knowledge** by translating research insights into accessible formats and actionable recommendations for diverse audiences.

4. **Amplify education and outreach** efforts to increase public awareness, build capacity, and inspire action on climate and sustainability goals.

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Our Core Objectives

- **OBJ1.** Develop Authoritative Estimates Of Landscape-Scale Density Of Wetland Coverage For Agricultural Landscapes
- **OBJ2.** Develop Authoritative Estimates For Rates Of OC Accumulation, GHG Fluxes To The Atmosphere, And Carbon Transports Into (And Out Of) Wetlands
- **OBJ3.** Develop Robust Estimates Of Hydrological Process Controls On OC Accumulation And GHG Fluxes From Wetlands
- **OBJ4.** Develop Robust Estimates Of The Synergies (And Conflicts) Of Wetlands As NBS For Carbon Storage Versus Other Benefits
- **OBJ5:** Use The Authoritative And Robust Estimates Of OC Accumulation And GHG Fluxes To Inform Policy And Practice Tools To Incentivize The Use Of Wetlands As NBS For Multiple Benefits In Agricultural Landscapes

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Objective 1. Wetland Mapping

Develop Authoritative Estimates Of Landscape-Scale Density Of Wetland Coverage For Agricultural Landscapes

Objective 1. Objectives

This cluster will create a wetland coverage database, including wetland gain (and loss) estimates over the past 30+ years for all agricultural landscapes in Canada.

Core team members:
Irena Creed
David Lobb
Ben DeVries
Genevieve Ali

Student and technical support.

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Objective 1. Tasks (from proposal)

- 1.1. Compile government/non-government held databases of wetland coverage across the agricultural landscapes of Canada.
- 1.2. Develop standardized estimates of landscape-scale wetland coverage in agricultural landscapes of Canada over a time series from 1984 to present.
- 1.3. Develop standardized estimates of landscape-scale rates of wetland loss (gain) associated with climate change and human modification of hydrological landscapes (i.e., drainage ditches and tile drainage).
- 1.4. Share and demonstrate wetland data products with potential users of these data—from individual farmers to government and industry organizations.

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Objective 1. Revised Tasks (from experience)

- 1.1. Compile government/non-government held databases of wetland coverage across the agricultural landscapes of Canada.
- 1.2. Develop standardized estimates of landscape-scale rates of wetland coverage in agricultural landscapes of Canada over a time series from **1970, 1990, 2005, and 2020+ (each year after 2020), with a focus on prairie pothole region, the Lake Winnipeg watershed, and the Great Lakes watershed.**
- 1.3. Develop standardized estimates of landscape-scale rates of **wetland loss (gain) (climatic variability/climate change) and wetland conversion (human modification) of agricultural landscapes**.
- 1.4. Share and demonstrate wetland data products with potential users of these data—from individual farmers to government and industry organizations.

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Progress to achieving tasks

Focus on areas that contain about 90% of wetlands on agricultural landscapes in Canada.

Source: Statistics Canada, Agriculture Division, Remote Sensing and Geospatial Analysis section, 2017. Agricultural Ecumene Boundary File – 2016.
https://open.canada.ca/data/en/dataset/317bf695-b6e2-4b60-90a8-51cd3c3d3d64

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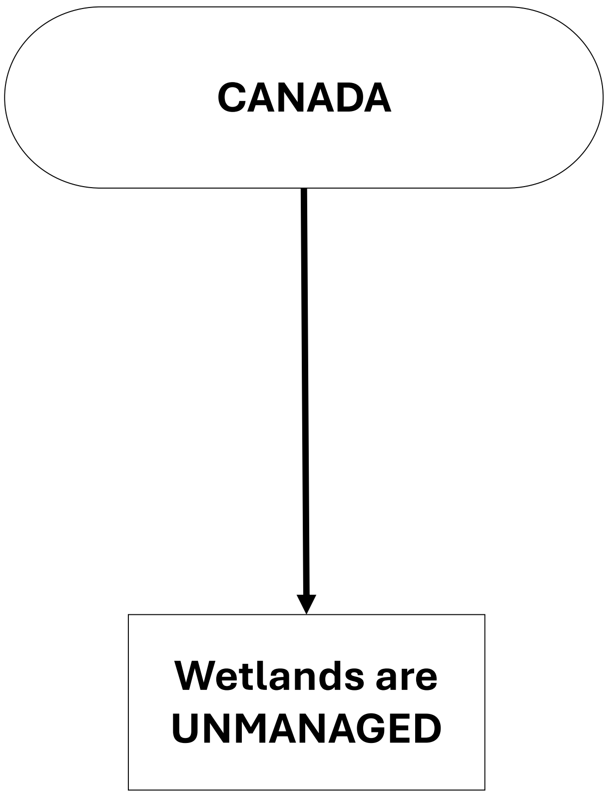
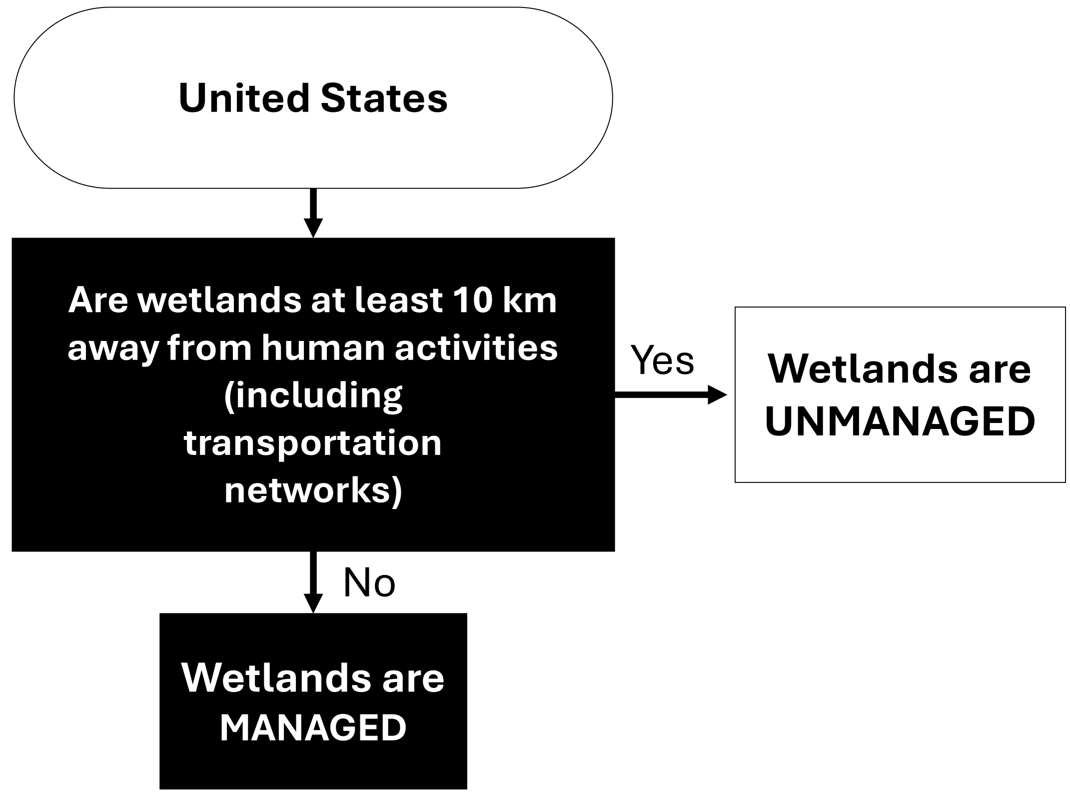
Are wetlands considered <u>managed</u> or <u>unmanaged</u>?

**In Canada,
all wetlands are considered
UNMANAGED.**



**In the United States,
most wetlands are considered
MANAGED.**



**But, even in the United States,
wetlands are still not included
in their reports.**

Are wetlands considered managed or unmanaged?

As Canada considers reclassifying wetlands from unmanaged to managed, the following factors need consideration:

1. There is a negative bias in the term "managed"; management can lead to either **positive** or **negative** outcomes in terms of carbon sequestration and GHG flux mitigation.

2. Human activity must be accounted for:
   (a) in the wetland itself, and
   (b) in the catchment contributing to the wetland.

3. The type, magnitude, and intensity of human activity must be considered.

4. The transient *vs.* permanent nature of human activities must be considered.

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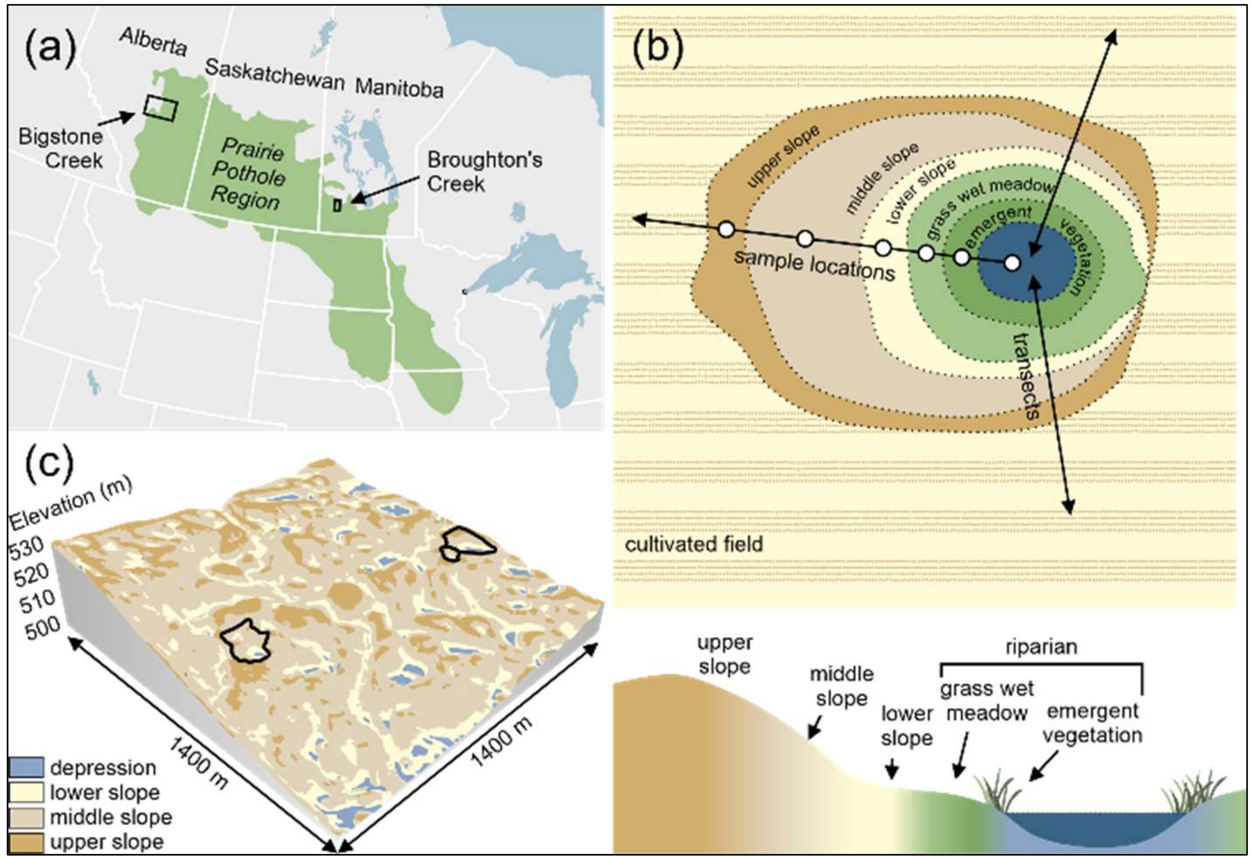
Further, upslope, wetland and downslope carbon must be tracked.

How do we define a wetland?

Photo Credit: Ducks Unlimited Canada

IPCC provides definitions, but each country can adapt them based on their specific circumstances.

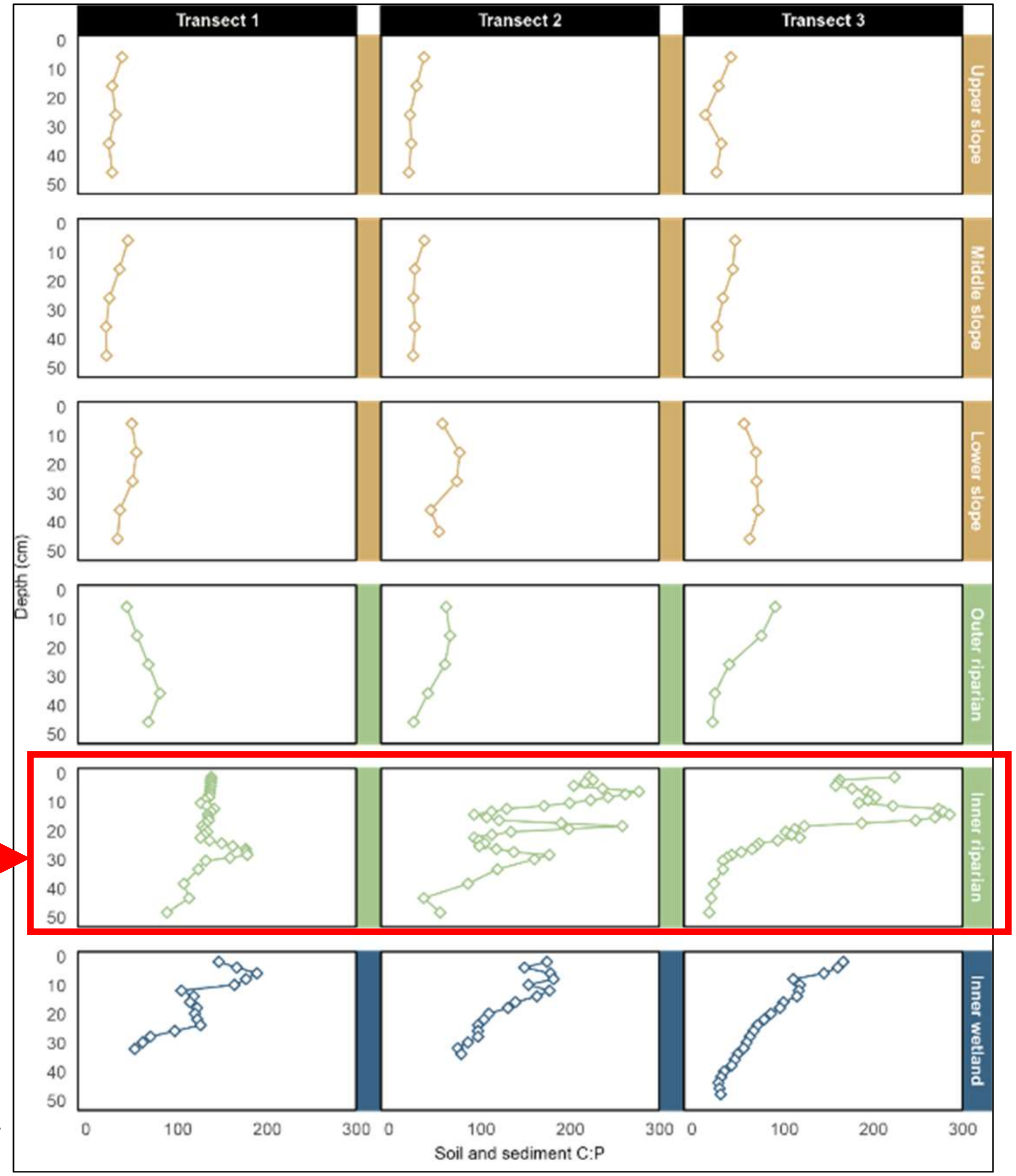
Should the definition include open water, emergent vegetation, wet meadow zone, riparian area?



Zarrinabadi et al. Under Review. Soil degradation mobilizes soil nutrients placing Canadian Prairie wetlands at risk. Soil Science Society of America Journal.

Riparian areas at slope bottoms are key accumulation sites for sediment, soil organic carbon, and soil particulate phosphorus.

Potential carbon pump?:
If riparian areas become inundated, they may switch from carbon sinks to sources



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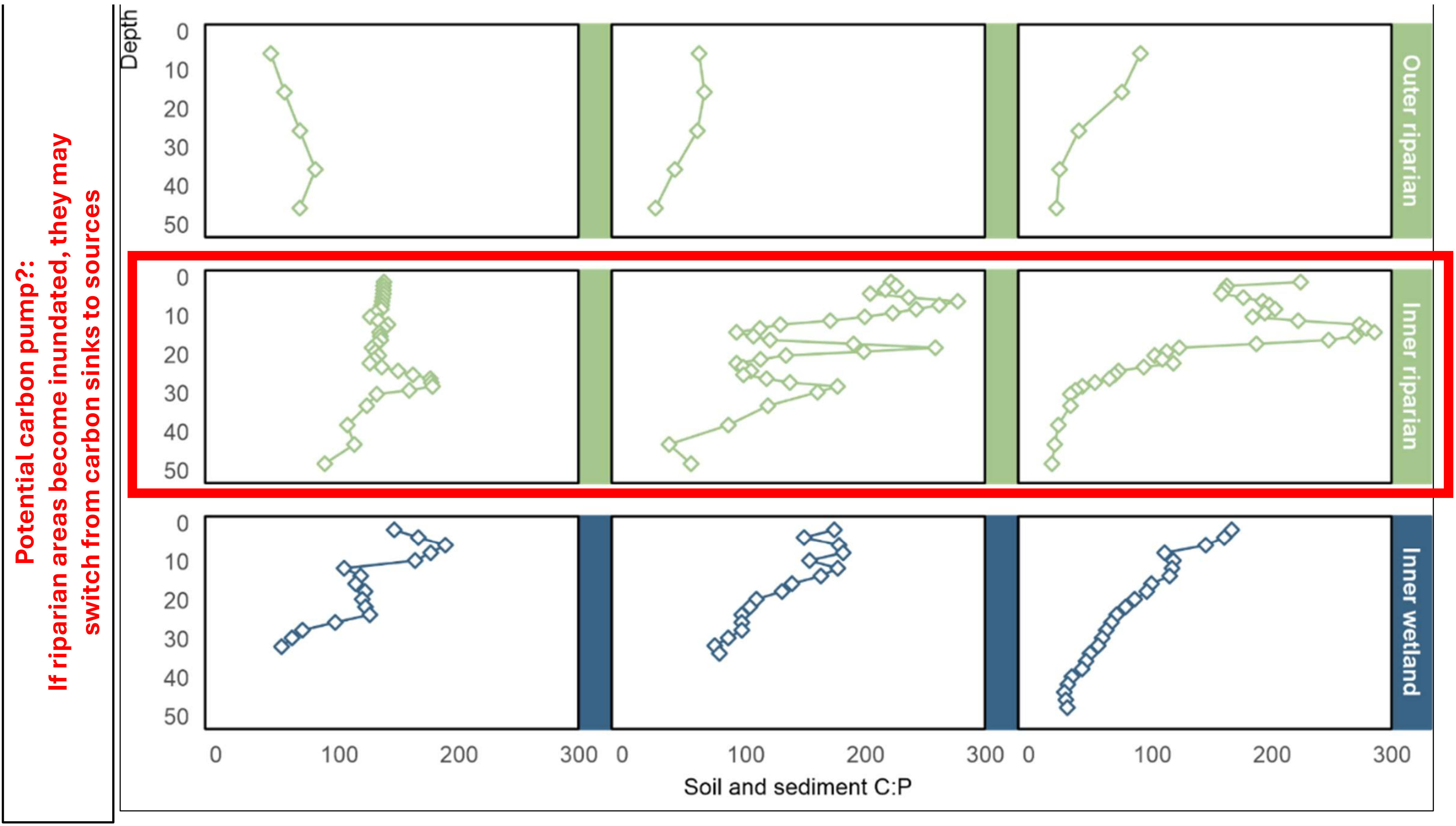
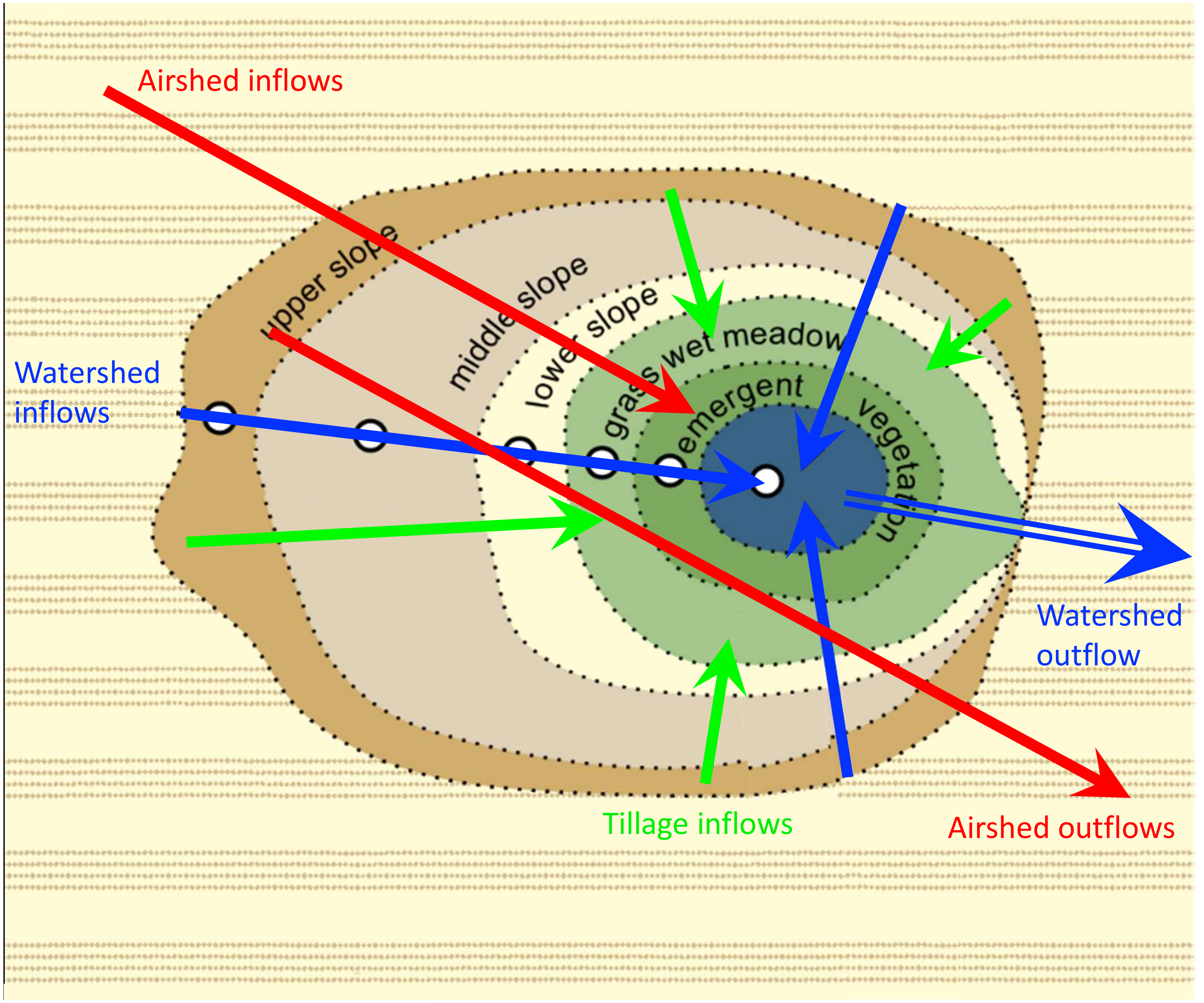

Potential carbon pump?:
If riparian areas become inundated, they may switch from carbon sinks to sources
Depth
Outer riparian
Inner riparian
Inner wetland
0
10
20
30
40
50
0
100
200
300
Soil and sediment C:P


Airshed inflows
upper slope
middle slope
lower slope
grass wet meadow
emergent
vegetation
Watershed inflows
Watershed outflow
Tillage inflows
Airshed outflows

As Canada considers reclassifying wetlands from unmanaged to managed, the following data are needed:

1990 Reference year (from Kyoto Protocol) used by Canada and other countries for emissions reporting.

1970 Residual year (reference - 20 years) used to estimate residual emissions leading up to 1990.

2005 Year used for Canada's Paris Agreement commitments and its 2030 climate targets.

2020+ Reporting years based on our work.

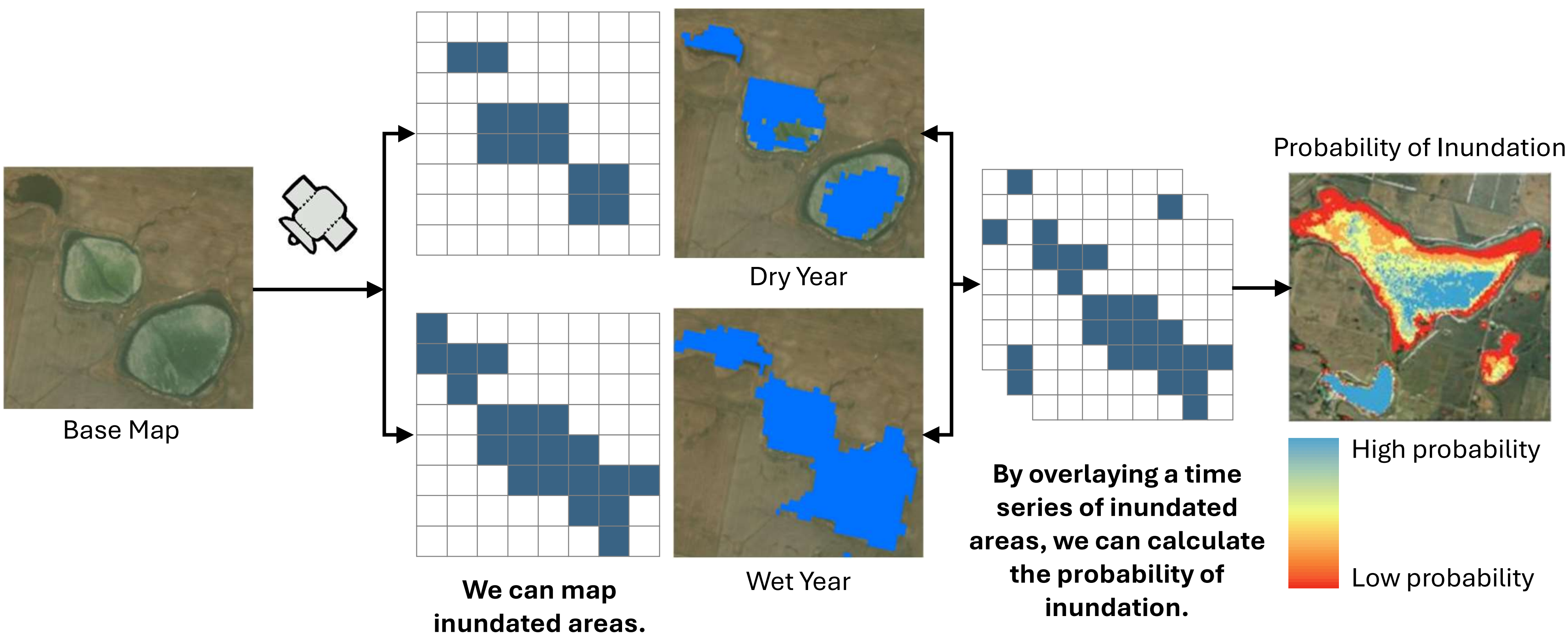
Challenge:

We want to automate updates of large-area wetland inventories to reduce the cost of boots-on-the-ground updates.

There are many satellites to map the different wetland components

Sensor	Sensor type	Open water	Emergent vegetation	Wet meadow	Riparian area	Spatial resolution	Temporal resolution
ASTER	optical	✓		✓	✓	15 m	4-6 days
GeoEye	optical	✓	✓	✓	✓	0.5-1.84 m	1.7 days
Ikonos	optical	✓	✓	✓	✓	1-4 m	3 days
Landsat MSS	optical	✓				60 m	16 days
Landsat TM, ETM, OLI	**optical**	✓				**30 m**	**16 days**
Quickbird	optical	✓	✓	✓	✓	0.65-2.62 m	1-3.5 days
RapidEye	optical	✓	✓	✓	✓	5 m	1 day
Sentinel-2	optical	✓		✓	✓	10-60 m	10 days
SPOT-1,2,3	optical	✓		✓	✓	20 m	2-3 days
SPOT-4	optical	✓		✓	✓	20 m	2-3 days
SPOT-5	optical	✓		✓	✓	10 m	2-3 days
SPOT-6/7	optical	✓	✓	✓	✓	6 m	1 days
Worldview-4	optical	✓	✓	✓	✓	1.24 m	1 day
ERS	SAR	✓		✓	✓	26 m	35 days
RADARSAT-1	SAR	✓	✓	✓	✓	8-100 m	24 days
RADARSAT-2	SAR	✓	✓	✓	✓	3-100 m	24 days
Sentinel-1	SAR	✓		✓	✓	20 m	6 days
TerraSAR-X	SAR	✓	✓	✓	✓	1-2 m	11 days
UAV	SAR	✓	✓	✓	✓	Up to 1 cm	Infrequent
Airborne	optical/SAR	✓	✓	✓	✓	Up to 1 m	Infrequent
ALOS	optical/SAR	✓	✓	✓	✓	7-154 m	14 days
ALOS-2	optical/SAR	✓	✓	✓	✓	1-3 m	14 days
JERS	optical/SAR	✓		✓	✓	18 m	44 days
Worldview-2,3	optical/SAR	✓	✓	✓	✓	1.24-1.84 m	1.1 days

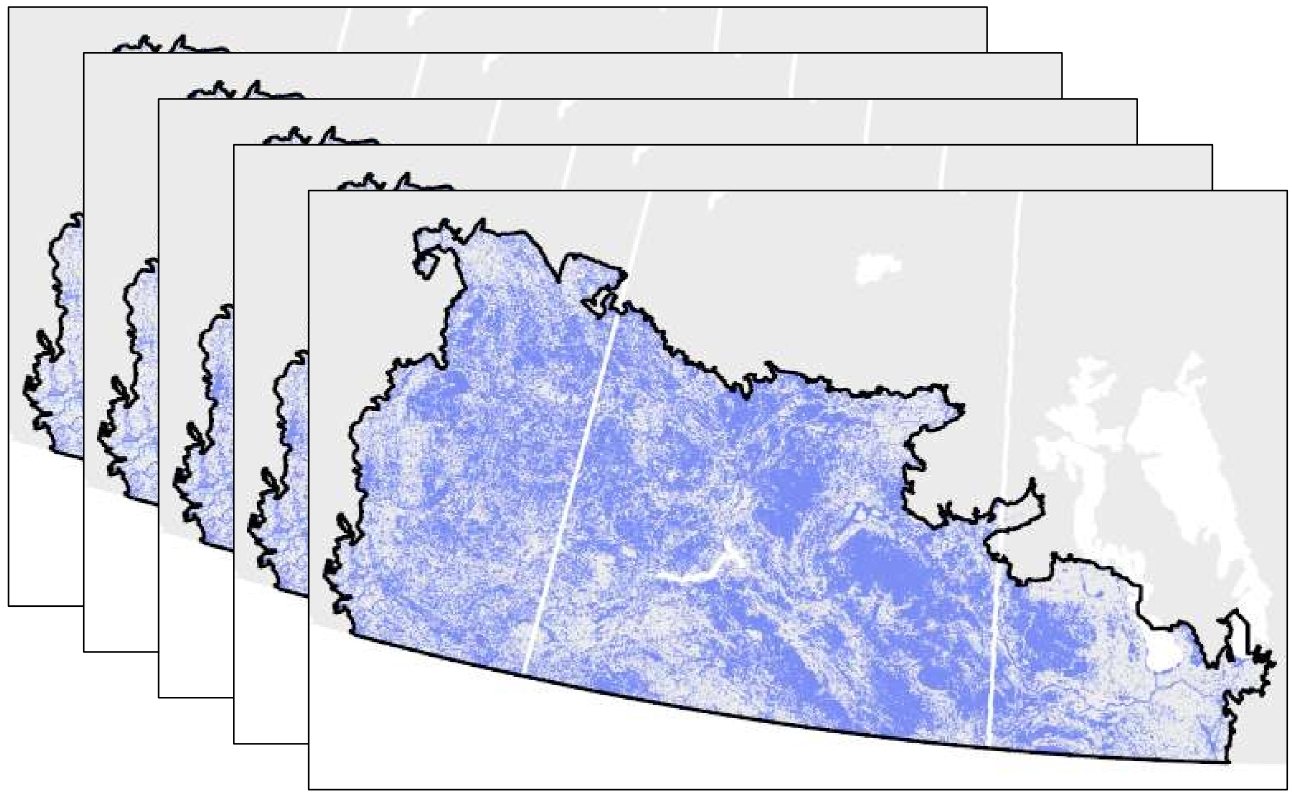
Using LANDSAT, we can map the probability of inundation.



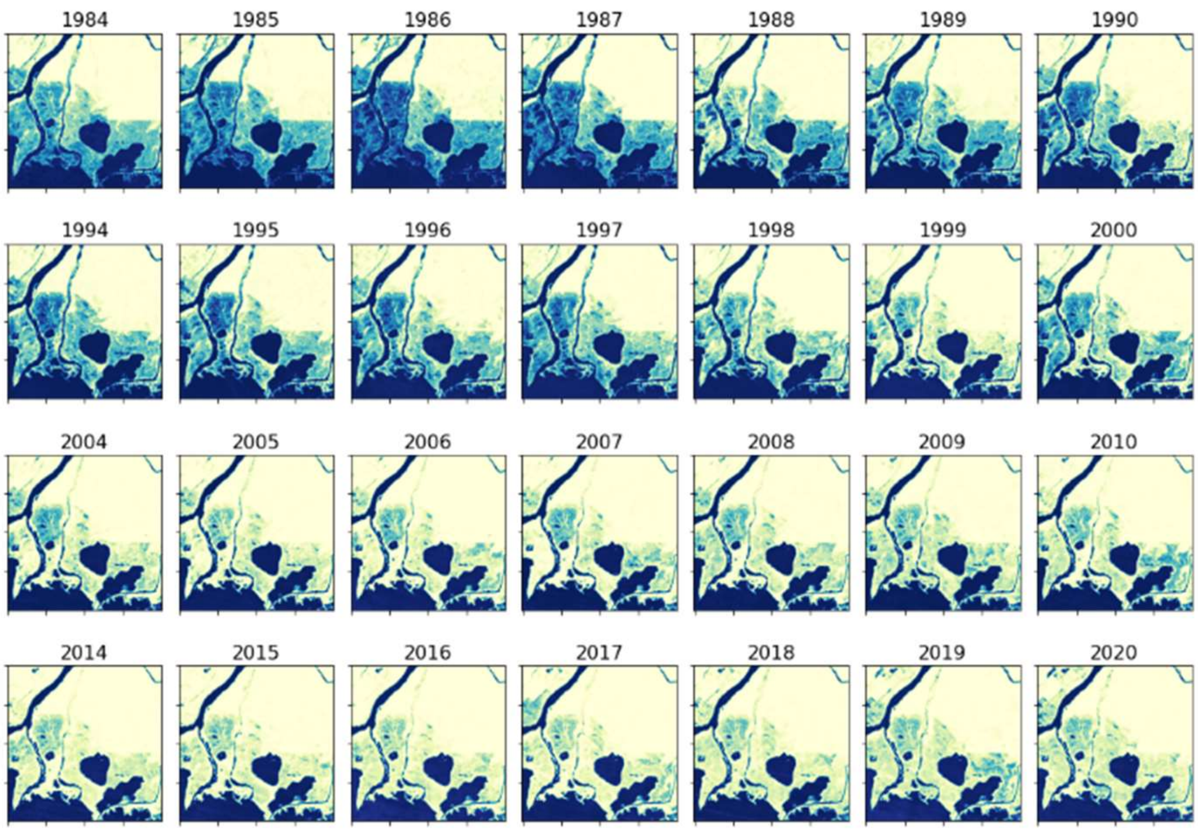
We calibrated the satellite-based inundation maps to ground-based wetland maps to create a “wetland” inventory.

We compared the temporal frequency of inundation—measured as the number of years (e.g., 1 through 10) a location was inundated within a 10-year window—with the DUC wetland inventory of catchments within the Prairie Pothole Region (PPR).

This comparison was used to develop wall-to-wall wetland coverage for the PPR.



But we can use the same data to examine within and between year variability in inundation to estimate hydroperiod dynamics, a very important driver of wetland carbon storage and GHG fluxes.



Ability to capture hydroperiod dynamics, including expansion into surround riparian areas, capturing processes that influence carbon transport/fate in contributing catchment to wetland.

DeVries et al. In prep.

With the innovation mindset of
continuously improving the wetland inventories …

We are leveraging data from next-generation sensors and applying statistical learning techniques to integrate multiple data sources—including optical and radar imagery, as well as novel geomorphometric indices derived from LiDAR.

This data fusion enhances our ability to identify and classify wetlands, ultimately enabling more accurate assessments of carbon storage and greenhouse gas (GHG) fluxes.

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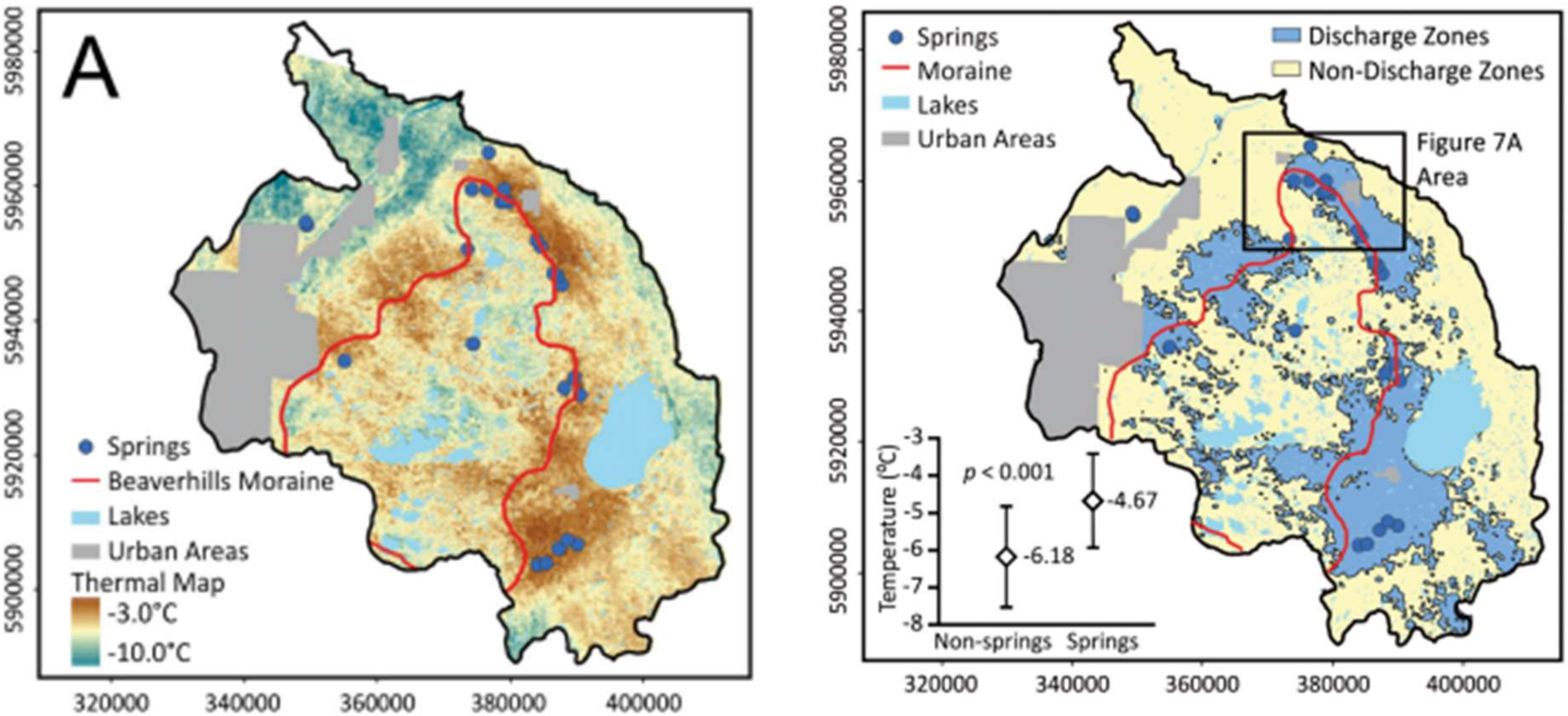
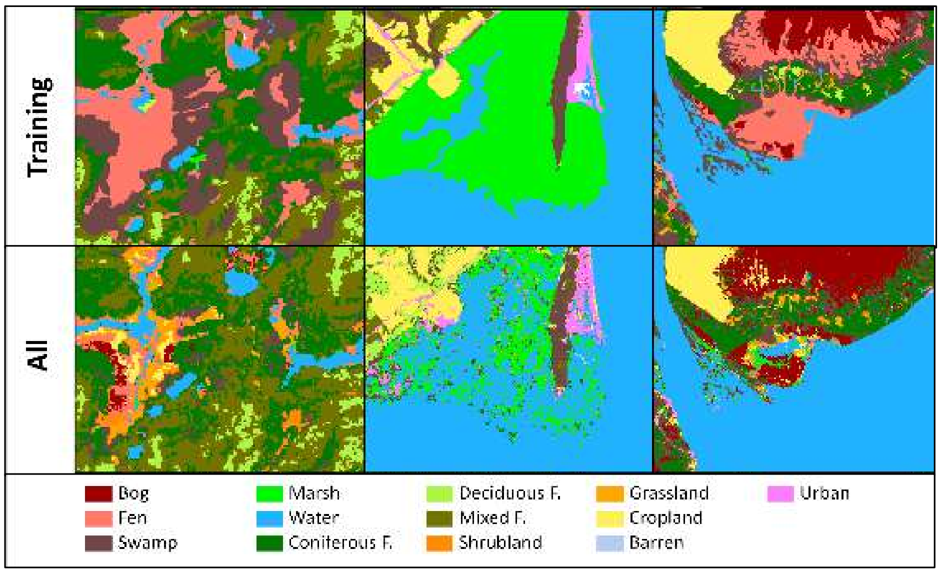
Wetland recharge vs. discharge status:
We are using Landsat thermal bands to classify wetlands as groundwater recharge or discharge wetlands.



Sass (Creed). 2014. Regional-scale mapping of groundwater discharge zones using thermal satellite imagery. *Hydrological Processes*, *28*, 5662-5673.

From wetland area to wetland type:
Using statistical learning techniques to combine
optical (Landsat seasonal composites, Sentinal-2 seasonal composites),
radar (Sentinel-1, ALOS-PALSARI1/2 annual composites), and
LiDAR data to improve wetland carbon tracking.



Further improvements needed:

- **Incorporate ancillary data like the AAFC crop map to eliminate known errors**
- **Use object-based classification to generalize "noisy" wetland features**

Lizak et al. In prep.

Collaboration between/within objectives

- Can we combine our wetland products to better estimate wetland carbon storage and GHG fluxes?

- Can we use our wetland products to generalize and scale OBJ 2 measurements for all mineral wetlands on targeted agricultural landscapes?

- Can we extend our wetland products to include mineral and peatland wetlands so that we can get wall-to-wall estimates of carbon storage and GHG fluxes for the Lake Winnipeg and Great Lakes watersheds?

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Forward-looking requests and opportunities

- What would we do if we had more resources?

- What other grants are we applying for to pursue additional opportunities?

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Anticipated impacts

- What knowledge/processes/products can we take to influence the narrative about natural climate solutions or affect change?

- What continuous improvement measures are being offered?

- What automated/repeatable/robust measurements are being offered?

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Objective 1. Objectives

This cluster will create a wetland coverage database, including wetland gain (and loss) estimates over the past 30+ years for all agricultural landscapes in Canada.

Core team members:
Irena Creed
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Genevieve Ali

Student and technical support.

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Objective 1. Tasks (from proposal)

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Objective 1. Revised Tasks (from experience)

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E.g., What would we do if we had more resources?

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Objective 2. GHG Fluxes

Develop Authoritative Estimates For Rates Of OC Accumulation, GHG Fluxes To The Atmosphere, And Carbon Transports Into (And Out Of) Wetlands

Objective 2.

This cluster will measure the exchange of GHG fluxes (CO2, CH4, and N20) between the atmosphere and the ecosystem, in wetlands on agricultural landscapes across the country.

This will combine conventional methods (chambers and dissolved gas techniques) with eddy covariance towers in wetlands. Environmental drivers of GHG fluxes will be explored and identified to inform models and management strategies for increasing wetland carbon storage while reducing GHG emissions.

Cores to quantify carbon stocks and OC accumulation will be collected at a subset of the sites to supplement others previously collected.

Team members: Pascal Badiou (DUC), Matt Bogard (U Lethbridge), Lauren Bortolotti (DUC), Gail Chmura (McGill), Irena Creed (UTSC), Larry Flanagan (U Lethbridge), Sara Knox (McGill), David Lobb (U Manitoba), Christian von Sperber (McGill).

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Objective 2. Tasks (from proposal)

- 2.1. Compile Published Information On Process Controls Of Wetland Carbon Stabilization And Published Data For All Components Of Wetland Carbon Budgets, Reconciling Differences In Estimates Due To Different Techniques/Tools.
- 2.2. Develop Standards And Protocols To Measure Wetland OC Accumulation And GHG Flux Rates.
- 2.3. Using Standards And Methodologies Developed In Task 2.2, Measure Wetland OC Accumulation And GHG Flux Rates.
- 2.4. Estimate Lateral Flows Of Carbon Into (And Out Of) Wetlands
- 2.5. Develop Models To Predict The Potential For Wetlands For OC Sequestration And GHG Reduction.

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Progress to achieving tasks

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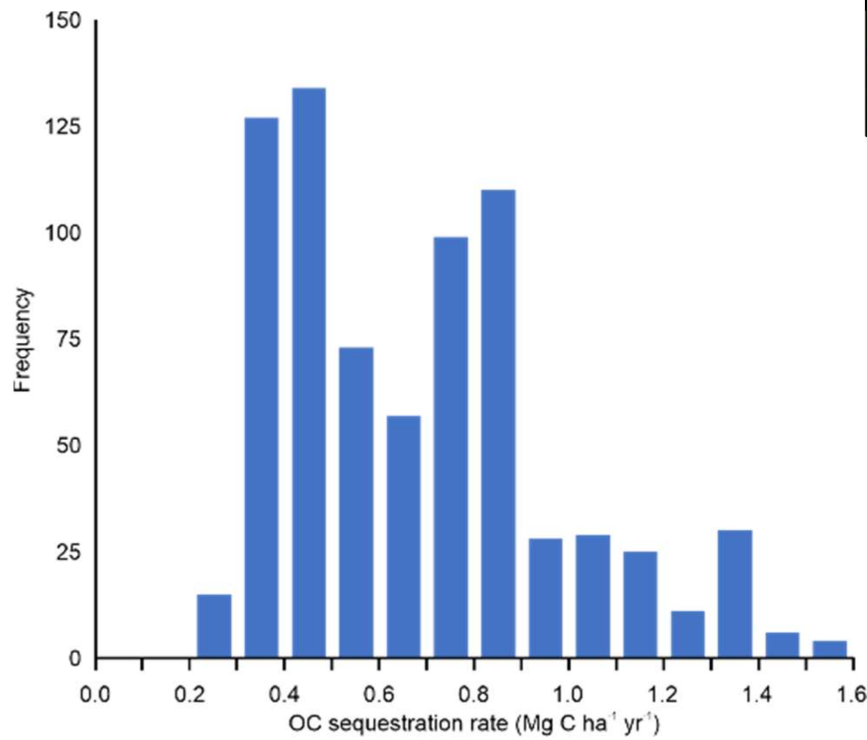
Carbon sequestration rates in undisturbed wetlands



We used ^{210}Pb and ^{137}Cs radioisotope dating to estimate the annual organic carbon (OC) sequestration rates.

21 intact wetlands, 0.03-41.55 ha,
40 sediment cores, 237 depth increments

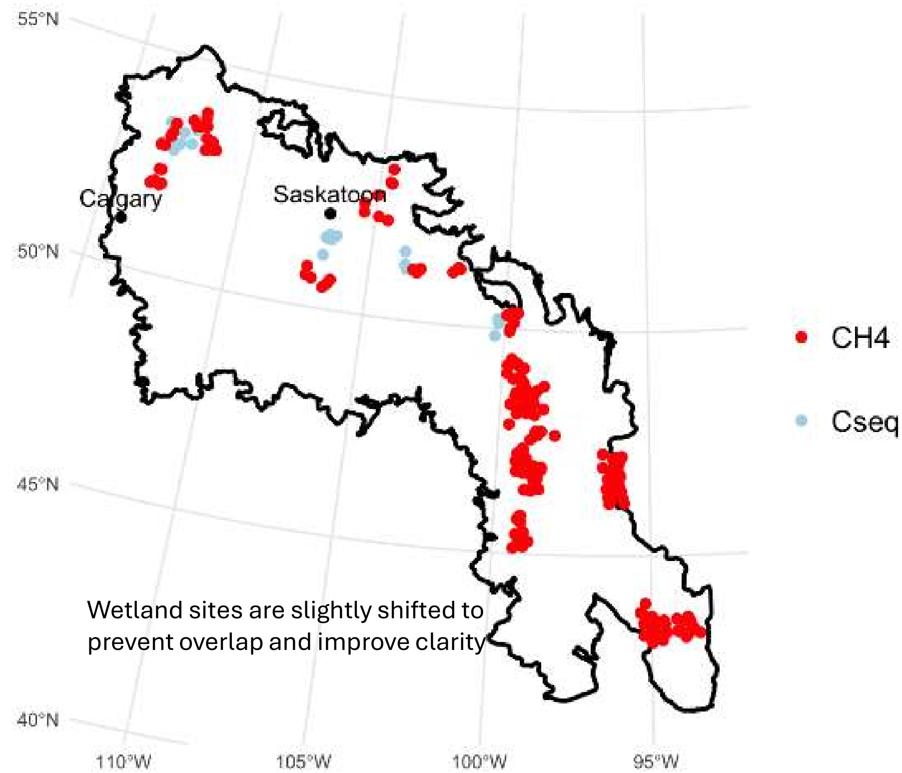
Median	**0.66 Mg ha^{-1} yr^{-1}**
Interquartile range	0.44-0.86 Mg ha^{-1} yr^{-1}

Mistry P, Creed IF, Trick CG, Enanga E, Lobb DA. 2024.
Technical note: Comparison of radiometric techniques for estimating recent organic carbon sequestration rates in inland wetland soils. Biogeosciences 21, 4699-4715.

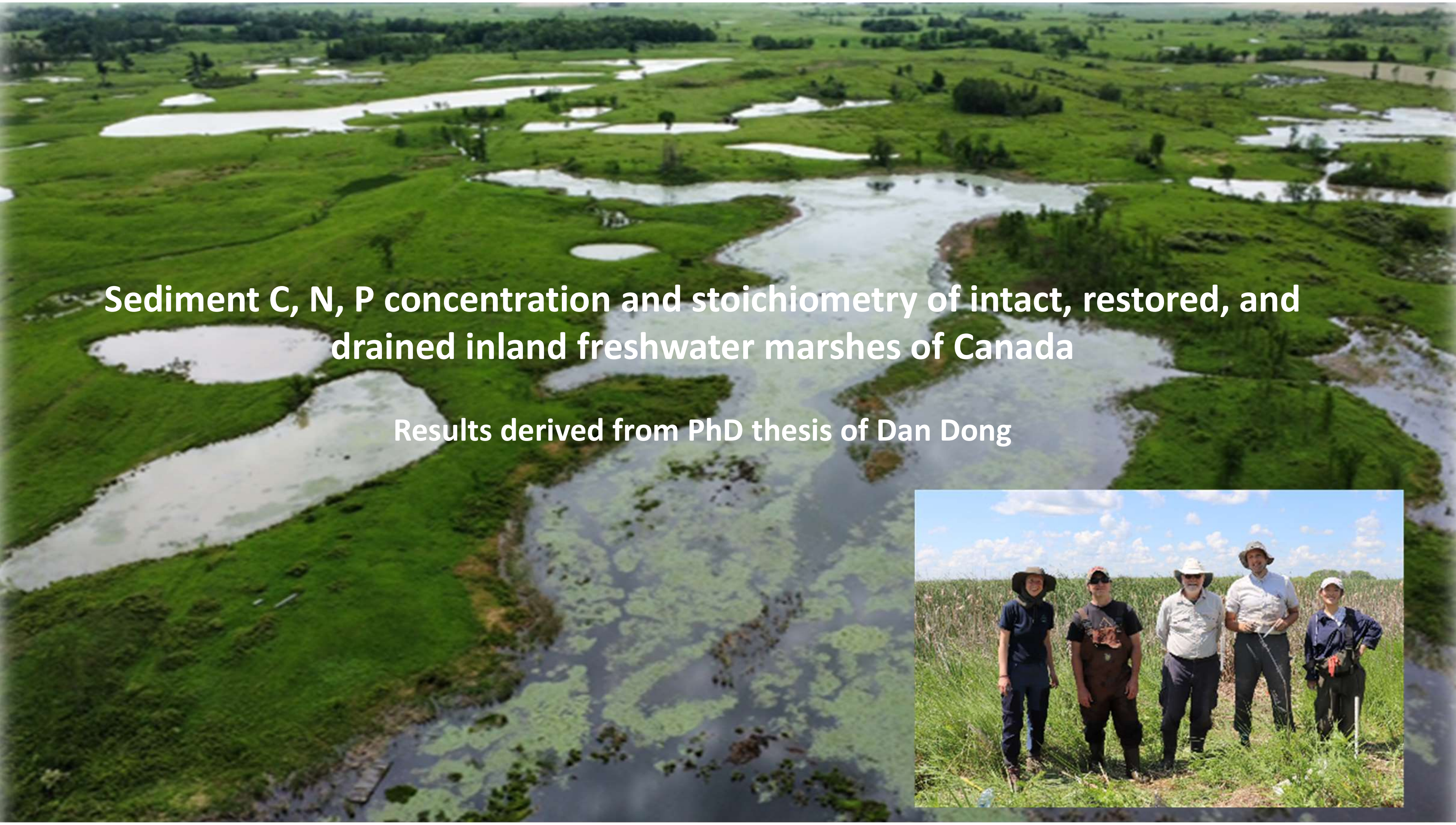
Our ground-based observations are a synthesis of data from different sources

CO_2 sequestration estimated from radiometrically dated (^{210}Pb) soil core increments
24 wetland sites (834 observations)

CH_4 fluxes estimated from chamber-based measurement techniques
202 wetland sites (490 observations)



Ma, Creed, Bansal, Badiou In Prep. Climate-induced shifts in carbon fluxes temperate inland wetlands: Implications for climate solutions.

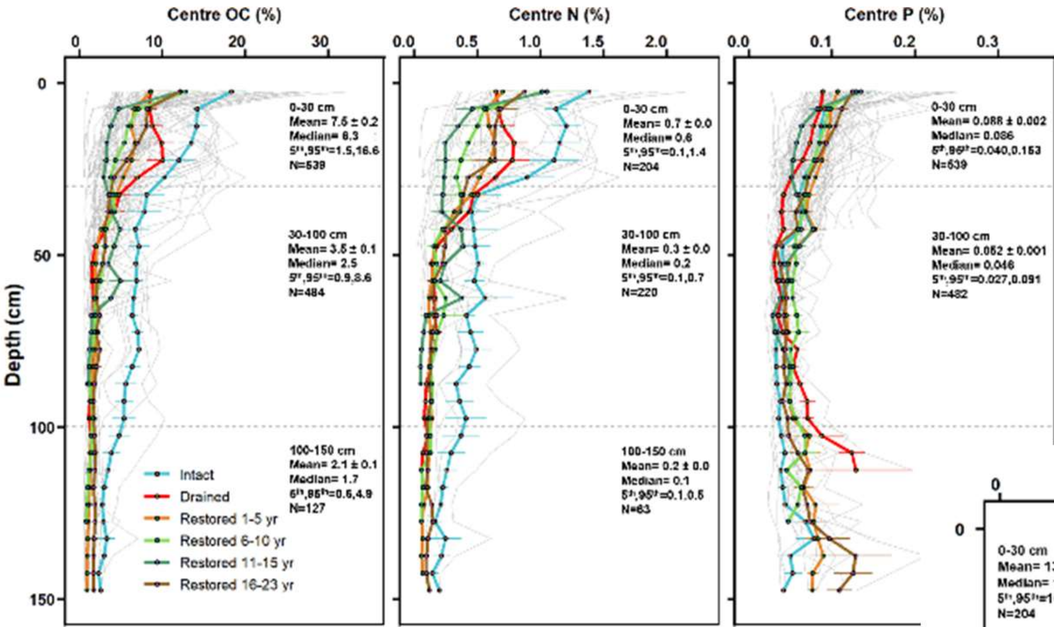


Sediment C, N, P concentration and stoichiometry of intact, restored, and drained inland freshwater marshes of Canada

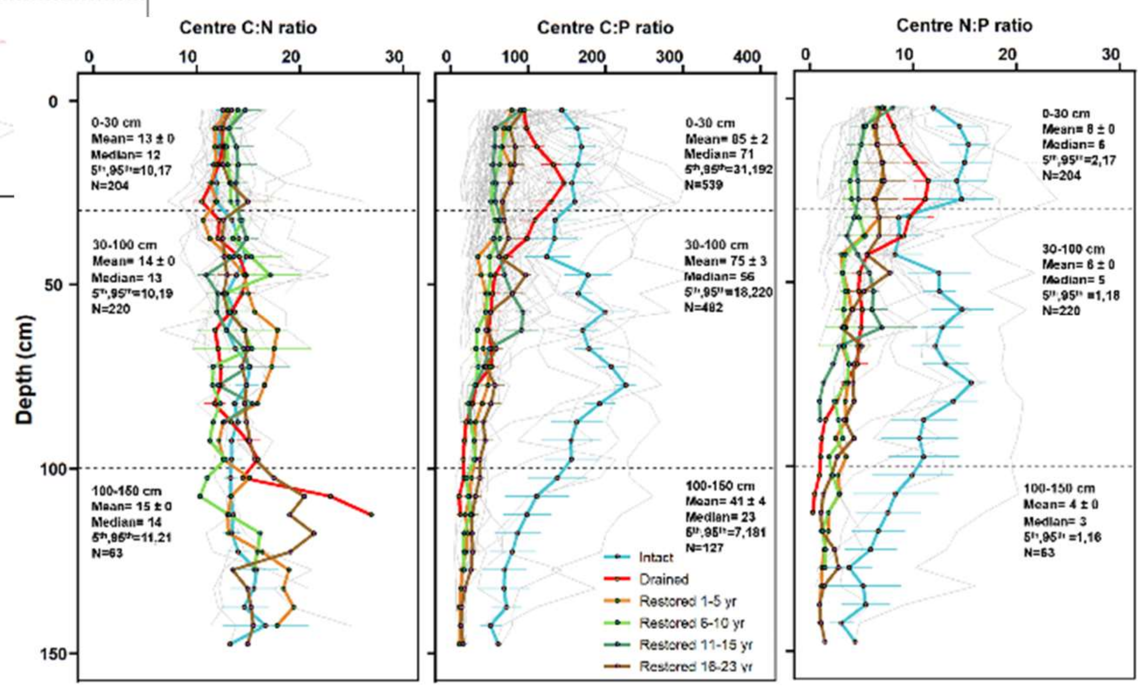
Results derived from PhD thesis of Dan Dong

Objective:
To examine the vertical and horizonal variability of C, N and P concentrations and stoichiometries in intact, drained and restored inland freshwater marshes.

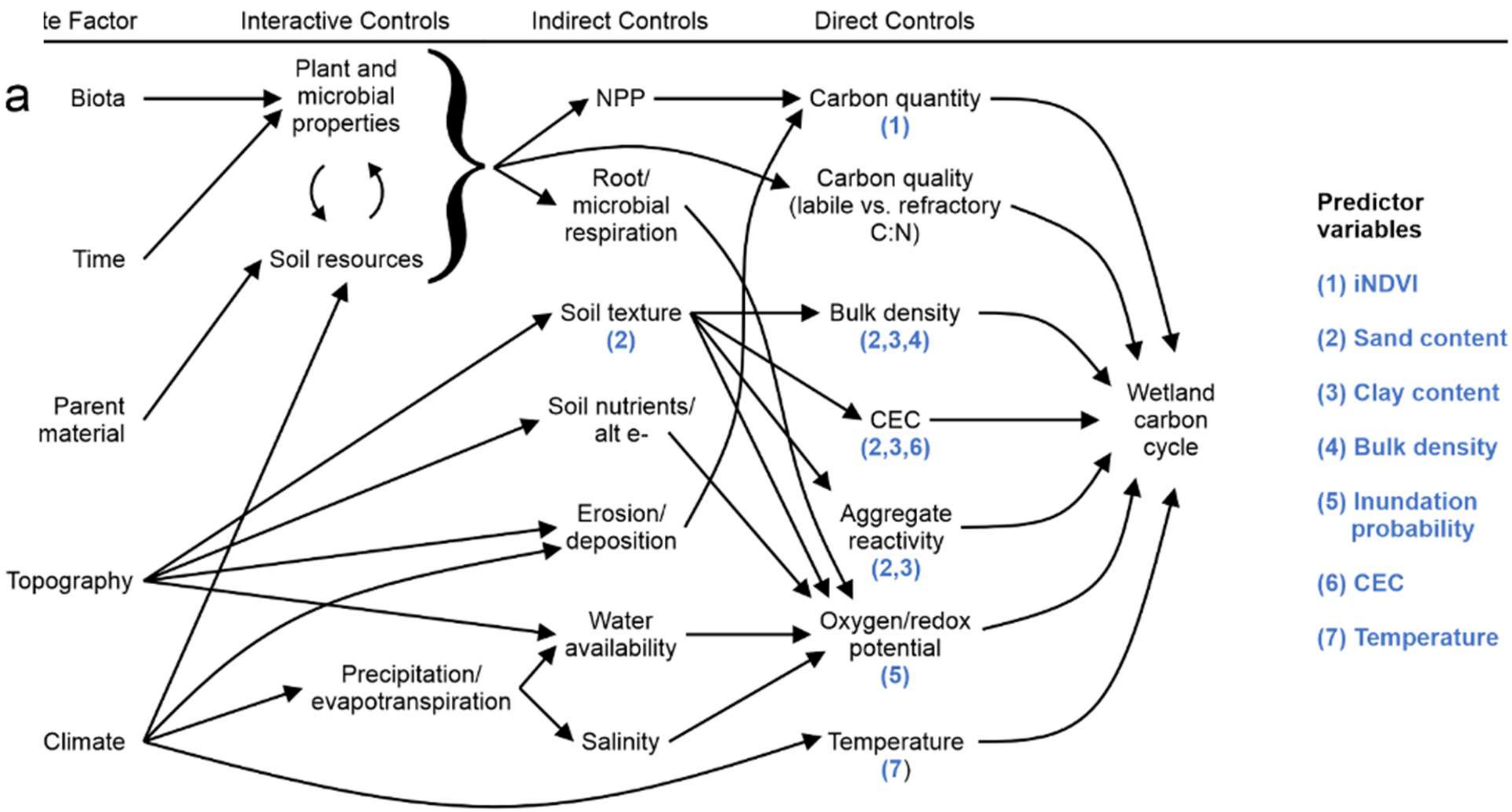
Hypothesis:
OC concentration: Intact> Restored > Drained
Distinct stoichiometric features (C:N, C:P, N:P ratios) in drained and restored marshes from intact reference due to the fertilization and rewetting disturbances.



C, N, P concentration and stoichiometric profiles of 3 intact, 3 drained and 24 restored wetlands in Camrose County, AB



System controls on carbon sequestration and GHG rates



Ma, Mistry, Badiou, Bansal, Creed. 2025. Factors regulating the potential for freshwater mineral soil wetlands to function as natural climate solutions. Wetlands 45:11.

Progress to achieving tasks

- 2.2. Develop Standards And Protocols To Measure Wetland OC Accumulation And GHG Flux Rates.
  - Pb210 and Cs137 core analysis for long-term carbon accumulation
  - Combination of dissolved gas, chamber, ebullition traps and micrometerology techniques for GHG monitoring and real-time carbon sequestration
  - Investigating dissolved gas sampling via drone (2025)
  - What about above ground and below ground biomass
  - Do we need a sub-group to harmonize protocols

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Progress to achieving tasks

- 2.3. Using Standards And Methodologies Developed In Task 2.2, Measure Wetland OC Accumulation And GHG Flux Rates.

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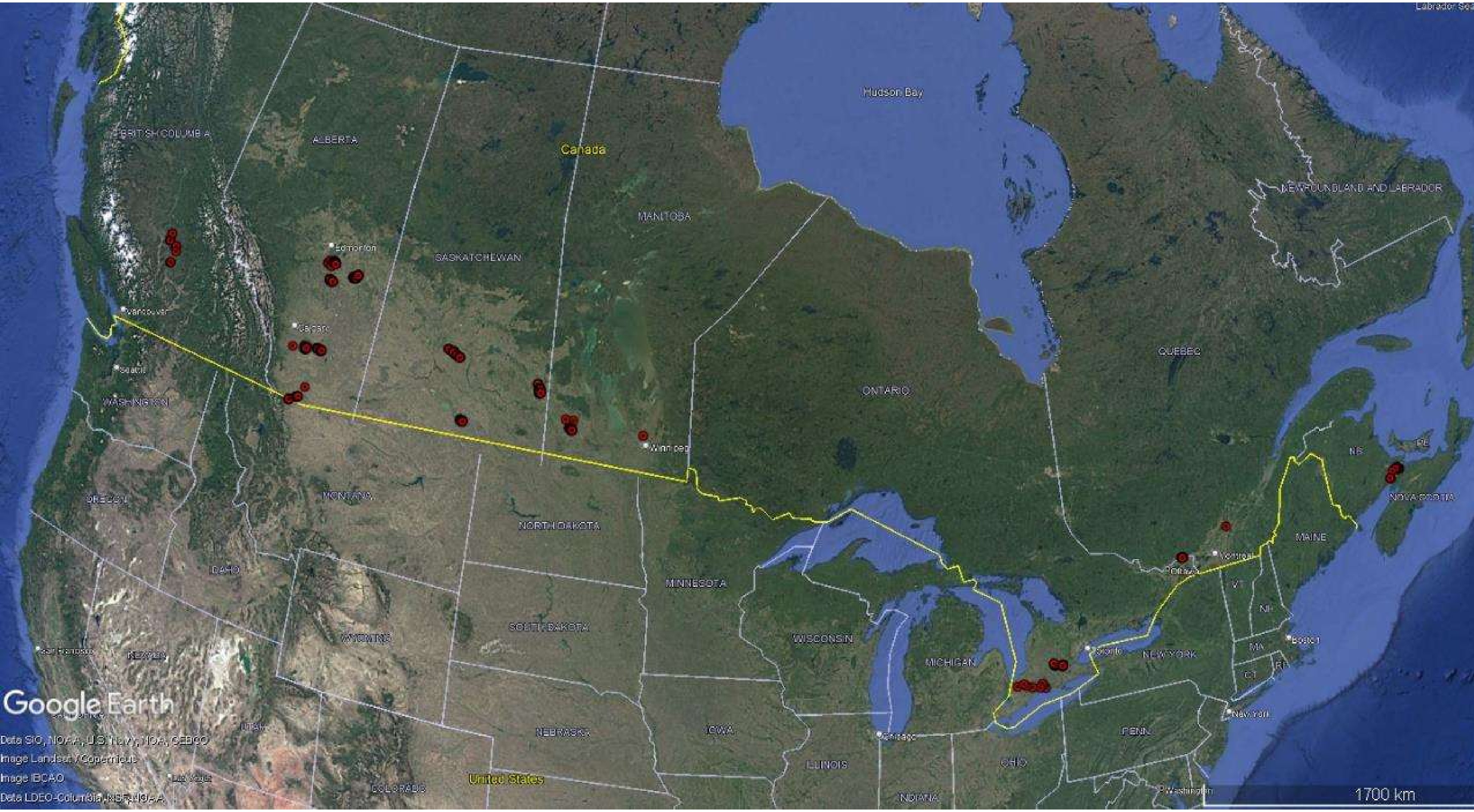
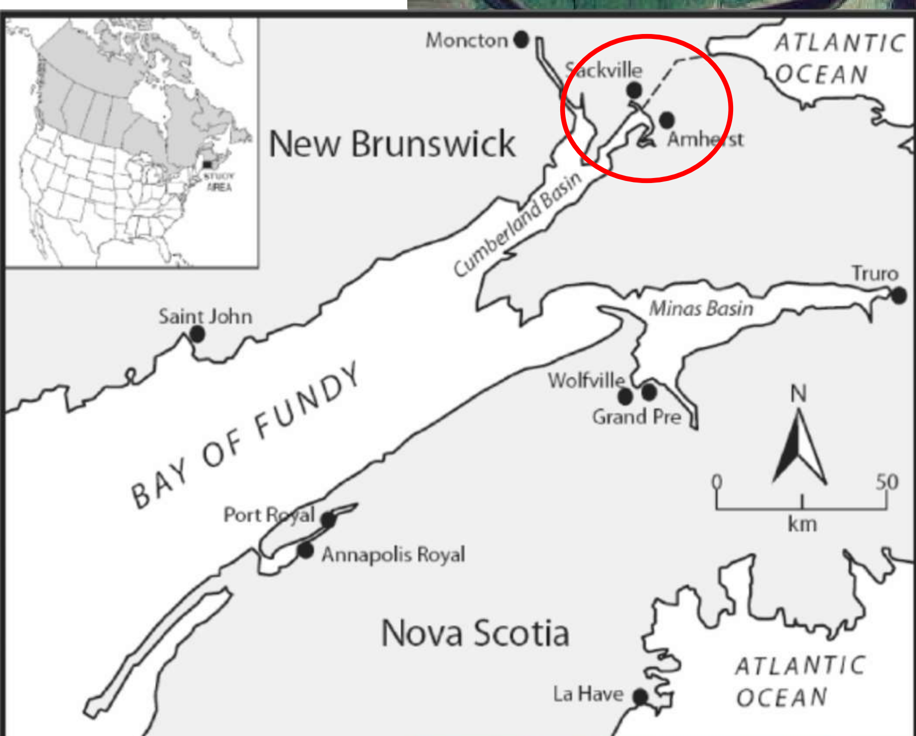
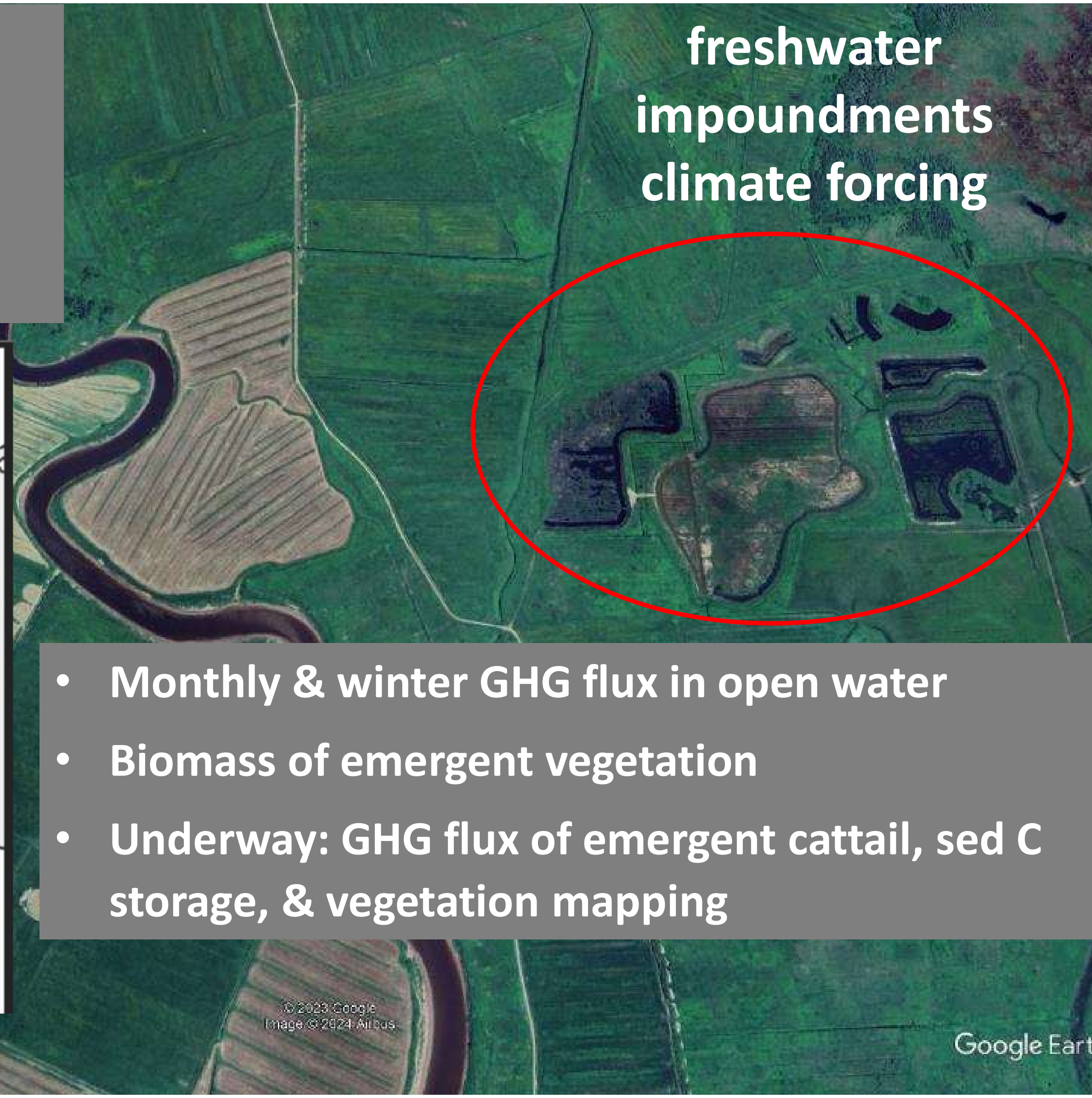
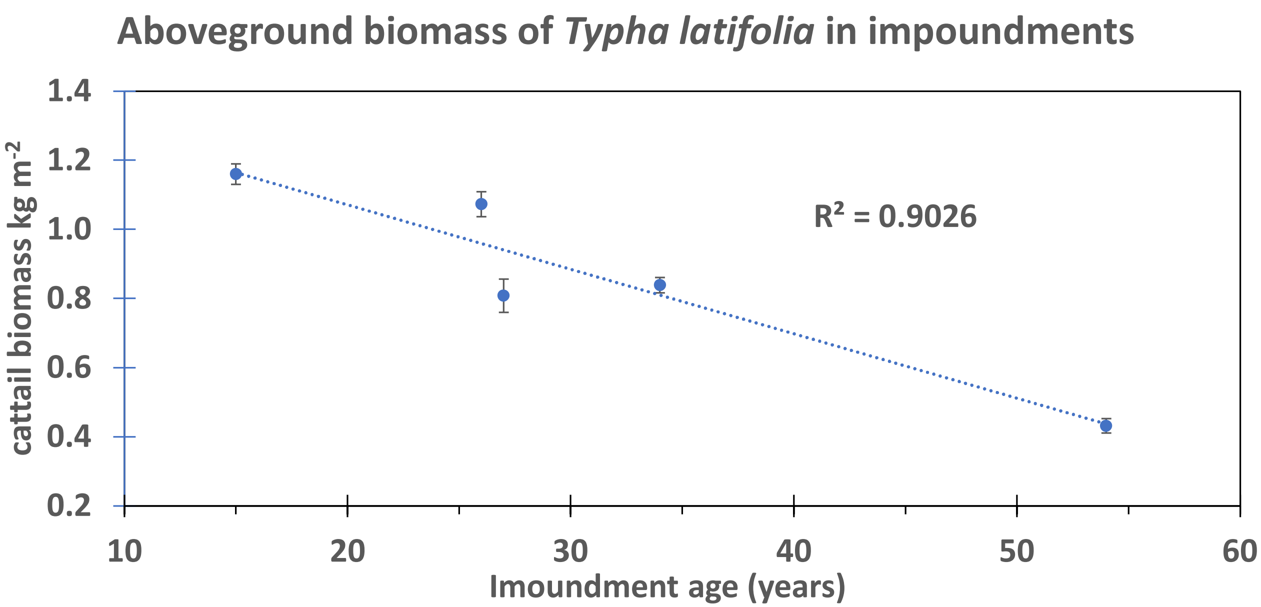

Labrador Sea
Hudson Bay
BRITISH COLUMBIA
ALBERTA
Canada
MANITOBA
NEWFOUNDLAND AND LABRADOR
Edmonton
SASKATCHEWAN
Vancouver
Calgary
QUEBEC
Seattle
ONTARIO
WASHINGTON
Winnipeg
NB
PE
MONTANA
NOVA SCOTIA
NORTH DAKOTA
MAINE
Montreal
Ottawa
IDAHO
MINNESOTA
VT
NH
WISCONSIN
SOUTH DAKOTA
WYOMING
Toronto
NEW YORK
Boston
MA
MICHIGAN
CT
RI
Google Earth
NEBRASKA
IOWA
New York
PENN
Chicago
ILLINOIS
OHIO
United States
COLORADO
INDIANA
Washington
1700 km
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Image IBCAO
Data LDEO-Columbia, NSF, NOAA

PI Gail Chmura, McGill University
With Ph.D. students
Wendy Ampuero-Reyes & Arunabha Dey
MSc. Student Rachel Plant





- **Monthly & winter GHG flux in open water**
- **Biomass of emergent vegetation**
- **Underway: GHG flux of emergent cattail, sed C storage, & vegetation mapping**

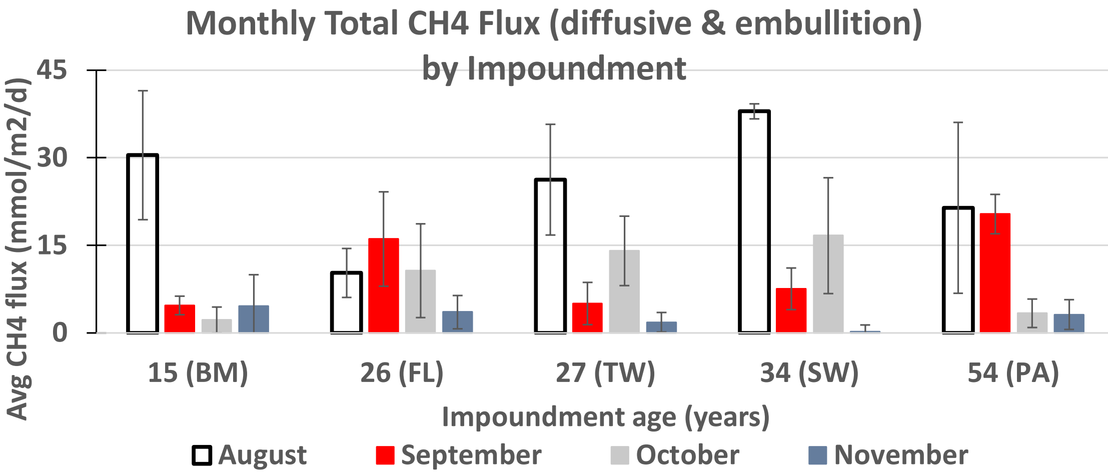


Equation for estimating *Typha latifolia* biomass in a culm*:*

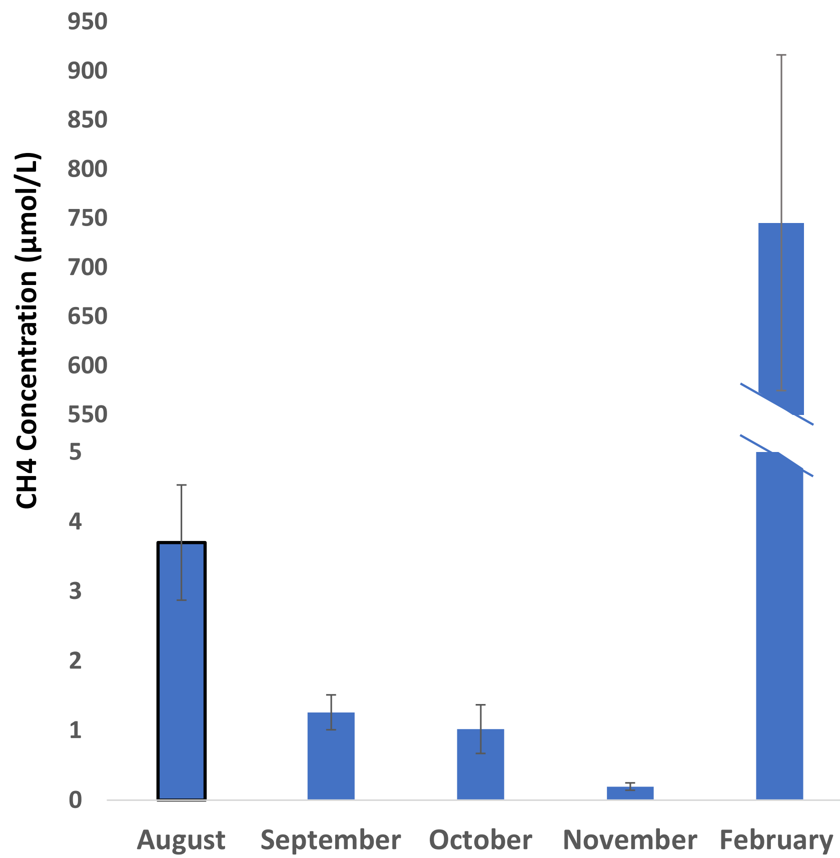
leaves & average length of leaves within a culm together are statistically significant predictors of biomass:

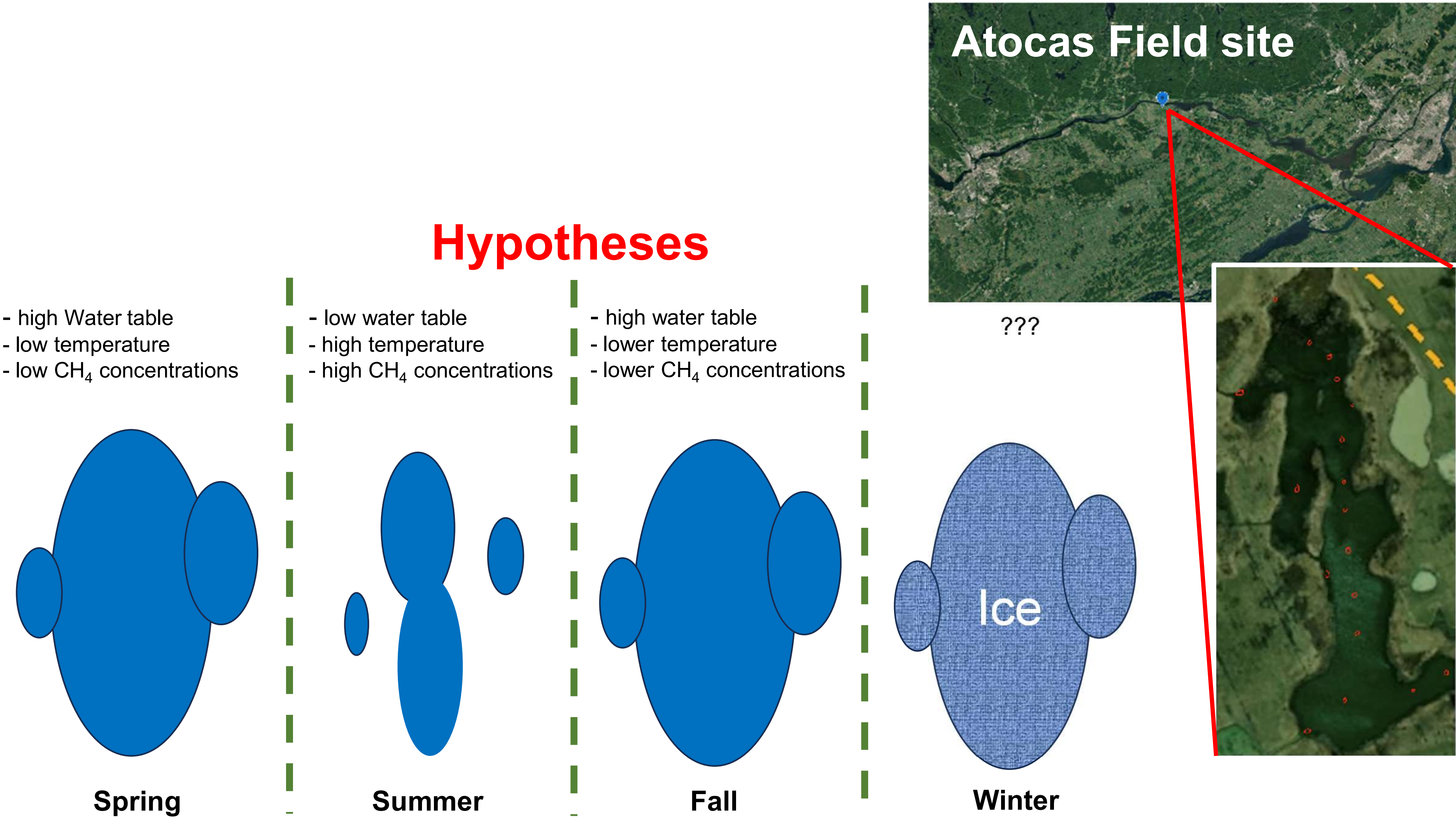
R^2= 68%, p <0.001

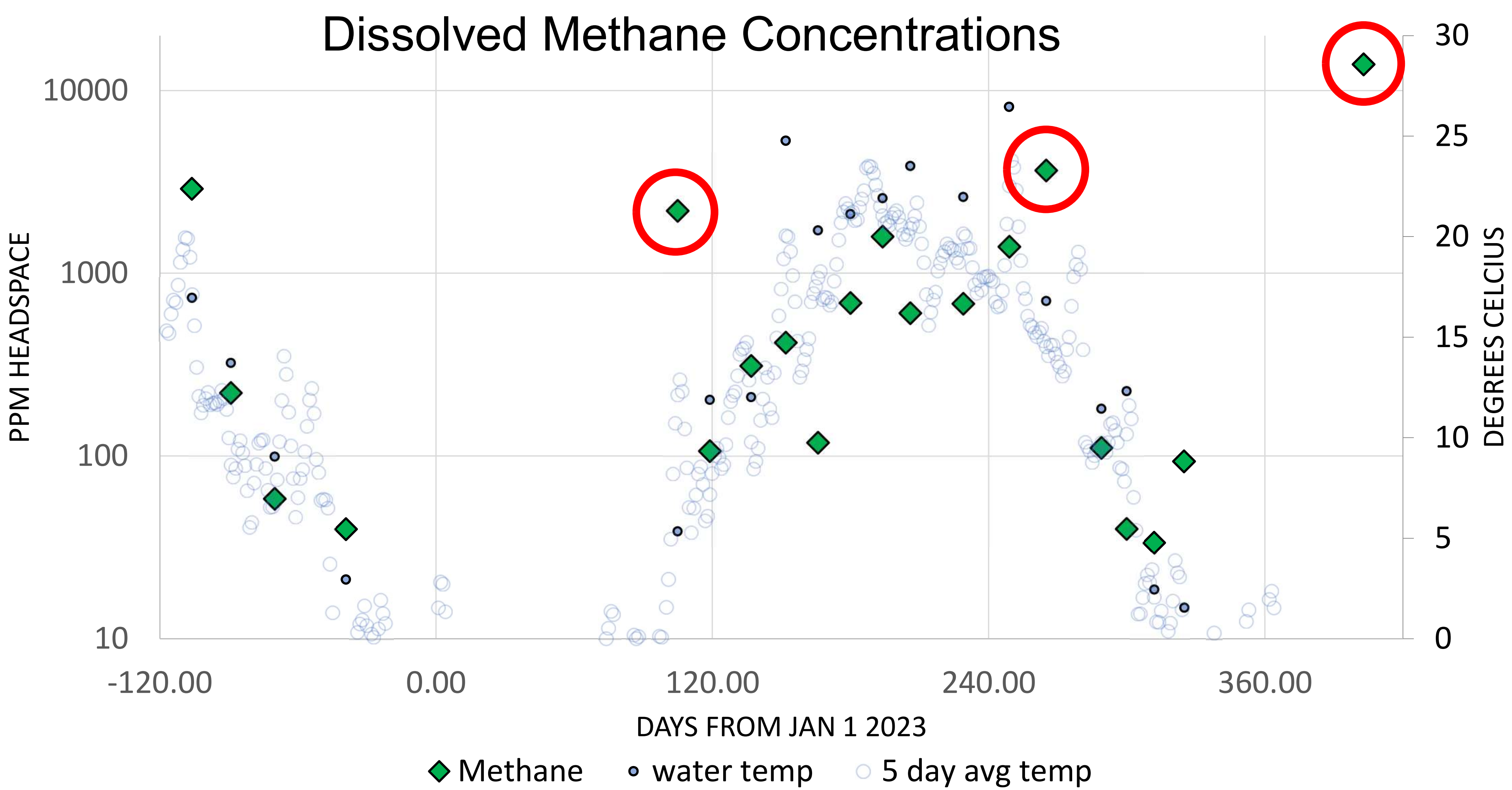
Culm Biomass (g) =-48.855 + (2.262 x #leaves) + (35.204 x Avg length, cm)



Average concentration of CH_4 in water of all impoundments by sample month

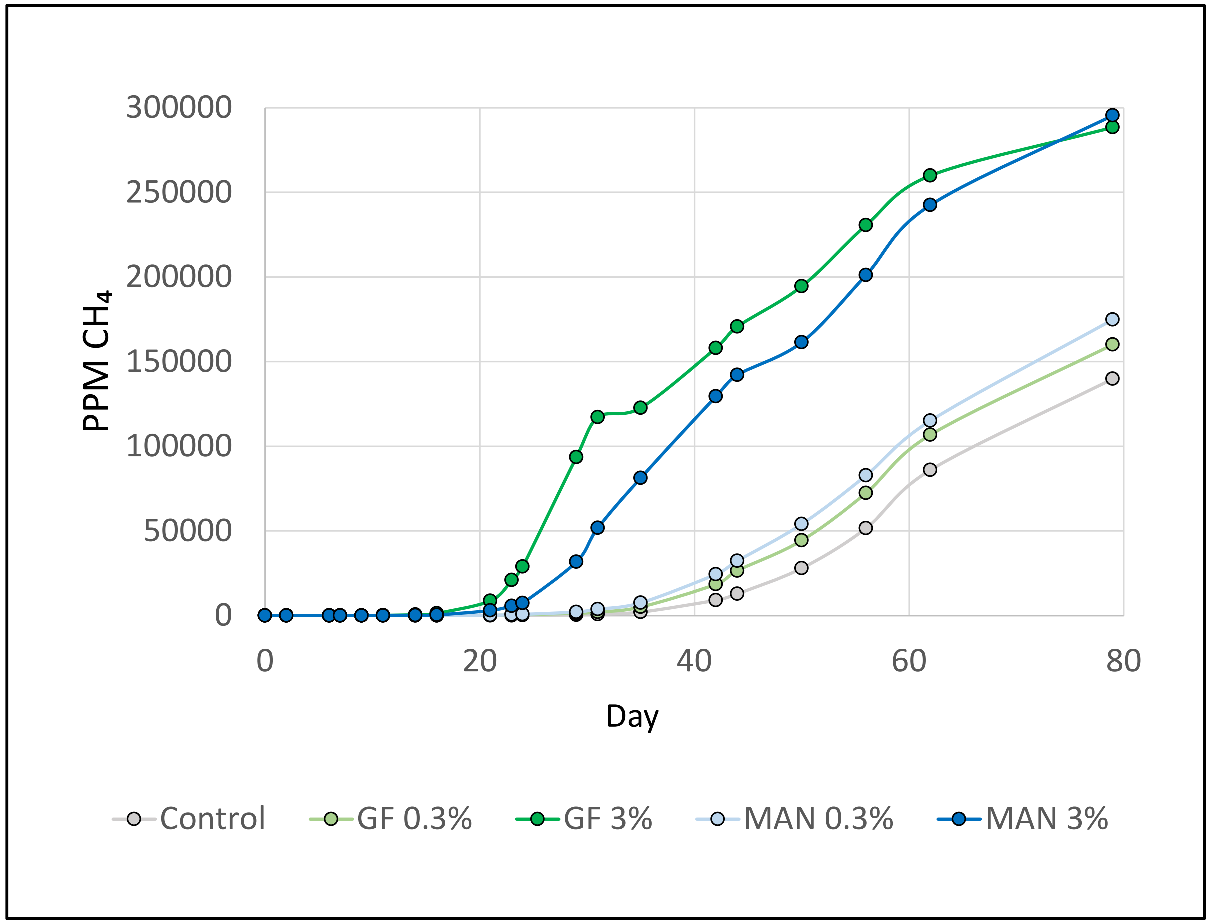



Atocas Field site
???
Hypotheses
- high Water table
- low temperature
- low CH4 concentrations
- low water table
- high temperature
- high CH4 concentrations
- high water table
- lower temperature
- lower CH4 concentrations
Ice
Spring
Summer
Fall
Winter



Dissolved Methane Concentrations
PPM HEADSPACE
10000
1000
100
10
DEGREES CELCIUS
30
25
20
15
10
5
0
-120.00
0.00
120.00
240.00
360.00
DAYS FROM JAN 1 2023
Methane
water temp
5 day avg temp

Soil incubations with Goose Feces (GF) and Manure (MAN)



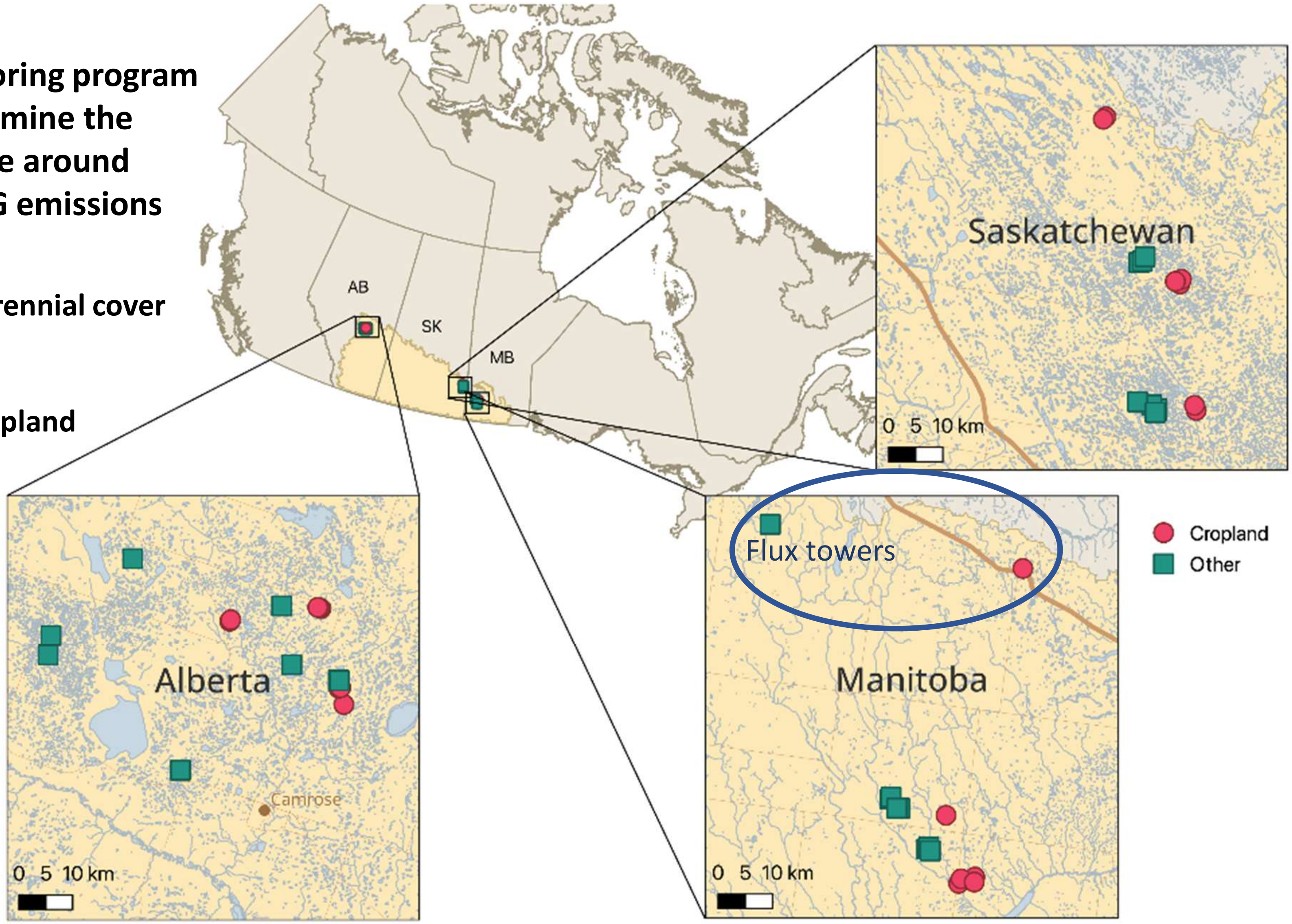
Extensive monitoring program in the PPR to examine the impact of landuse around wetlands on GHG emissions

Wetlands in perennial cover

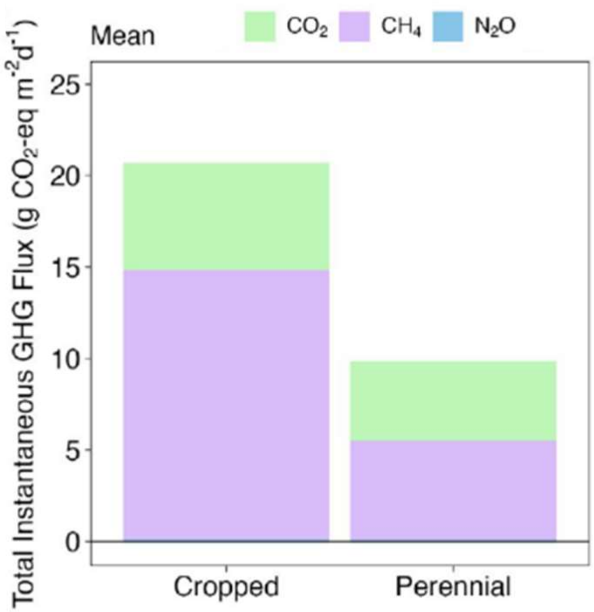
- **↑SO4 ↓TP**

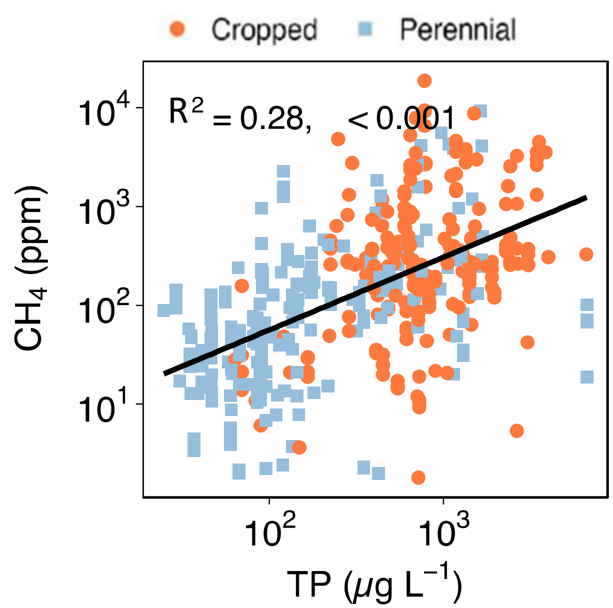
Wetlands in cropland

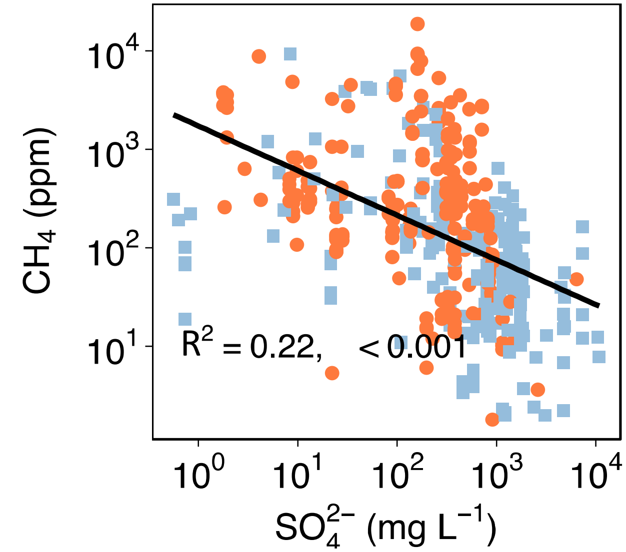
- **↓SO4 ↑TP**



CH_4 fluxes are higher in wetlands in cropland







Conserving Canada's *Wetlands*

Logozzo et al., in review

Bogard Lab Overview

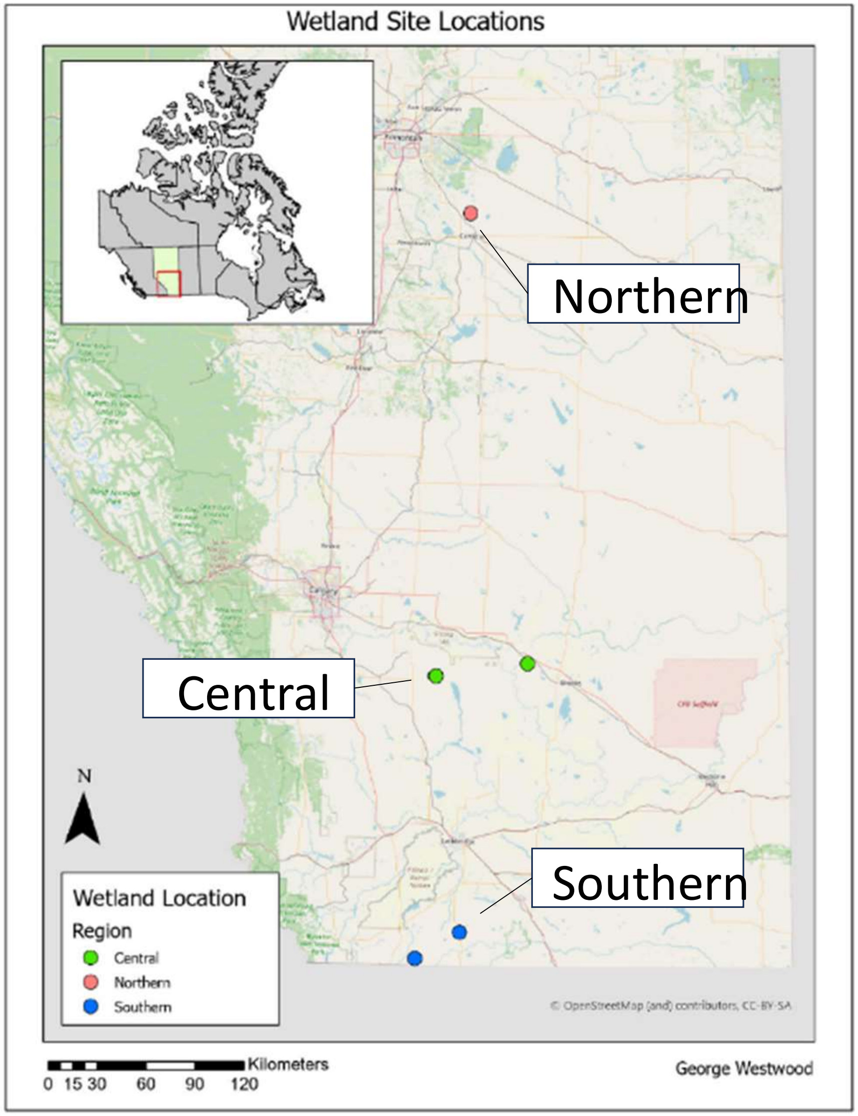
Sites

We assessed wetlands sites from three regions between 2021 - 2024 within the southern Alberta PPR.

- Northern (N)
- Central (C)
- Southern (S)

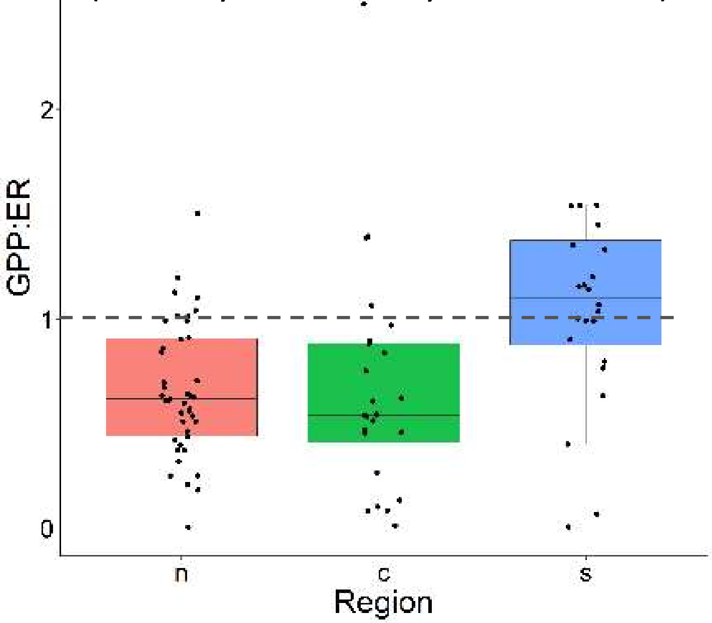
Summary of Variables

- Dissolved oxygen (DO)
- Water quality data
- Dissolved organic carbon (DOC)
- Dissolved inorganic carbon (DIC)
- O2 and H2O isotopes
- GHG emissions

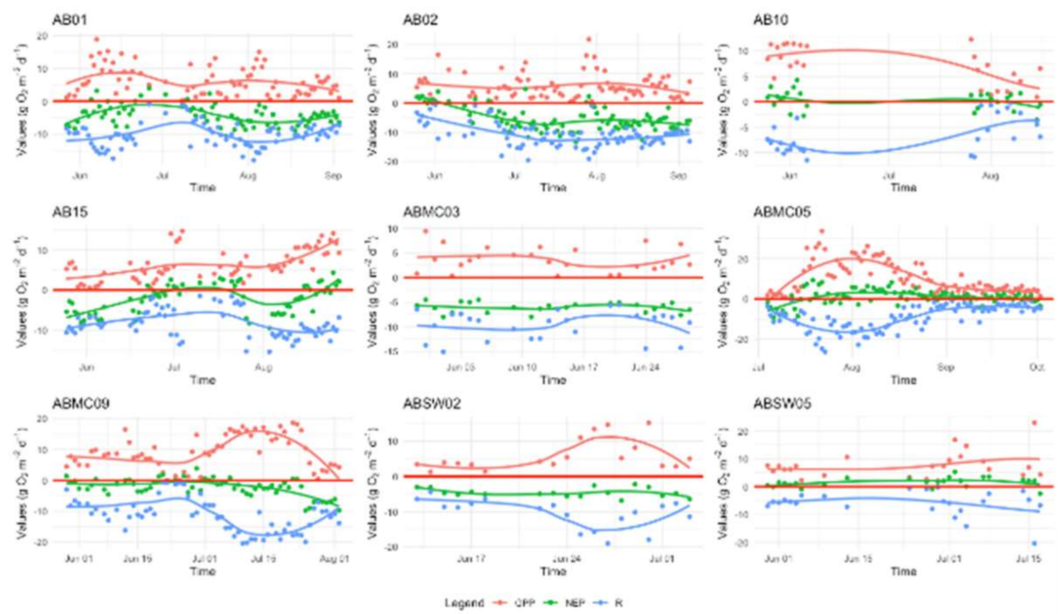


Metabolism varied between and among regions

From our stable isotope samples (monthly to bi-weekly at more sites):

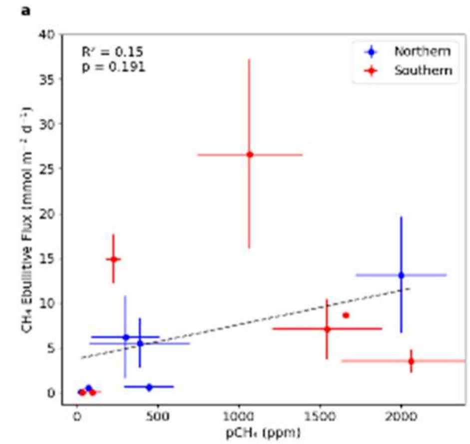


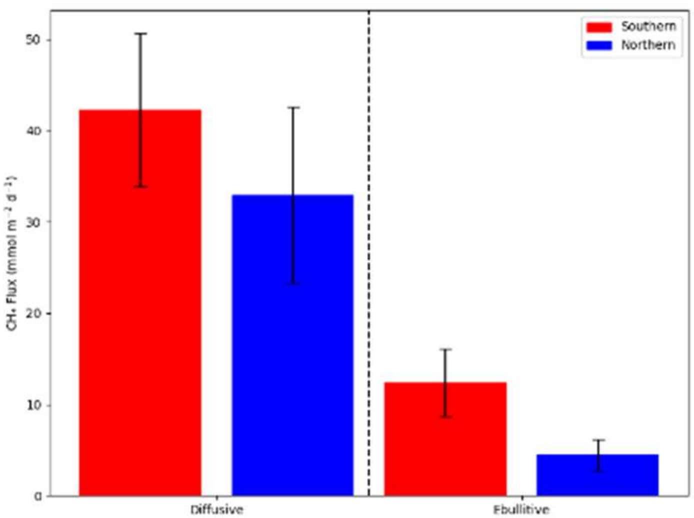
From our sensor deployments at select sites (daily metabolism):

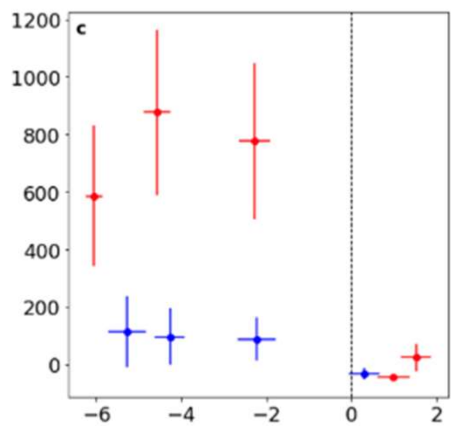


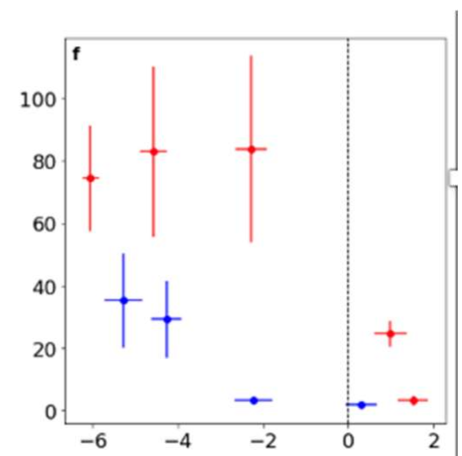
- GPP exceeded ER in southern zone (autotrophic)
- Correlates with carbon availability, emissions patterns (next slide)

Adding Ebullitive Emissions To the Story

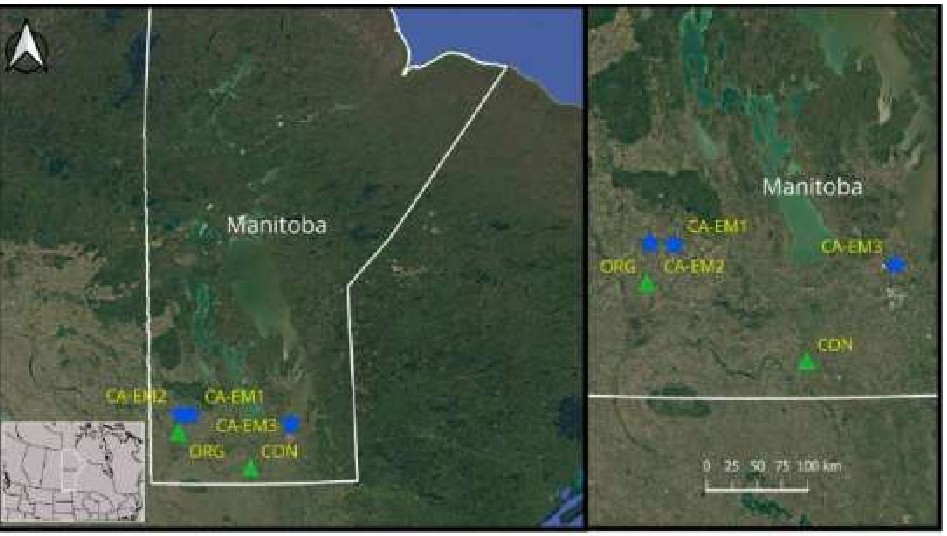




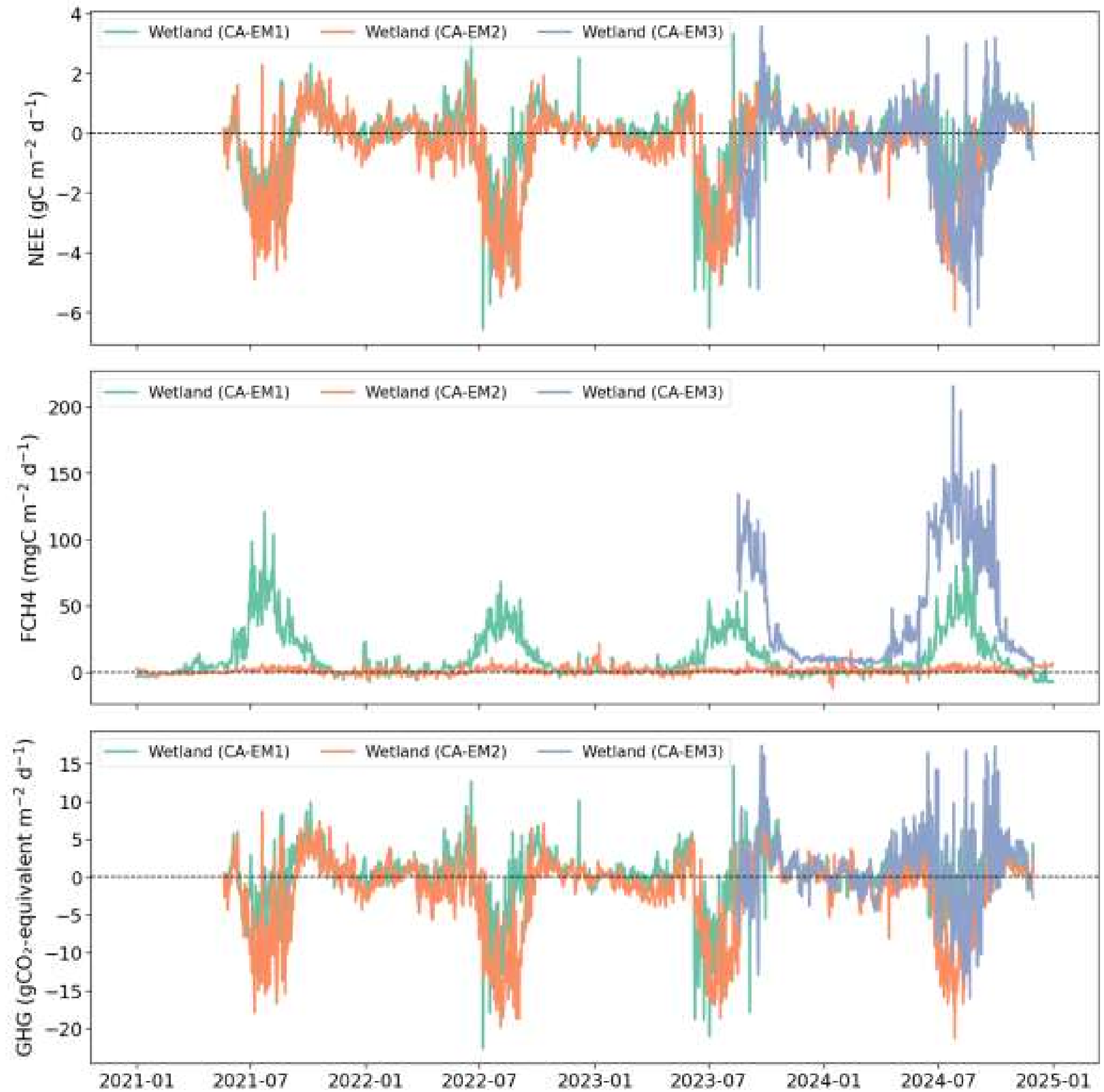




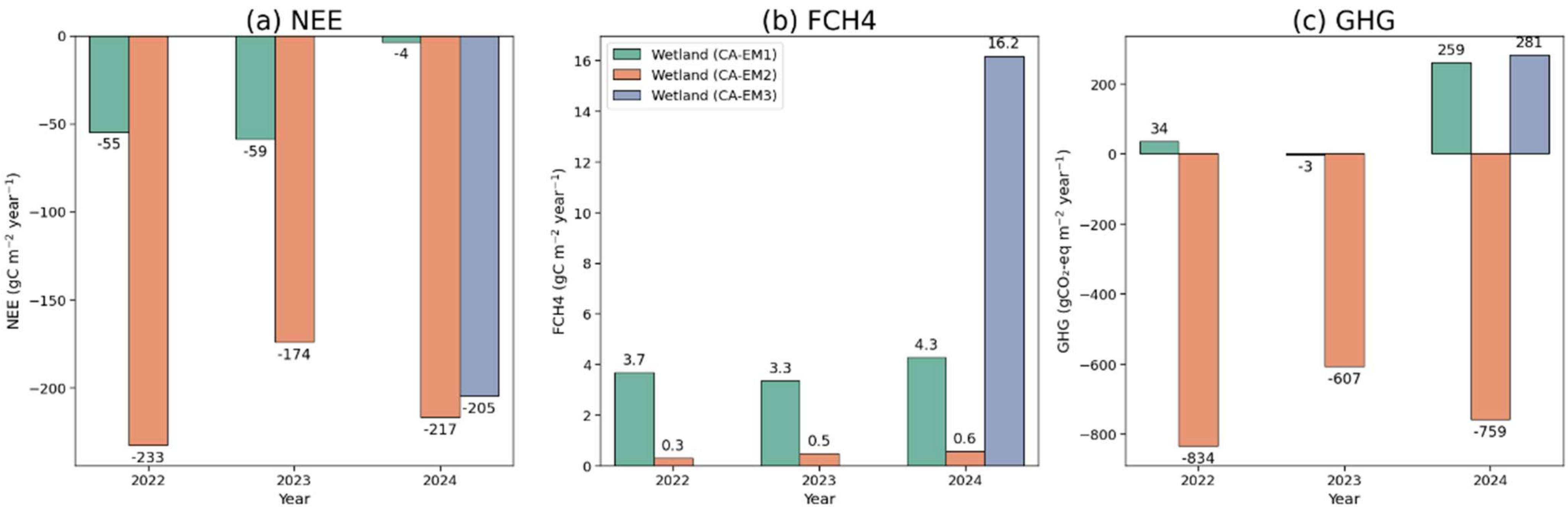
Daily mean fluxes of NEE, FCH4 & GHGs



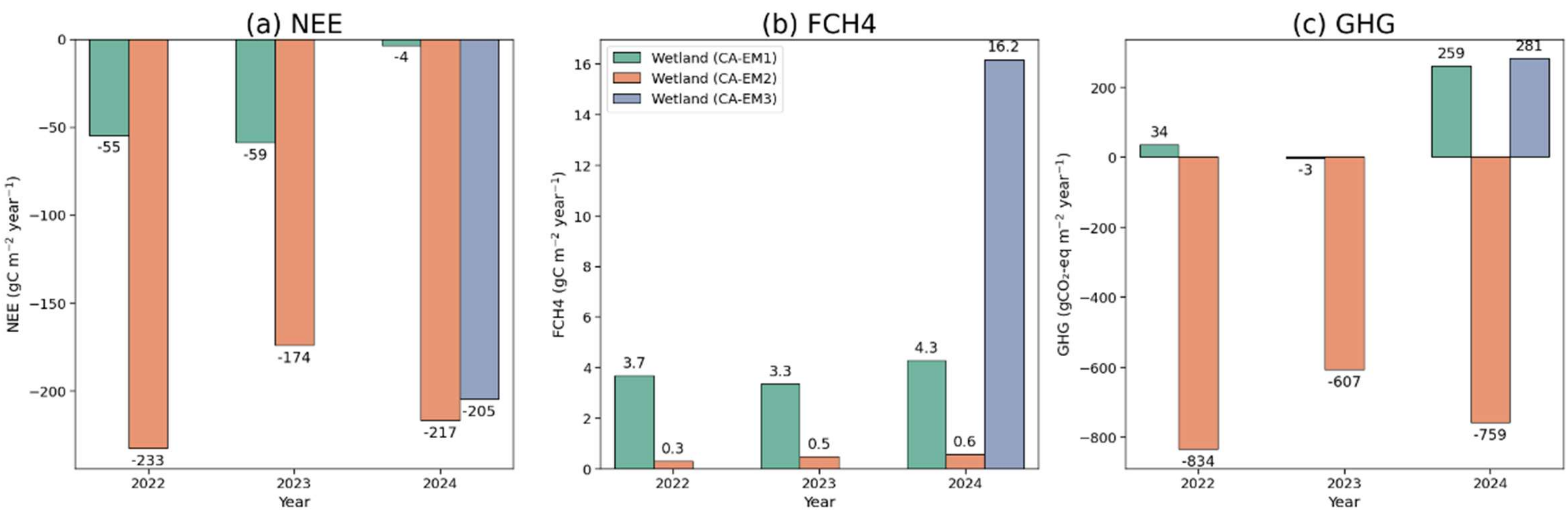
Mineral wetland flux tower network

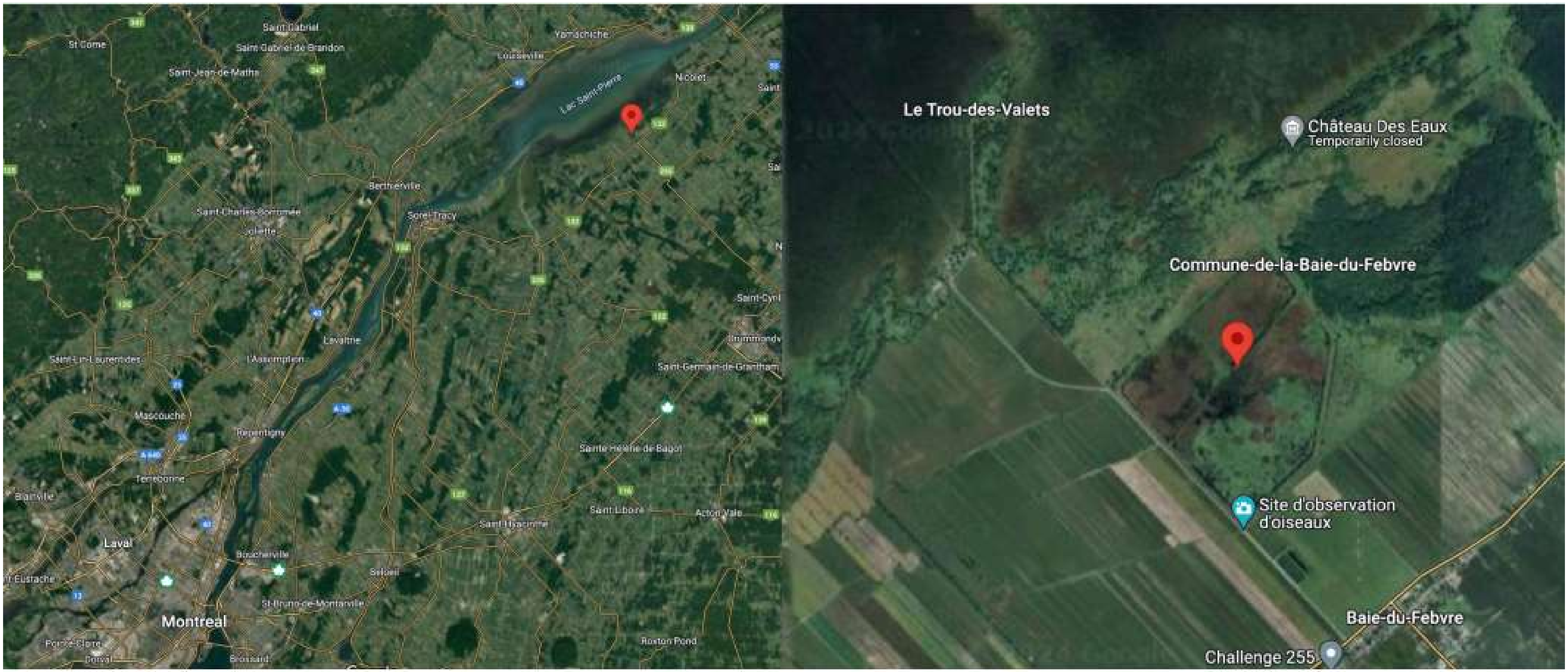


Large variability in GHG fluxes across sites

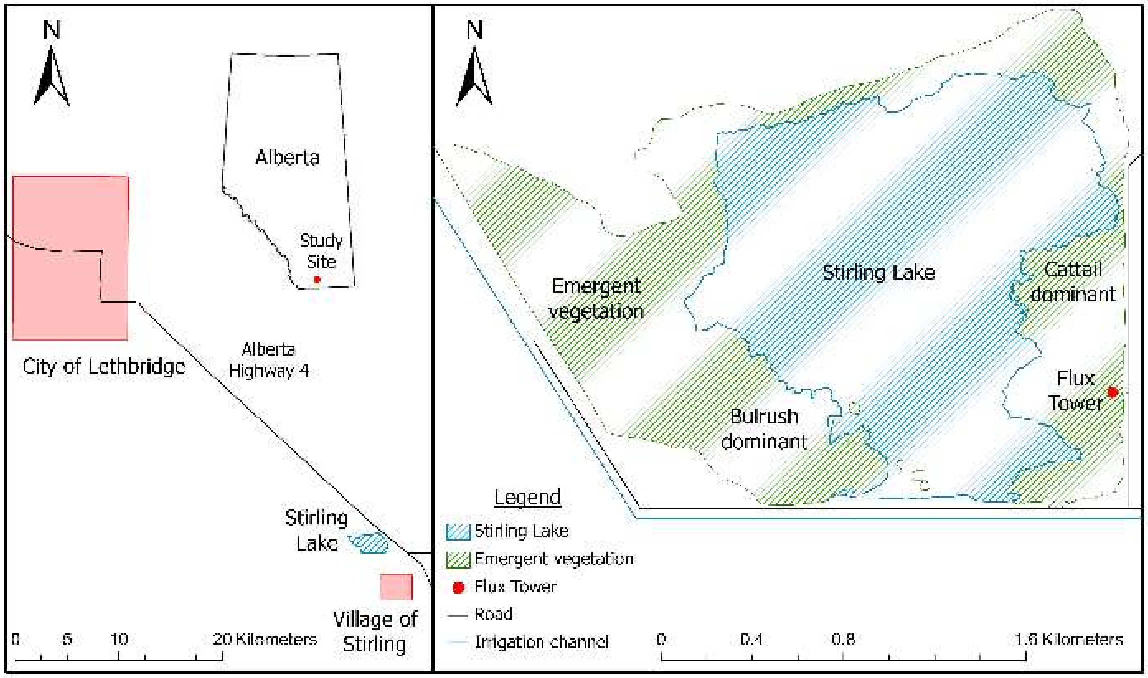


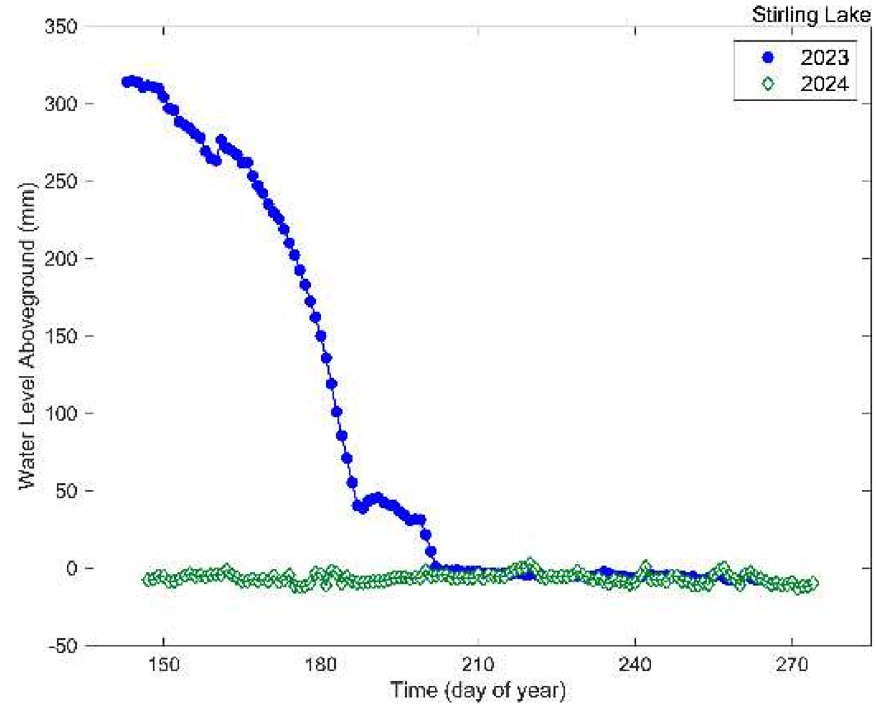
Large variability in GHG fluxes across sites





New wetland site in Quebec



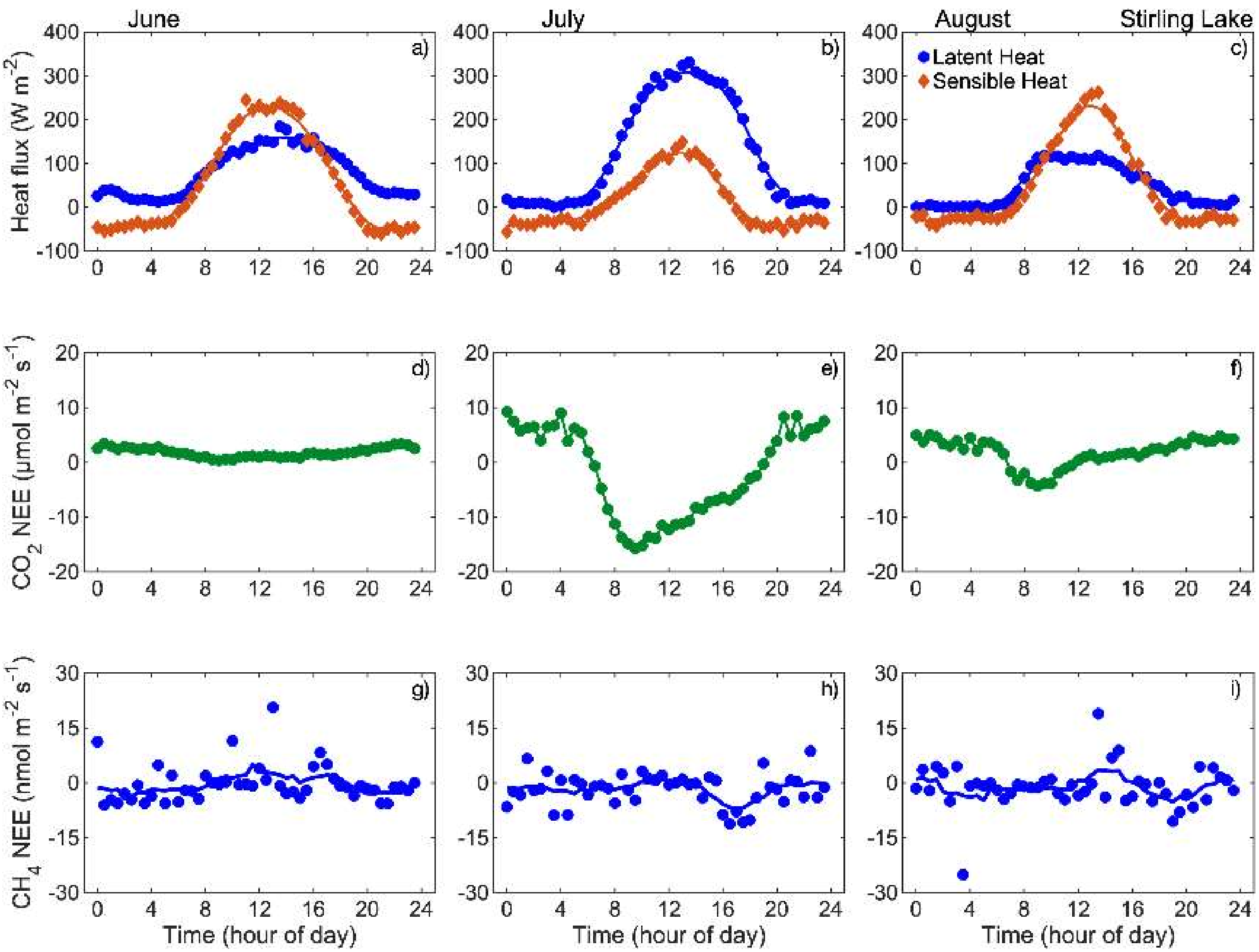


University of Lethbridge Flanagan Lab

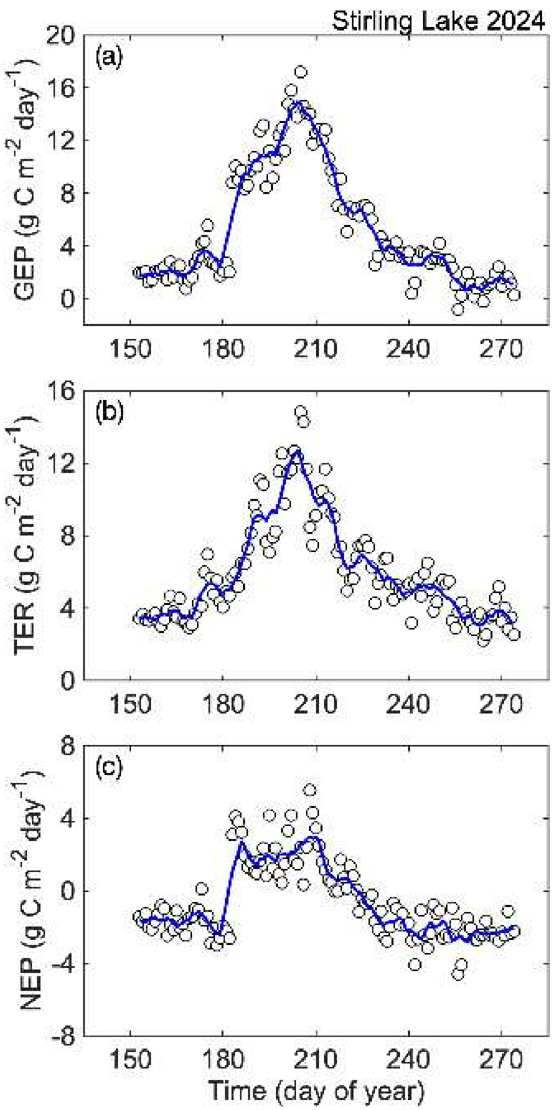
Sub-Project Goals:

Establish an eddy flux ecosystem – Stirling Lake wetland tower in a new prairie pothole wetland

Conduct comparative ecosystem analyses of CO_2 and CH_4 fluxes within the ECCC CAAF project and other related projects in Alberta



June
July
August
Stirling Lake
a)
b)
c)
d)
e)
f)
g)
h)
i)
Latent Heat
Sensible Heat
Heat flux (W m^{-2})
CO_2 NEE (µmol m^{-2} s^{-1})
CH_4 NEE (nmol m^{-2} s^{-1})
Time (hour of day)
Time (hour of day)
Time (hour of day)



Stirling Lake Wetland (2024) NEP = GEP - TER

CO_2 Budget (May – September)	**(g C m^{-2} $season^{-1}$)**
Ecosystem Photosynthesis (GEP)	652
Ecosystem Respiration (TER)	730
Net Ecosystem Productivity (NEP)	-78 (net loss)
Net Ecosystem Productivity (considering both CO_2 & CH_4)	-80 (net loss)

Methane Sustained-Flux Global Warming Potential (100-year)
(1 kg CH_4 = 45 kg CO_2)

Progress to achieving tasks

- 2.5. Develop Models To Predict The Potential For Wetlands For OC Sequestration And GHG Reduction.

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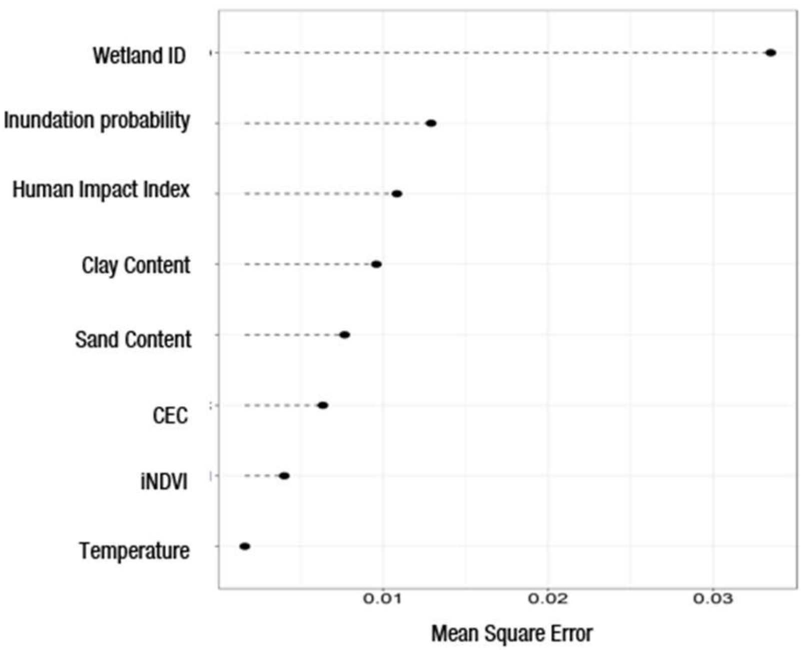
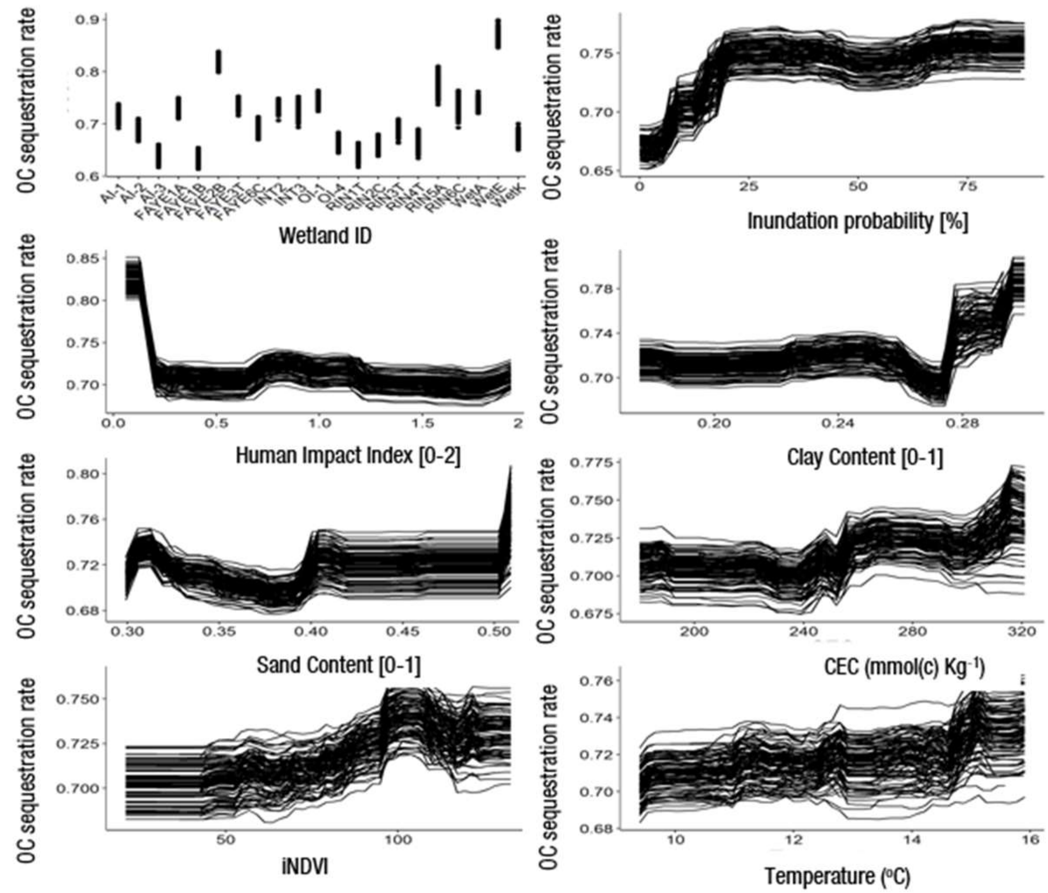
Using machine learning model (random forest) to aid in the prediction of carbon sequestration rates



OC = Organic Carbon
CEC = Cation exchange capacity
iNDVI = integrated Normalized Difference Vegetation Index



Mistry P, Creed IF, Trick CG, Lobb DA. In Preparation. Reducing uncertainties in net carbon capture to advance wetlands as natural climate solutions.

GWP* - a new CO_2-equivalent metric

nature > npj climate and atmospheric science > articles > article

Article | Open access | Published: 28 September 2024

New perspectives on temperate inland wetlands as natural climate solutions under different CO_2-equivalent metrics

Shizhou Ma, Irena F. Creed & Pascal Badiou

npj Climate and Atmospheric Science 7, Article number: 222 (2024) | Cite this article

GWP*

Protection: immediate net cooling that align with the Paris Agreement.

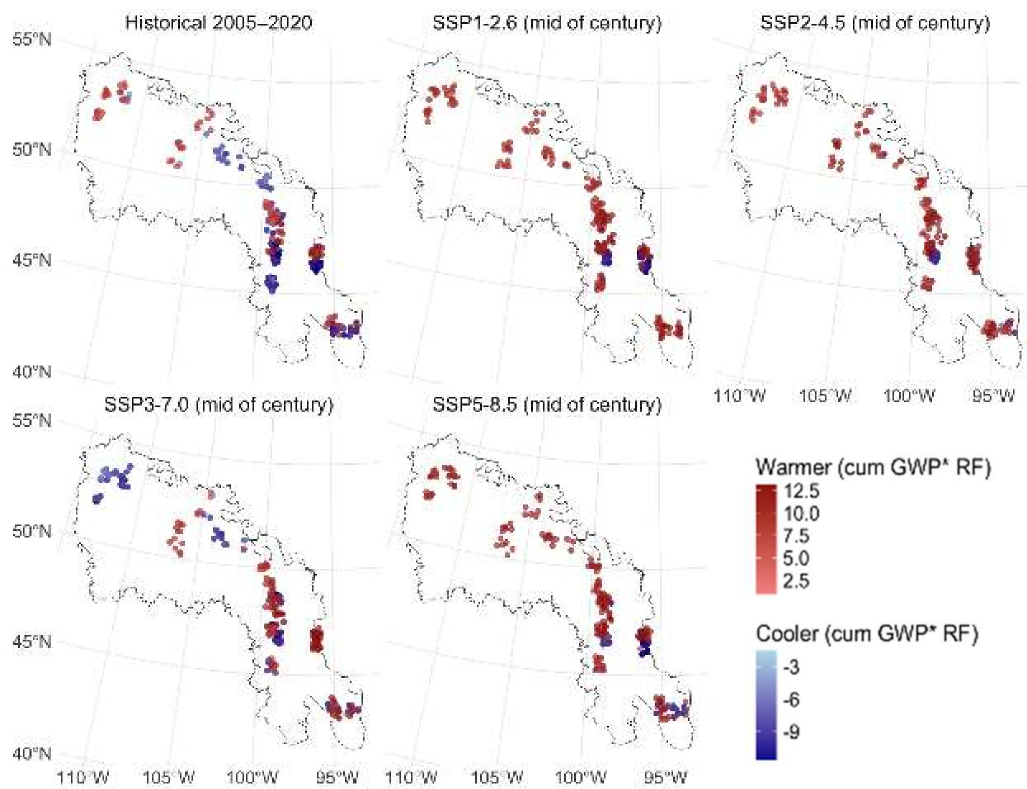
Restoration: immediate reduced warming, with net cooling occurring over longer time scales (100 years).

Wetlands are effective short and long-term natural climate solutions.

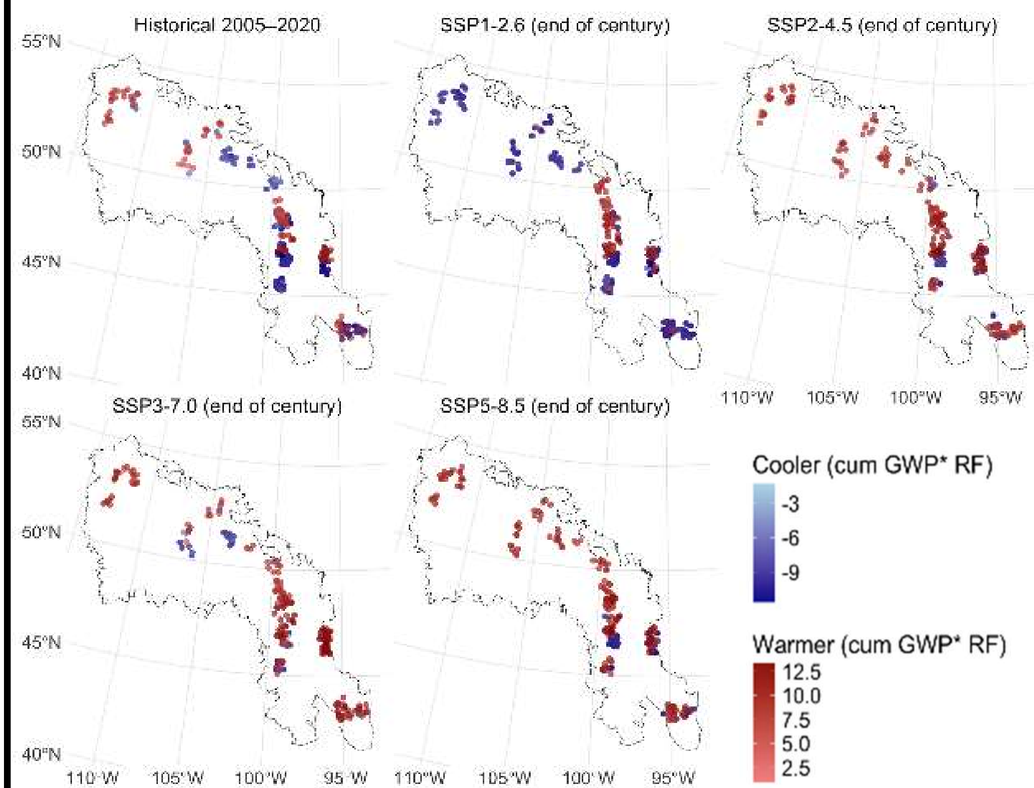
Ma, Creed, Badiou. 2024. New perspectives on temperate inland wetlands as natural climate solutions under different CO_2-equivalent metrics. Npj Climate and Atmospheric Science 7, 222.

For each wetland, annual radiative forcing from 2005-2090 using GWP* was calculated

Post-GWP* conversion:
Mid of century estimations under different climate projections



Post-GWP* conversion:
End of century estimations under different climate projections



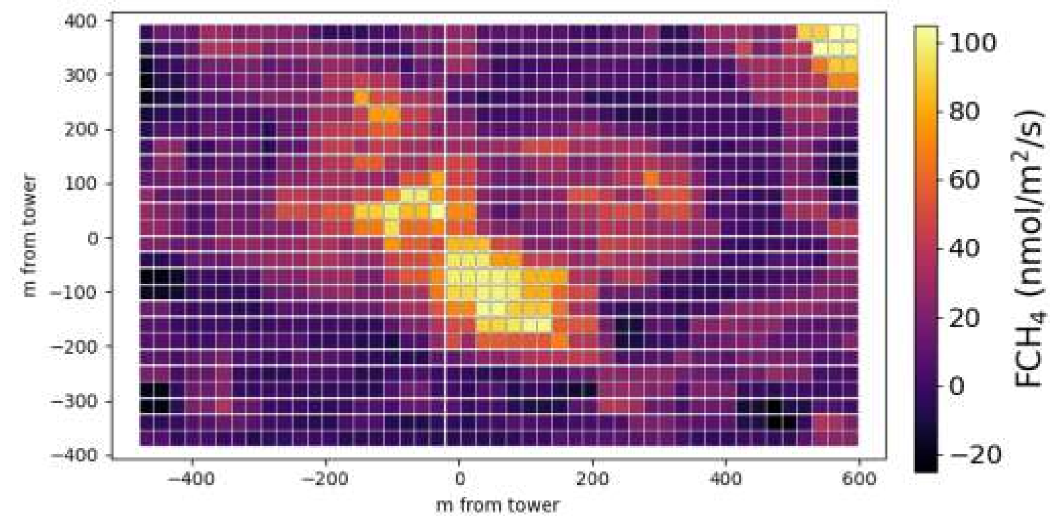
Ma, Creed, Bansal, Badiou In Prep. Climate-induced shifts in carbon fluxes temperate inland wetlands: Implications for climate solutions.

PREDICTING WETLAND CH_4 FLUX SPATIAL HETEROGENEITY WITHIN AND BEYOND A FLUX TOWER FOOTPRINT

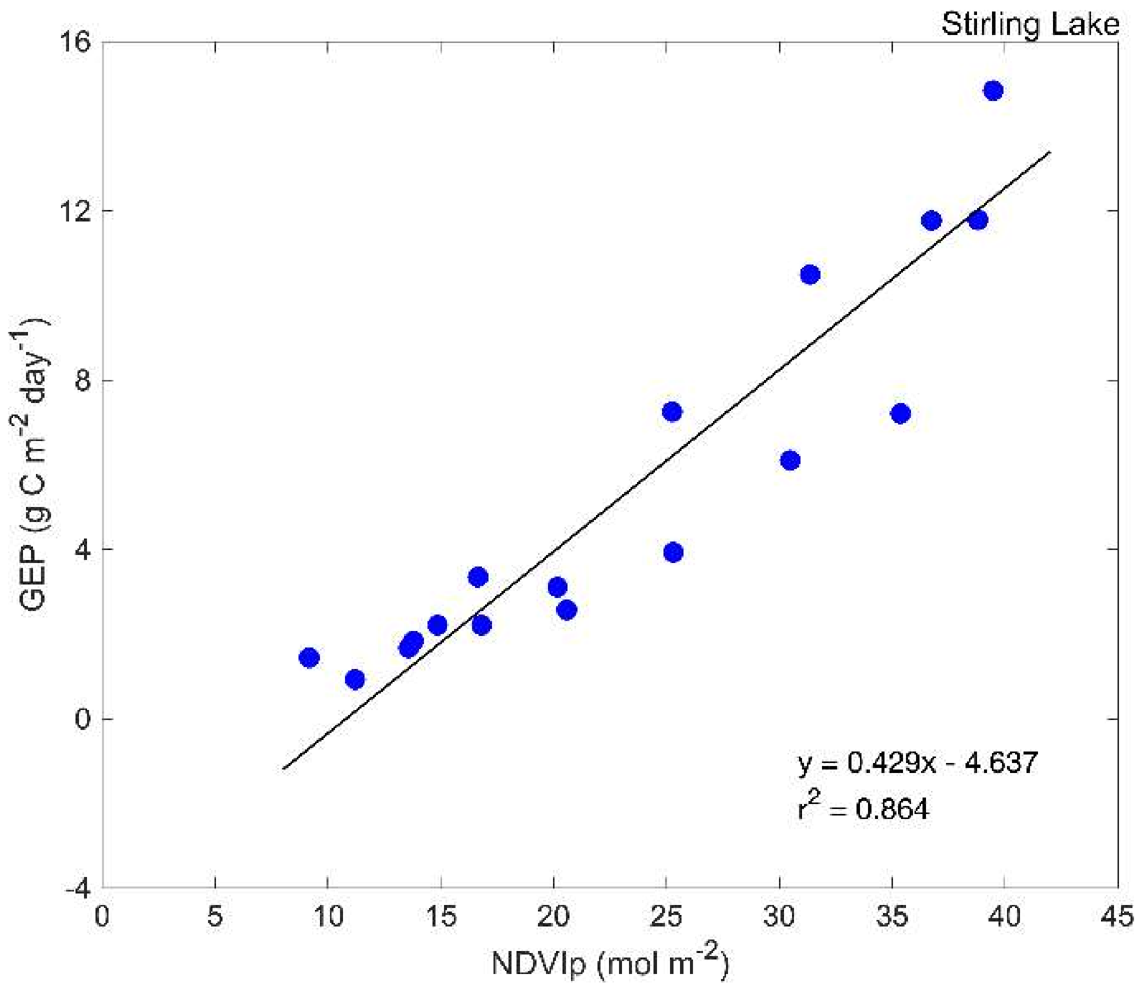
Obj. 2 Predict FCH_4 – Extrapolate found relationships to upscale FCH_4 estimates beyond flux towers.

Satellite image 2021/09/09

Modelled FCH4 2021/09/09



Ng et al. (in prep)



Stirling Lake
GEP (g C m-2 day-1)
NDVIp (mol m-2)
y = 0.429x - 4.637
r2 = 0.864
16
12
8
4
0
-4
0
5
10
15
20
25
30
35
40
45

Collaboration between/within objectives

- Collaboration within objective:
  - Coordination and sharing of dissolved gas techniques and bubble trap methods
  - DUC assisting with site selection
  - Potential for using results from flux towers to further test GWP* on current C fluxes

- Collaboration between objectives:
  - Coordination and sharing of data from Objective 2 to assist with modeling efforts in Objective 3
  - Expect integration of carbon stock and flux data into Objective 5 task associated with Holos

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Forward-looking requests and opportunities

What would we do if we had more resources?

- Objective 2.4 – work on lateral fluxes
    - Biological carbon fluxes
    - Quantify fluxes from surface ditches associated with wetland drainage
- Test soil amendments for reducing emissions in newly restored wetlands
- Quantify impacts of wetland drainage on carbon stocks and GHG emissions (experimental wetland drainage).
- Others?

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Anticipated impacts

Publicly available data sets of wetland carbon fluxes.

Generation of new regionally specific default emissions factors for Canadian agricultural landscapes.

Better understanding of wetlands as nature-based climate solutions over longer timescales.

Ability to target wetland conservation and restoration of wetlands that will be climate positive or less climate negative (in the short-term).

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Objective 3. Modeling

Develop Robust Estimates Of Hydrological Process Controls On OC Accumulation And GHG Fluxes From Wetlands

Objective 3

Develop Estimates of Hydrological Process Controls on Carbon Sequestration and Greenhouse Gas Fluxes from Wetlands in Agricultural Landscapes

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Cluster for Objective 3

This cluster will bring their expertise in developing models of wetland carbon cycling, erosion- and runoff-mediated carbon transport into and from wetlands, and hydrological processes affecting carbon transport among wetlands and between wetlands and other water bodies

Team members:
Ameli Ali
Arhonditsis George
Badiu Pascal
Creed Irena
Lobb David
von Sperber Christian
...and
an impressive number of technicians, postdoctoral research associates, and graduate students

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Objective 3. Tasks (from proposal)

- 3.1. Using data collected across our network of wetland sites, develop process-based models of carbon cycling.
- 3.2. Estimate the hydrological connectivity of wetlands to the watersheds in which they are embedded.
- 3.3. Determine the influence of hydrological connectivity on the “atmospheric-versus-aquatic” fate of carbon for wetlands in agricultural landscapes.
- 3.4. Develop web-based interactive computer tools to explore the response of wetland hydrological connectivity type and travel time to different climatic scenarios.

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Objective 3. Tasks (from experience)

- 3.1. Using data collected across our network of wetland sites, develop both data-driven and process-based models of carbon **(and nitrogen and phosphorus)** cycling.

- 3.2. Estimate the hydrological connectivity of **wetlands to other wetlands** and **wetlands to the watersheds** in which they are embedded.

- 3.3. Determine the influence of hydrological connectivity on the “atmospheric-versus-aquatic” fate of carbon **(and nitrogen and phosphorus)** for wetlands in agricultural landscapes.

- 3.4. Develop web-based interactive and/or open-source computer tools to explore the response of **wetland gain/loss,** and **drainage/rewetting** on hydrological connectivity type and travel time to different climatic scenarios.

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Integrating Regional Assessment with Watershed Planning and Field-level Implementation

Basin-Scale Modelling

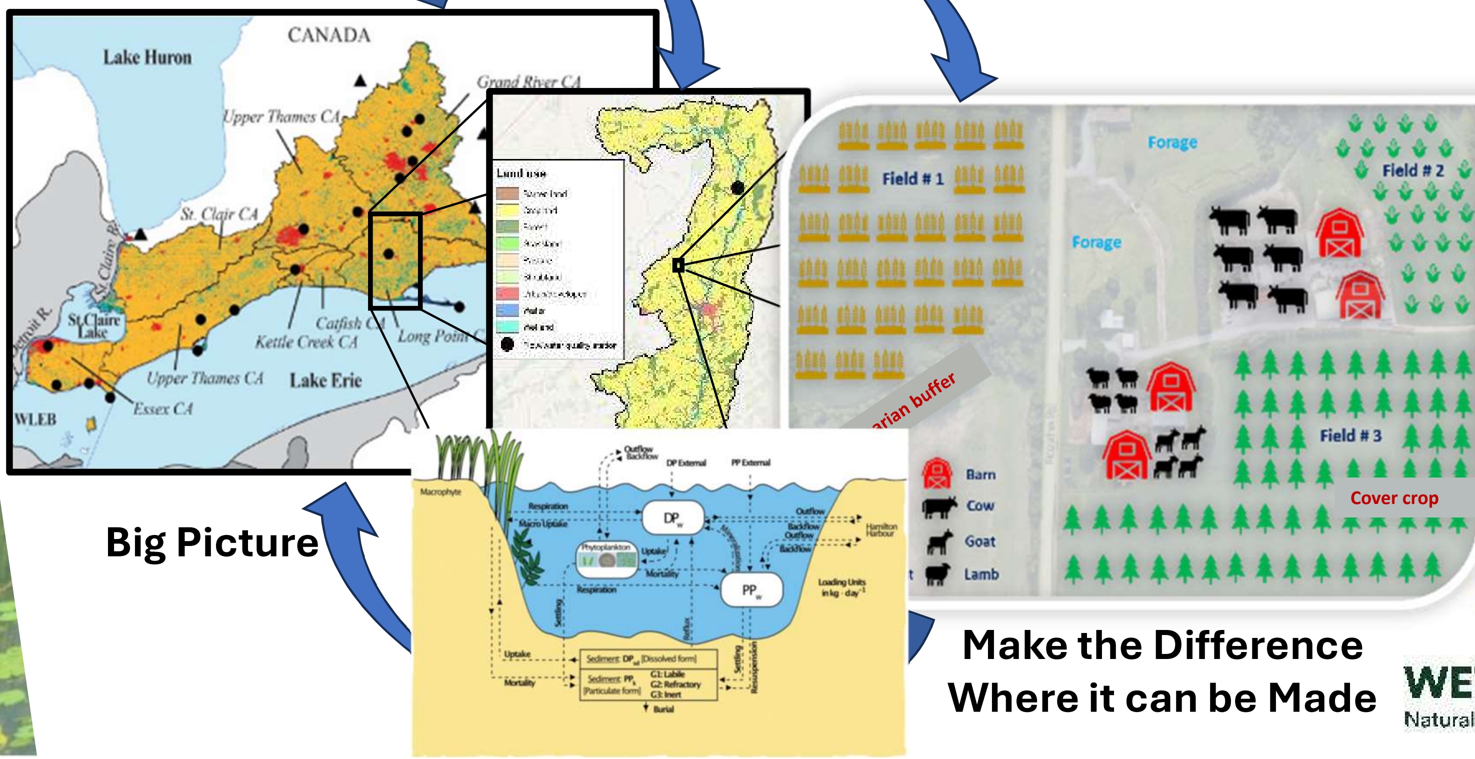
Regional assessment of high risk for C, N, P fate/ transport in time and spa

Watershed Modelling

Mechanistic understanding at the catchment level

Farm-level Modelling

Design in-field conservation practices at the scales that matter the most



Big Picture

Make the Difference Where it can be Made

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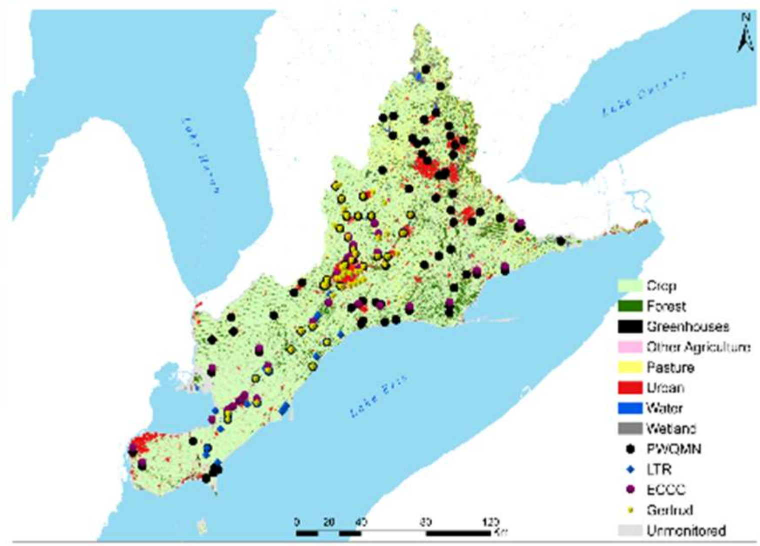
Significant measurement and modelling efforts focus on the Lake Winnipeg and Great Lakes basins, which together host over 90% of Canada's agricultural wetlands.

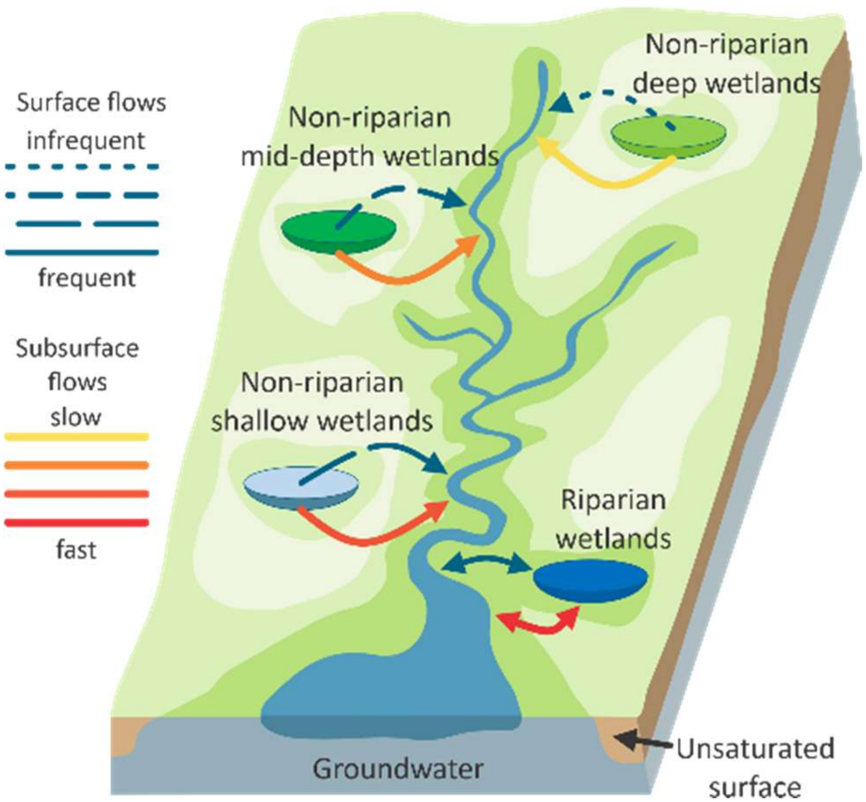
Great Lakes:
Toxic and nuisance algae caused by nutrient pollution; contaminated and degraded Areas of Concern; Great Lakes coastal wetlands and nearshore health is under threat due to the impacts of climate change and other stressors; and toxic chemicals.

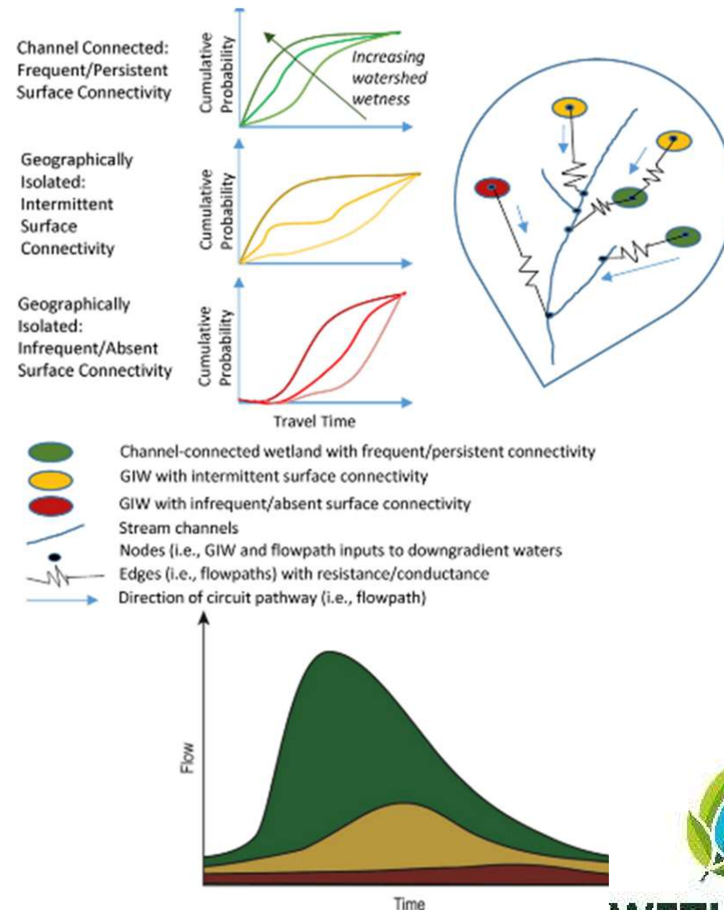
Lake Winnipeg:
Toxic and nuisance algae caused by nutrient pollution; climate change impacts



WETLANDS
Natural Climate Solutions

GIS and airborne/satellite imagery are used to monitor spatial and temporal changes in wetlands and their influence on downstream waters across the two targeted basins.





WETLANDS

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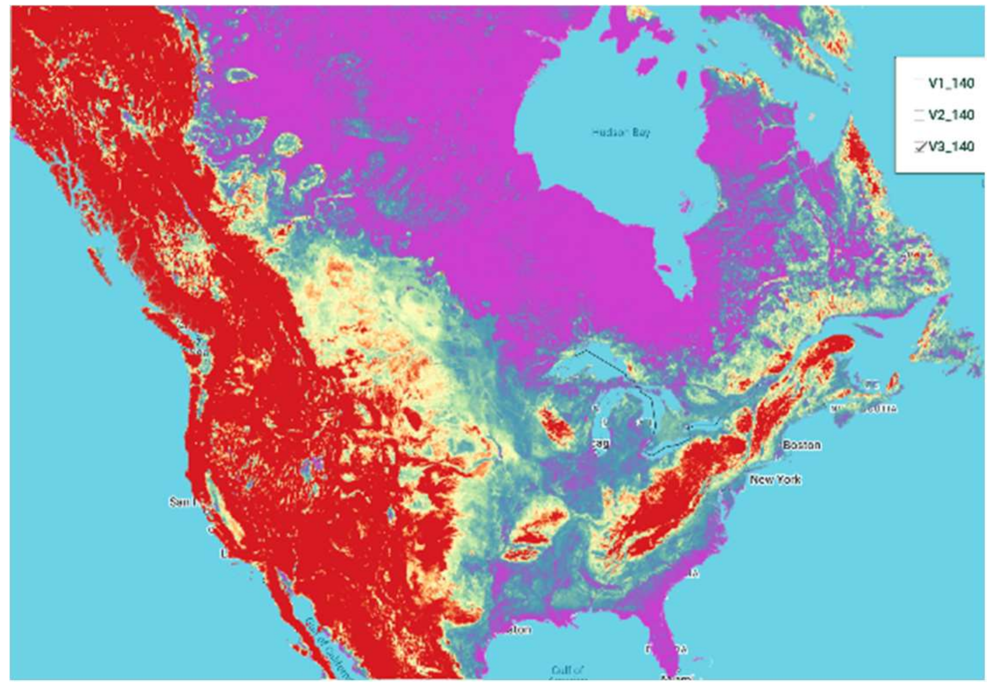
Mapping and characterization of hydrological linkages between wetlands and the stream drainage networks.

Groundwater Table (GWT) Depth Estimation
Mapping GWT using spatially and temporally resolved inundation data to infer wetland-groundwater dynamics.

Recharge *vs.* Discharge Areas
Classifying wetlands act as sources (recharge) or sinks (discharge) of groundwater within the basin.

Surface *vs.* Subsurface Connections
Distinguishing between surface and lateral/vertical subsurface exchanges that connect wetlands to adjacent landscapes.

Surface Connection Types
Classifying surface connections as ephemeral (event-driven), seasonal (periodic), or perennial (persistent flow paths).



Powered by 20M+ observations, our XGBoost model delivers the most accurate 500 m-resolution groundwater table product for wetland-rich landscapes.

Janssen J., Tootchi A., and Ameli A. (2025). Tackling water table depth modeling via machine learning: from proxy observations to verifiability. Advances in Water Resources.

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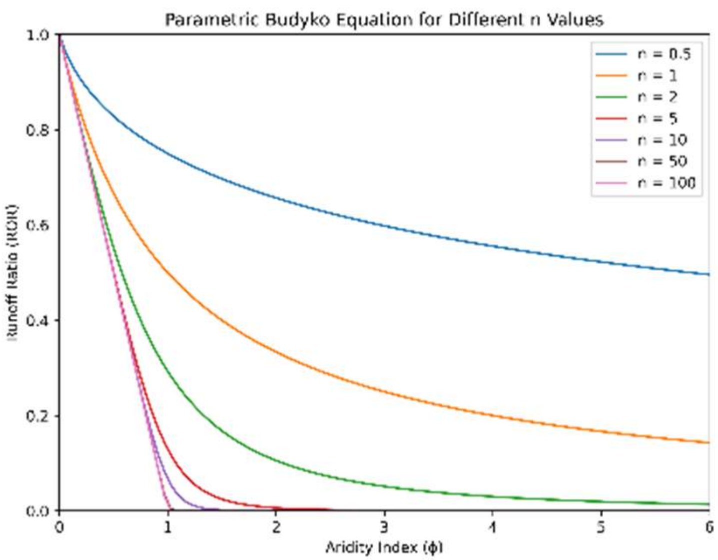
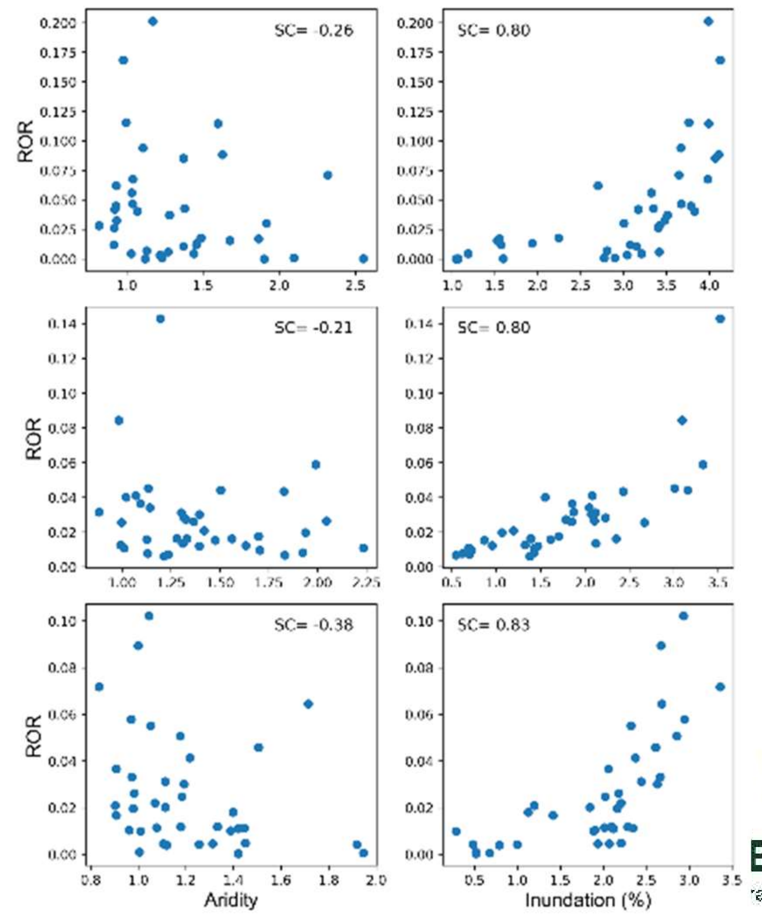
Natural Climate Solutions

Ameli's Inundation Index <u>outperforms</u> Budyko's Aridity Index in explaining inter-annual variation in the runoff ratio in the PPR

Budyko Curve for different n values



What we observe in PPR (SC: Spearman Correlation)



Joe Janssen

Javad Rahmani

Ardalan Tootchi

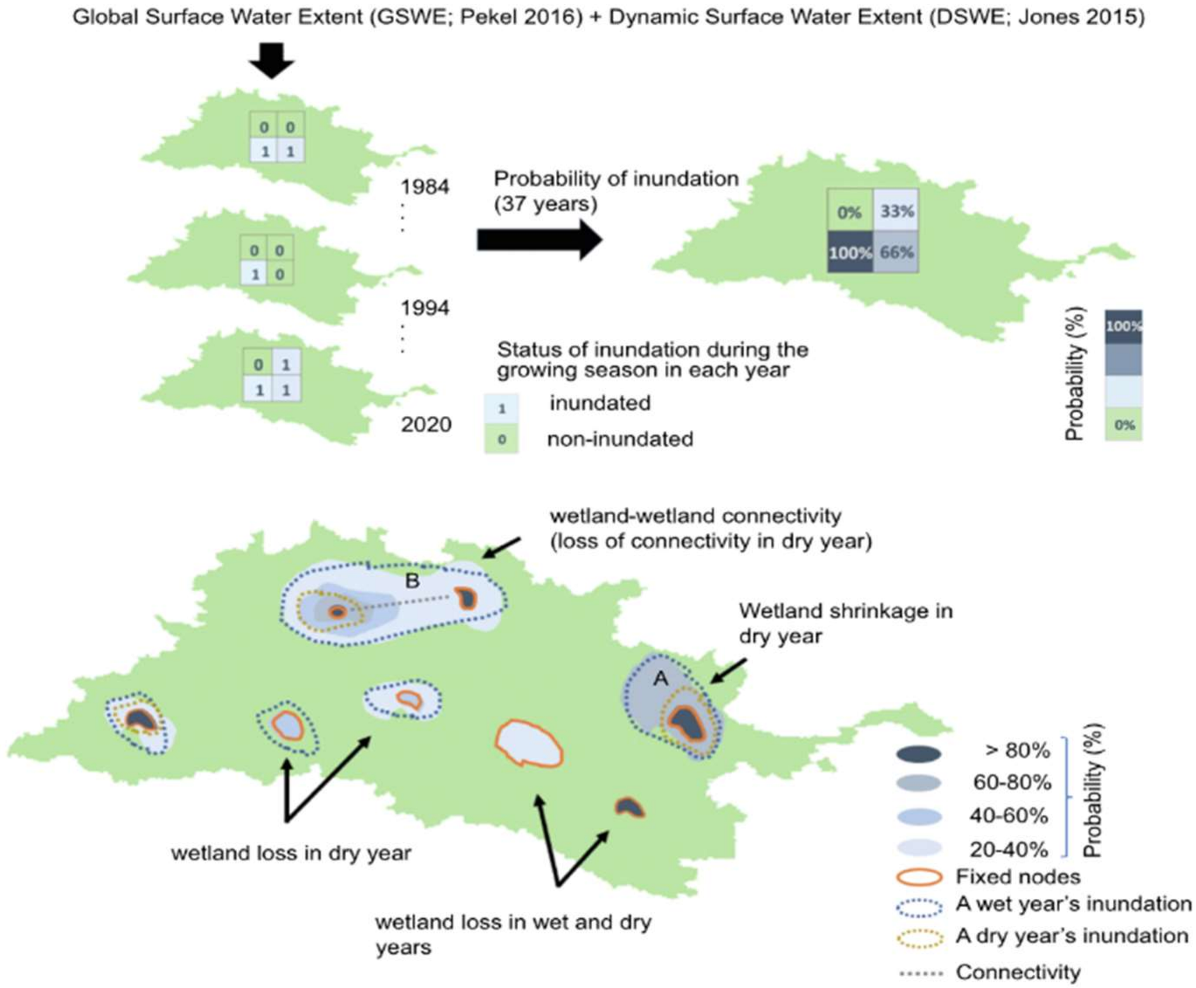
ETLANDS
ral Climate Solutions

Mapping wetlandscapes—networks of hydrologically connected wetlands—to track their spatial extent and connectivity over time.

Michael Dallosch

Forough Fendereski

Sassan Mohammady



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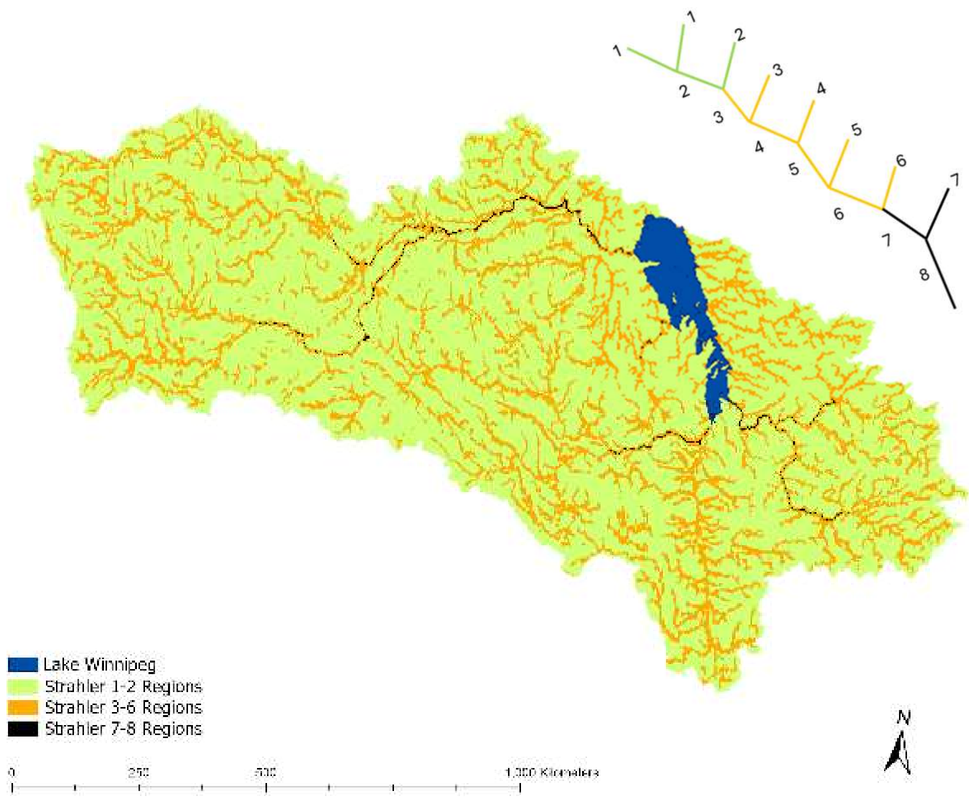
Assessment of how wetland gains or losses affect C, N, and P loading to the Great Lakes, using data-driven models to evaluate watershed-scale management outcomes.



Temporal → Year

Climate → Precipitation (mm)
Temperature (°C)

Inundation Connectivity →
Inundated Area Connected to Streams (m^2)
Ratio Inundated Area Connected to Streams to Total Inundated Area (%)
Ratio Inundated Area Connected to Streams to Contributing Area (%)
Ratio Inundated Area Disconnected from Streams to Inundated Area in LWW (%)

Inundation Morphometry → Shape of Inundated (Perimeter : Area)

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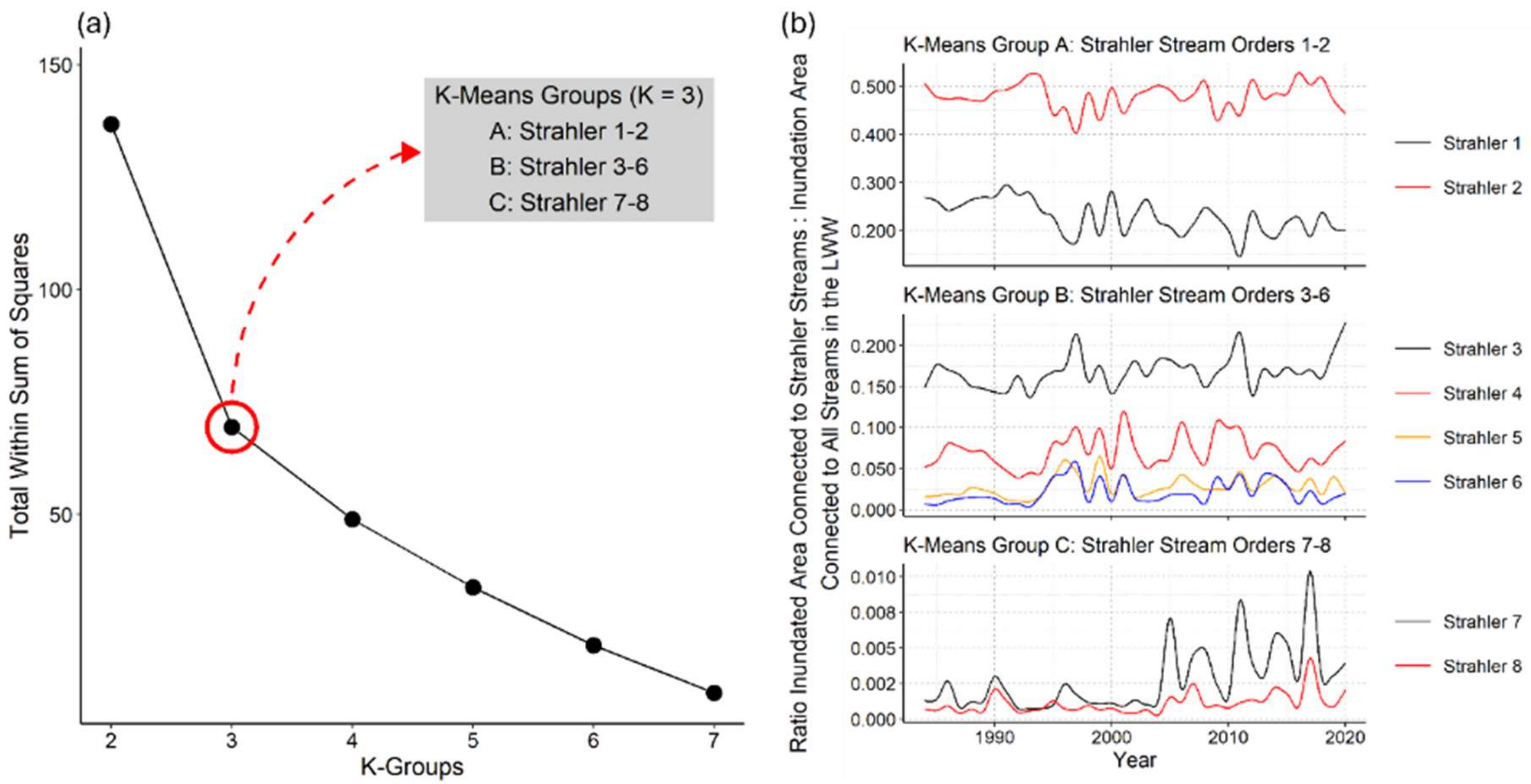
Wetlands can be clustered into headwater upper reaches (stream order 1-2), middle reaches (3-6) and lower reaches (7-8).



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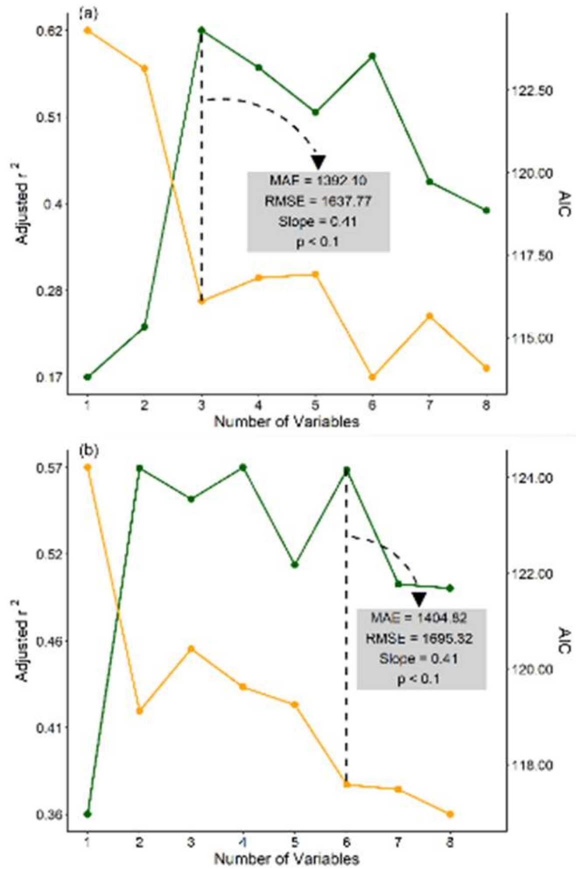
Headwater gatekeeper wetlands
– and their disconnection versus connection to the stream drainage network – shape P delivery

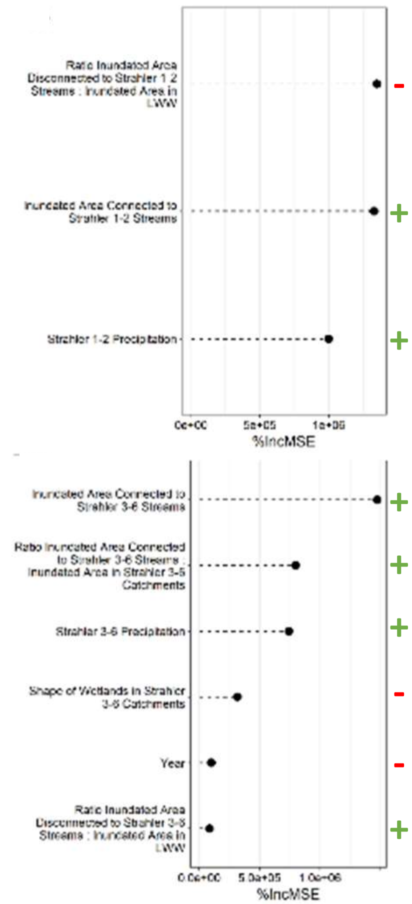
Model Selection

Strahler 1-2

Strahler 3-6



Variable importance

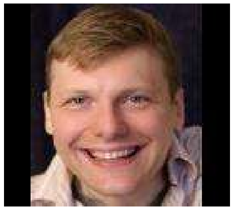


Headwater disconnected wetlands hold back P, decreasing P loads downstream

Headwater connected wetlands release P, increasing P loads downstream

WETLANDS
Natural Climate Solutions

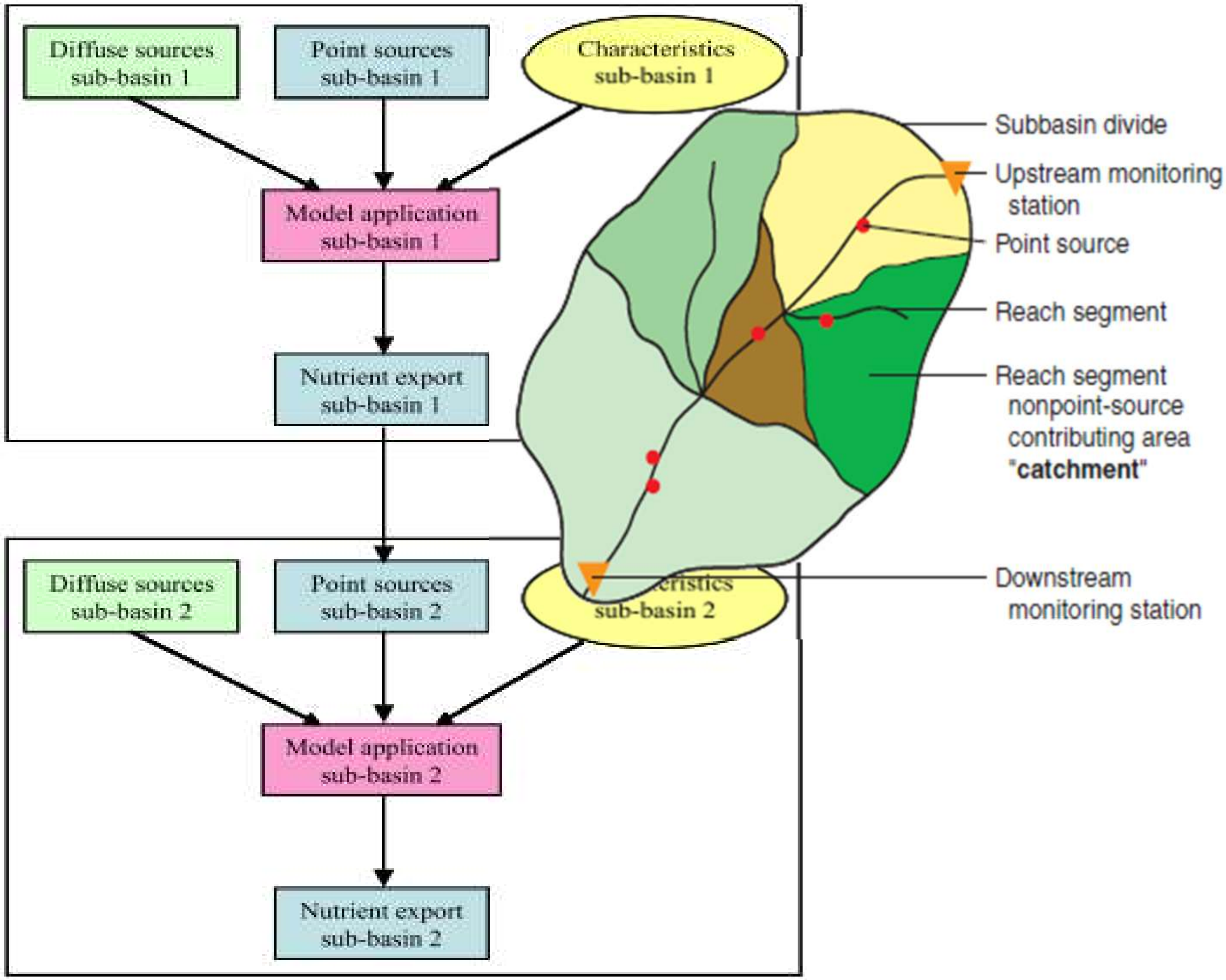
SPAtially Referenced Regressions On Watershed attributes



Alex Neumann

Odai Al Balasmeh

Akunne Okoli



WETLANDS
Natural Climate Solutions

SPAtially Referenced Regressions On Watershed attributes

Nayyer Mirnasl

DIC
DOC
TN
TP

Mean Annual Loading

$$\overline{MAL_i} = \left(\sum_{n=1}^{N} \sum_{j=1}^{J_i} \beta_n S_{n,j} e^{(-\alpha Z_j)} H_{i,j}^{S} H_{i,j}^{R} \right)$$

Nutrient Export Coefficients

Land Uses

Land–to-Water Delivery Factors

Stream *(S)* Reservoir *(R)* Attenuation Terms

$$H_{i,j}^{S} = \prod_{c=1}^{3} e^{(-k_{sc} L_{i,j,c})}$$

$$H_{i,j}^{R} = \prod_{m=1}^{M_i} e^{\left(-\frac{k_r}{q_{l_m}}\right)}$$

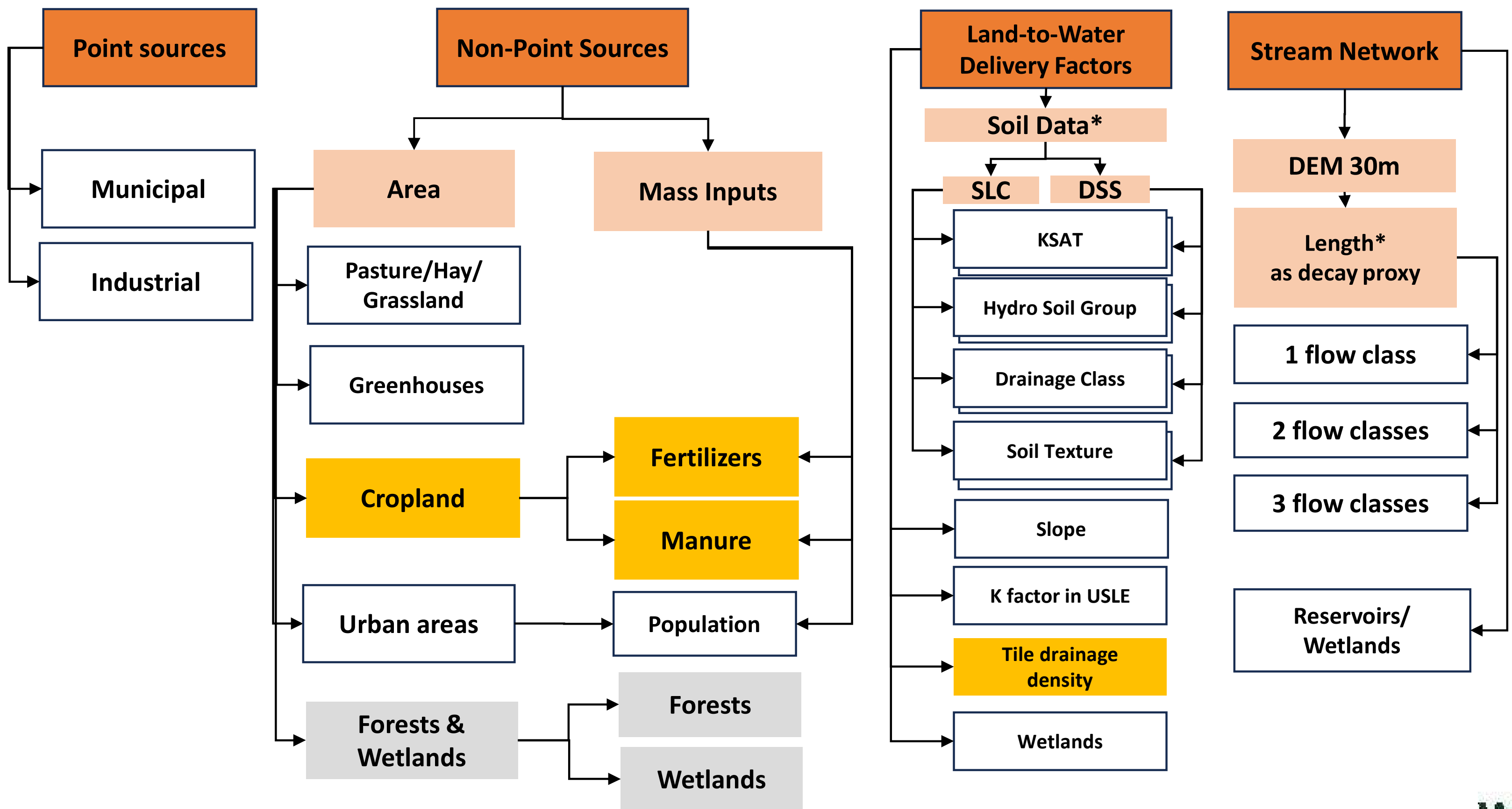
$$P(Model|Data) = \frac{P(Data|Model)P(Model)}{P(Data)}$$

$$\propto P(Data|Model)P(Model)$$

Future = … ∝ **Present** **Past**

WETLANDS
Natural Climate Solutions

SPAtially Referenced Regressions On Watershed attributes



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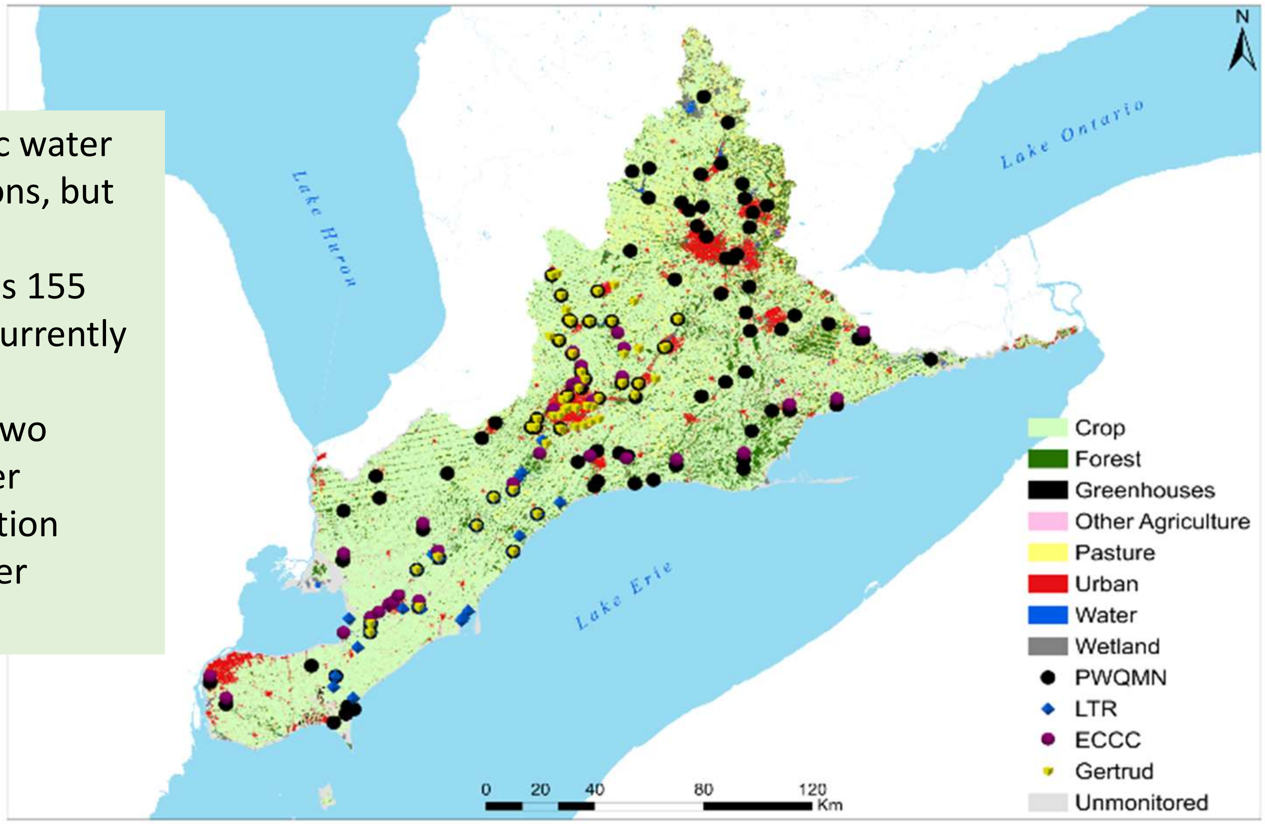
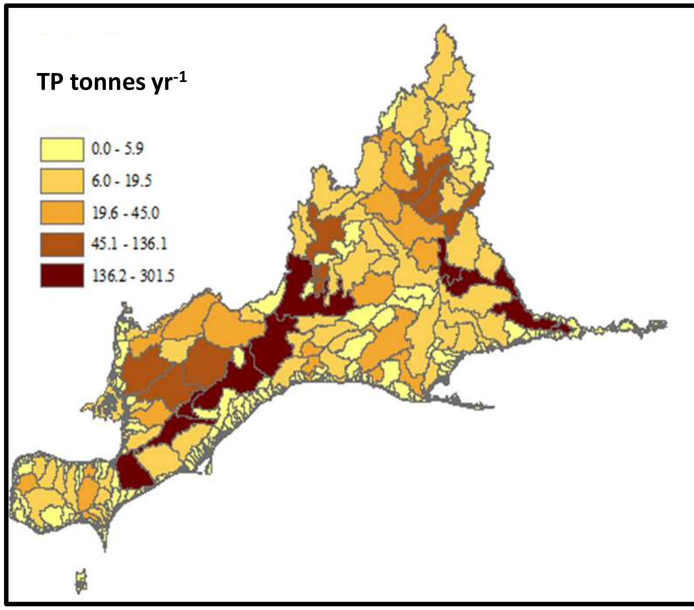
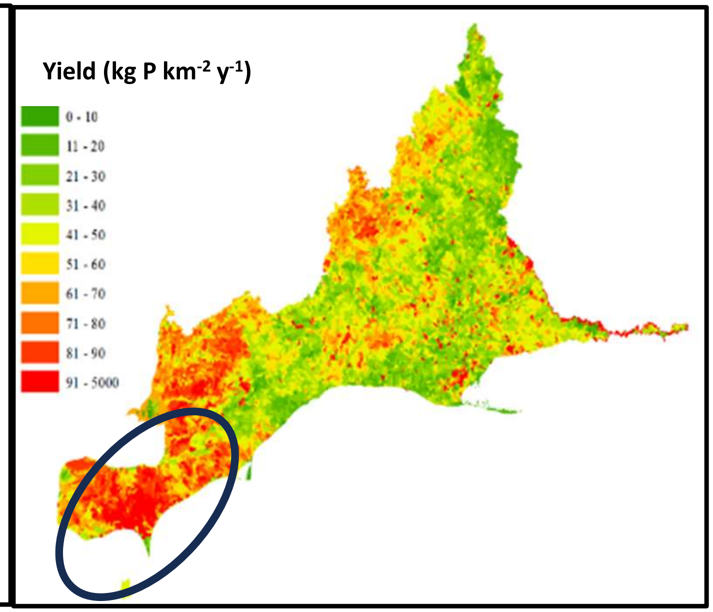
Lake Erie

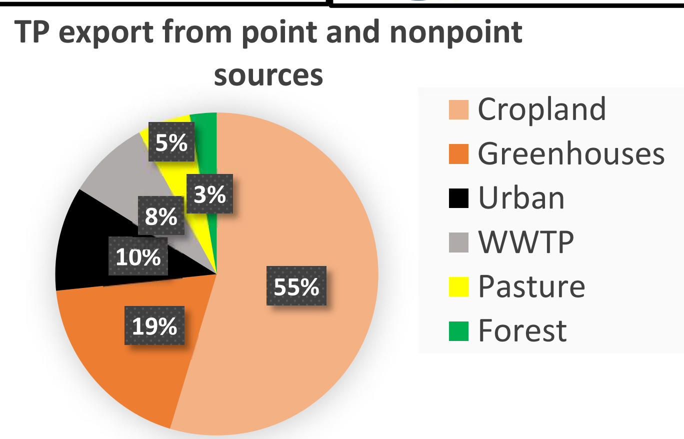
- PWQMN has 367 historic water quality monitoring stations, but 101 currently active.
- Water Survey Canada has 155 HYDAT stations, but 81 currently active.
- We included data from two additional sources: Lower Thames Valley Conservation Authority, and Freshwater Research Inc



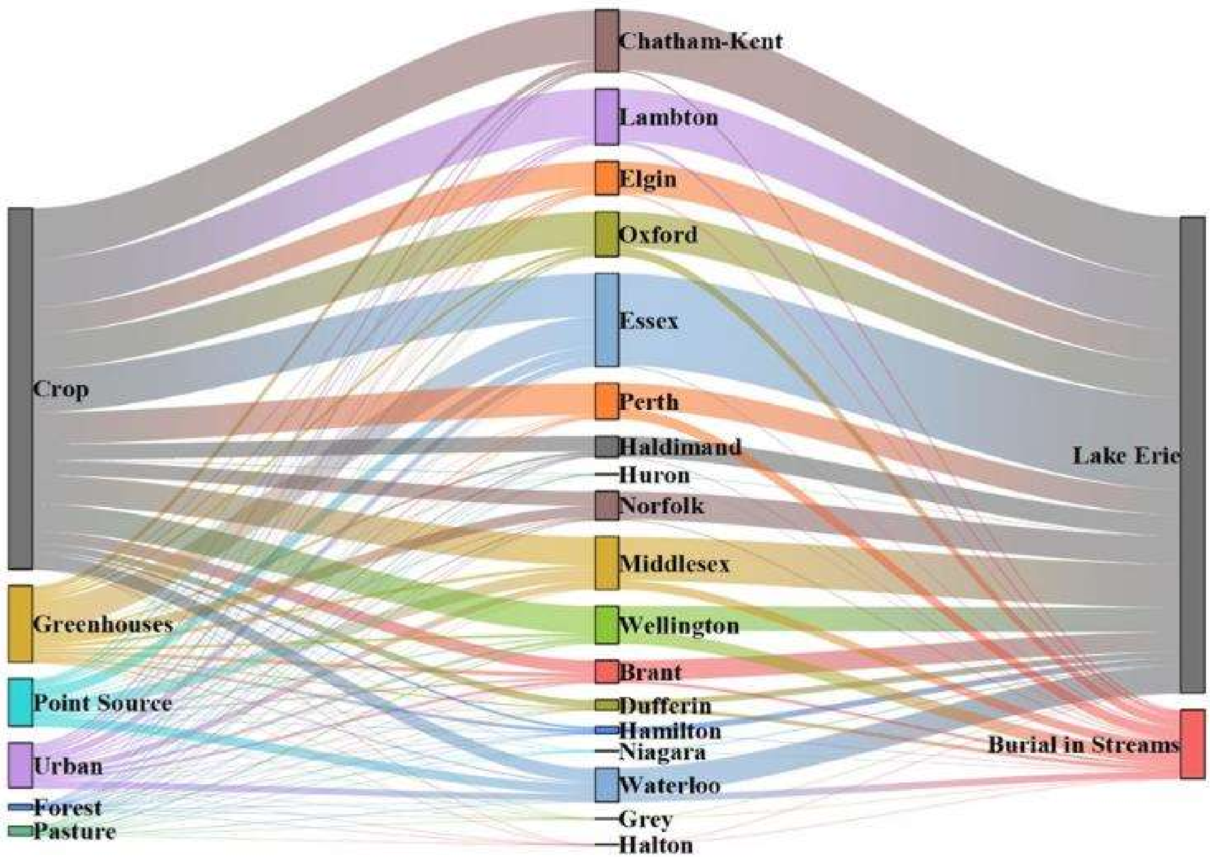
SPAtially Referenced Regressions On Watershed attributes

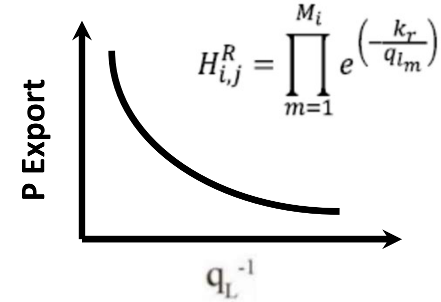


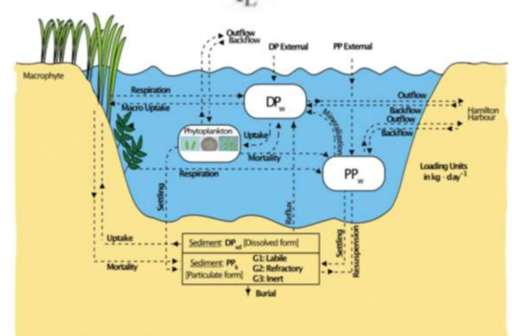




SPAtially Referenced Regressions On Watershed attributes



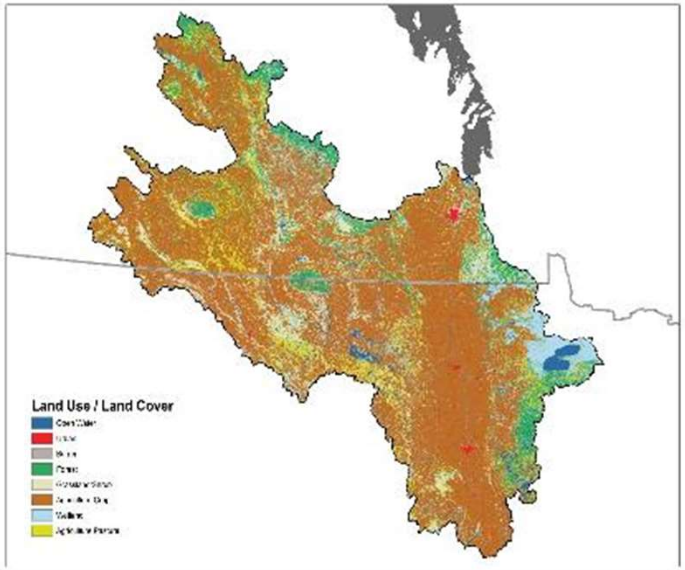


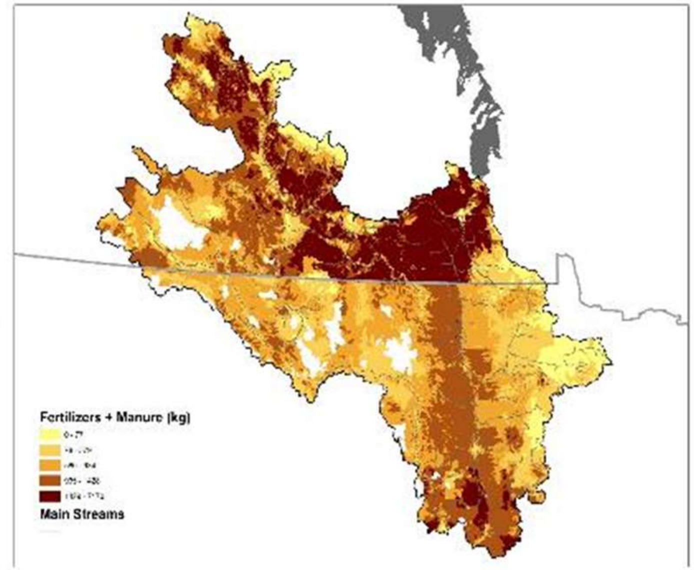


WETLANDS
Natural Climate Solutions

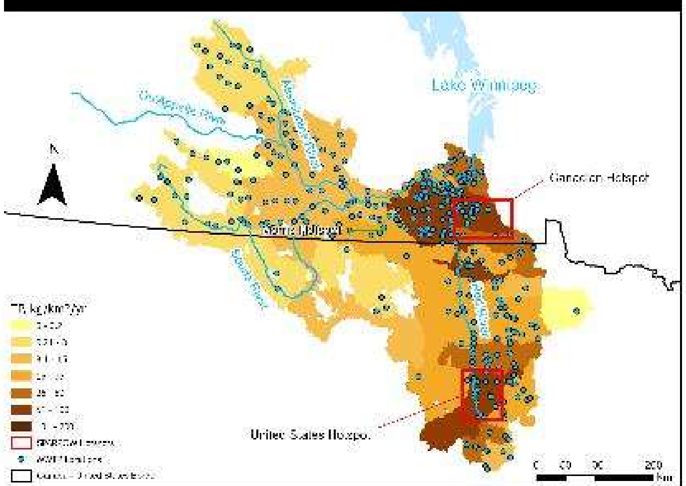
<u>SPA</u>tially <u>R</u>eferenced <u>R</u>egressions <u>O</u>n <u>W</u>atershed attributes

Lake Winnipeg

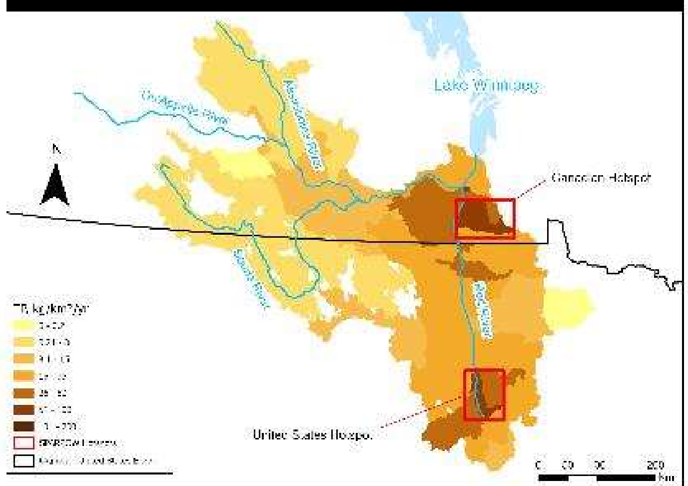




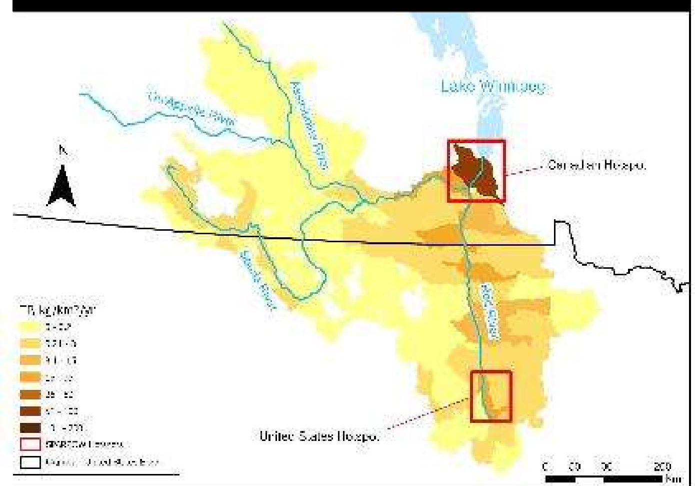
TP Contribution to Lake Winnipeg from Agricultural Inputs, Forests and Wetlands, and Stream Channels. With WWTP locations indicated.



TP Contribution to Lake Winnipeg from Agricultural Inputs only



TP Contribution to Lake Winnipeg from wastewater treatment plants (WWTP) only



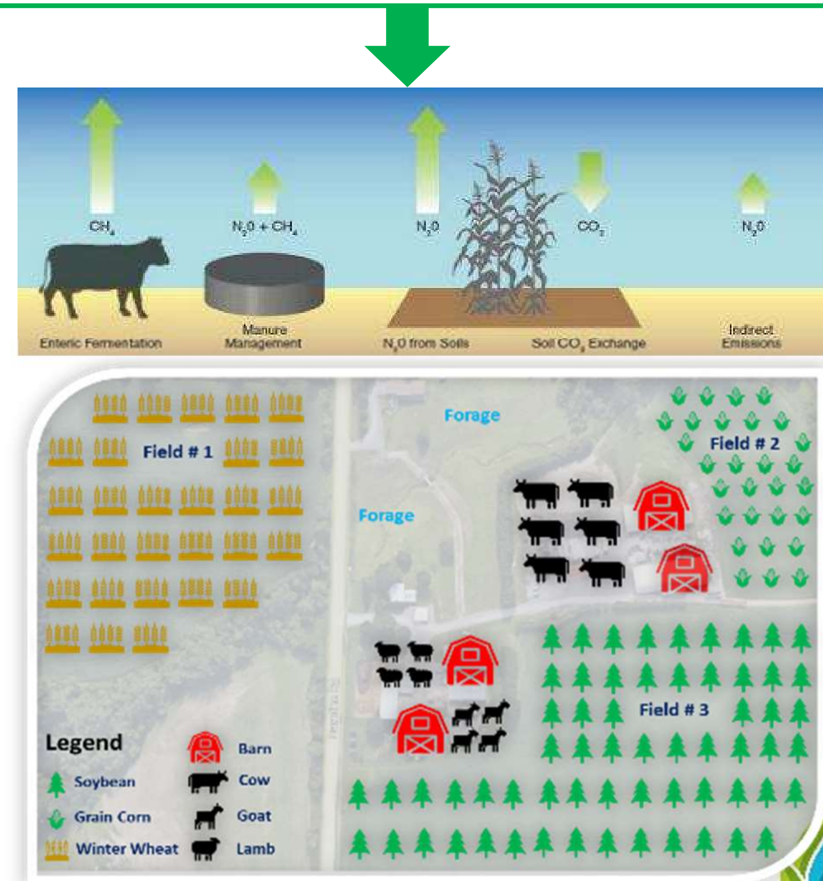
Holos model

To estimate GHG emissions from farms and test best management practices to reduce emissions

- ❑ Model based on empirical flux estimates
- ❑ Primarily based on IPCC Tier 2 (2006) methodology: modified to reflect Canadian conditions
- ❑ Yearly and seasonal time steps
- ❑ Farm-level scale
- ❑ Boundaries of the system are the farm gate

Uses of Holos model

- ➢ Understand, predict and control of food-production systems
- ➢ Identify areas of deficient knowledge
- ➢ Answer various "what if?" scenarios
- ➢ Adding value to experiments

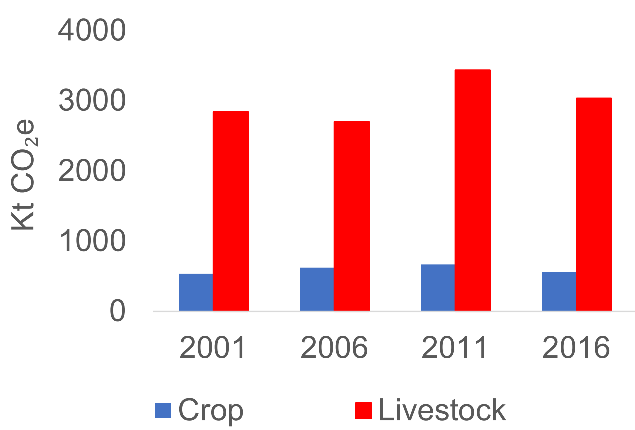


The concept of Virtual Farm as a model to understand the impact of agriculture on GHG emissions.

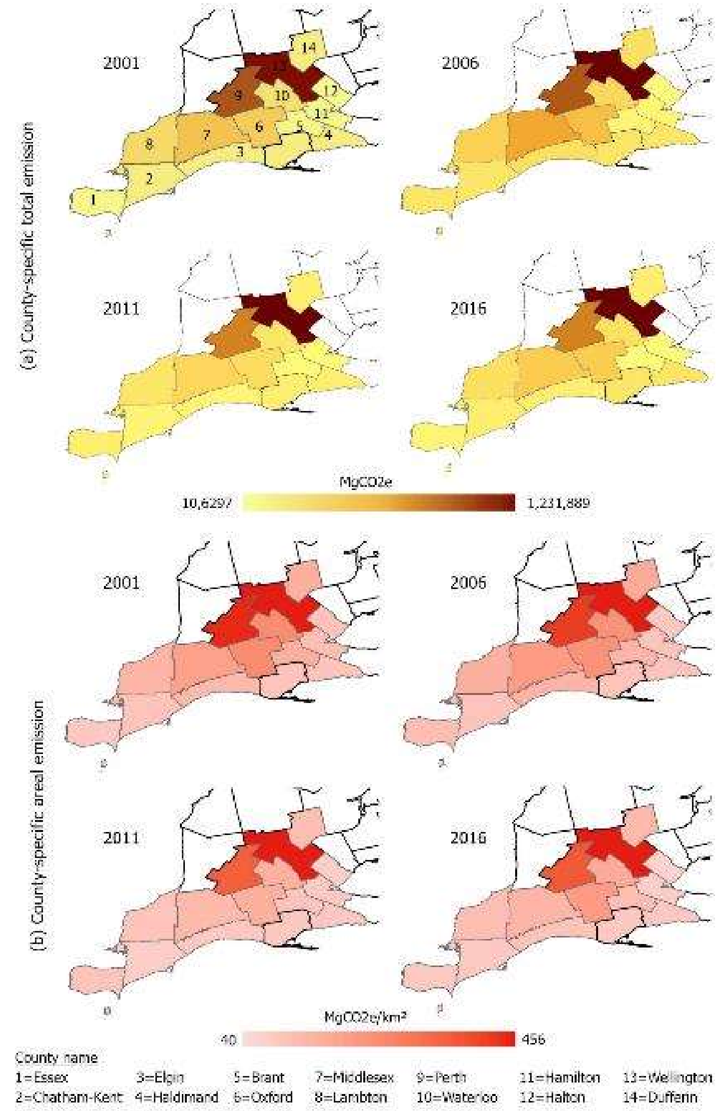
GHG emission from Lake Erie counties

❖ Years: 2001, 2006, 2011, and 2016

❖ Total-farm emission:
Crops versus livestock



GHG emission Crop vs livestock (2001 – 2016)



County-specific total and areal GHG emission from 2001 - 2016

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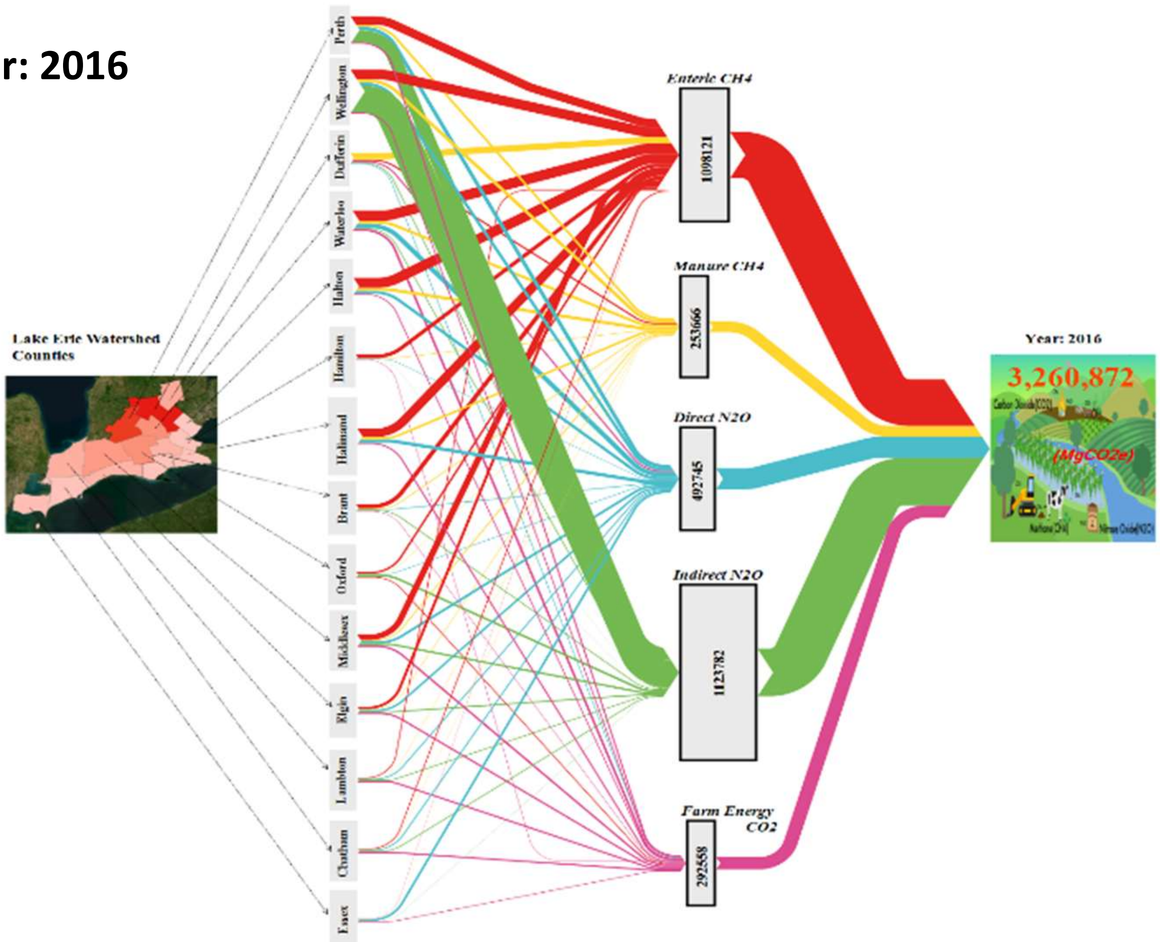
GHG Fluxes from agricultural farms

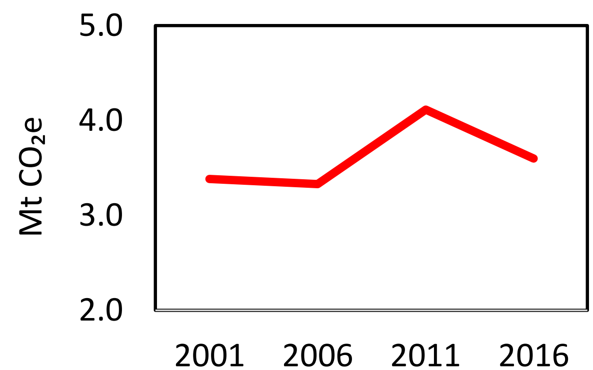
Year: 2016



GHG flux from all agricultural farms in Lake Erie counties in 2016

Ratnajit Saha

Total emission from Lake Erie Counties



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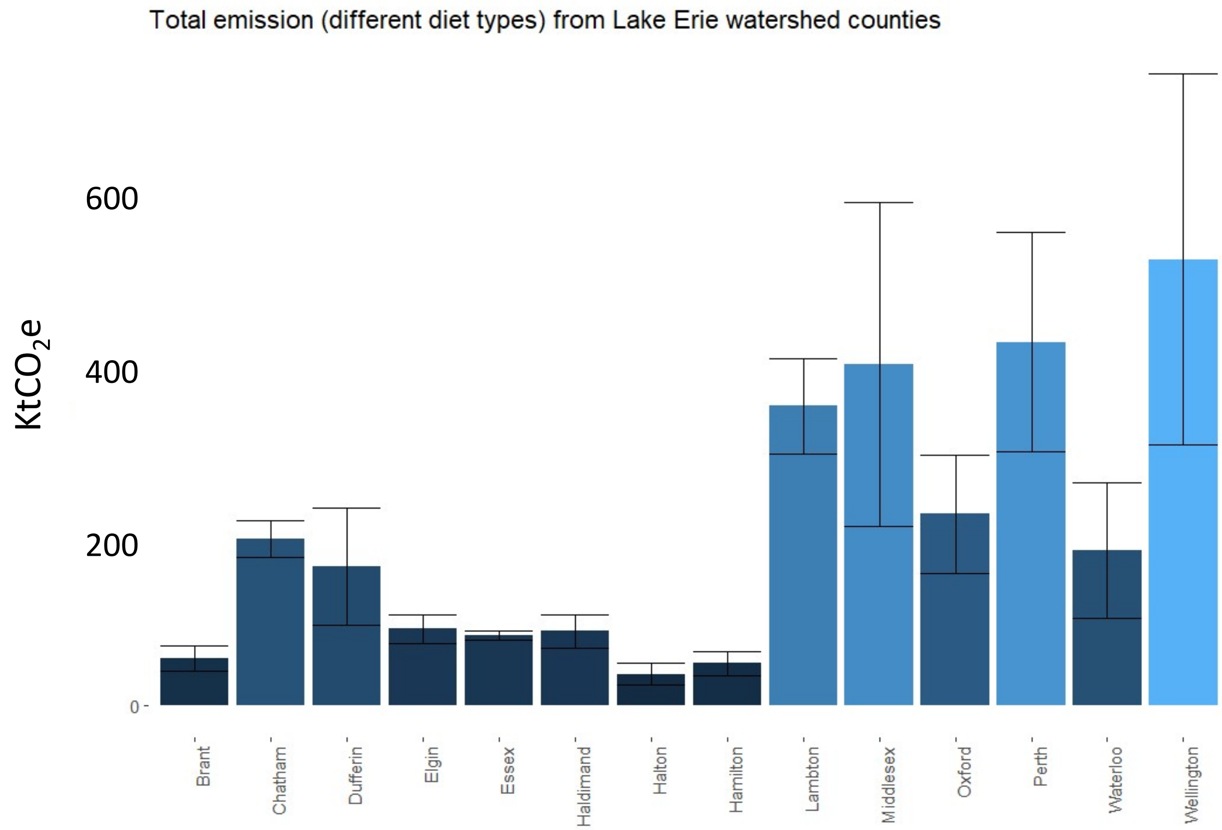
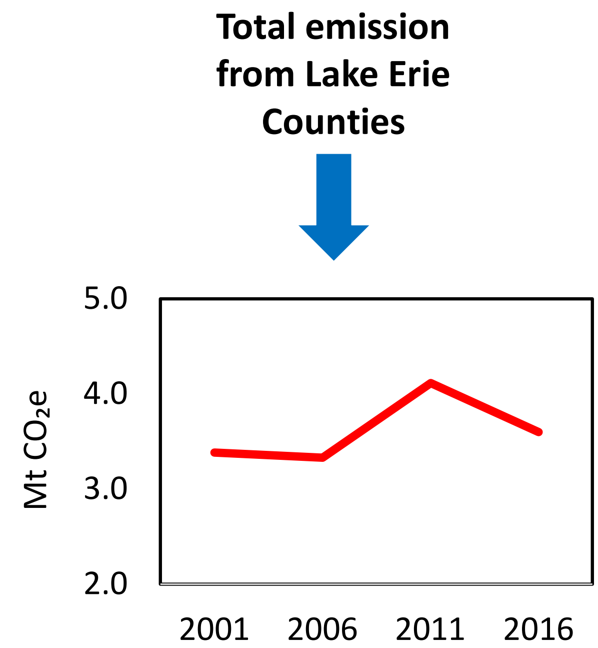
GHG Fluxes from agricultural farms

Year: 2016



GHG fluxes from agricultural farms in Lake Erie counties in 2016



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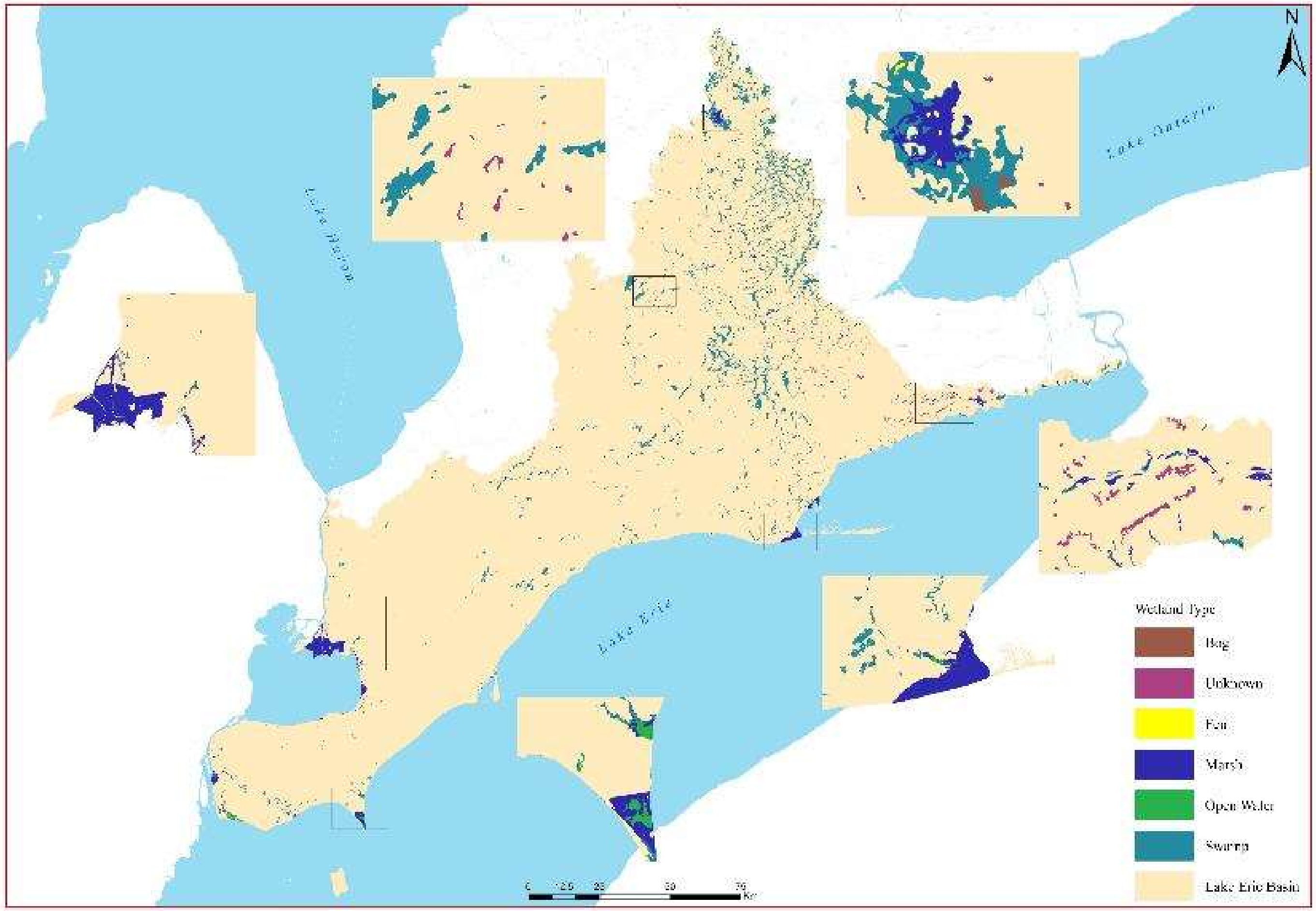
Natural Climate Solutions

Wetlands in Lake Erie Watershed

Areas of various types of wetlands

Types of wetland	Area km^2
Bog	1.43
Fen	1.03
Marsh	185.72
Open Water	21.29
Swamp	698.84
Unknown	60.38



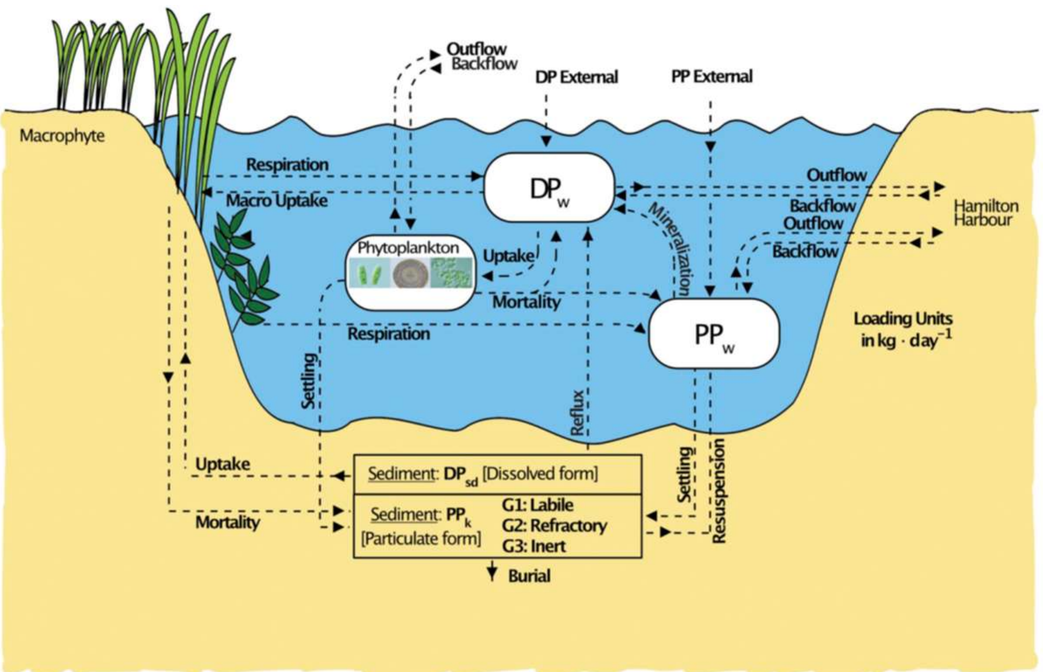
Location of different types of wetlands in Lake Erie watershed (source: OMNRF)

WETLANDS
Natural Climate Solutions

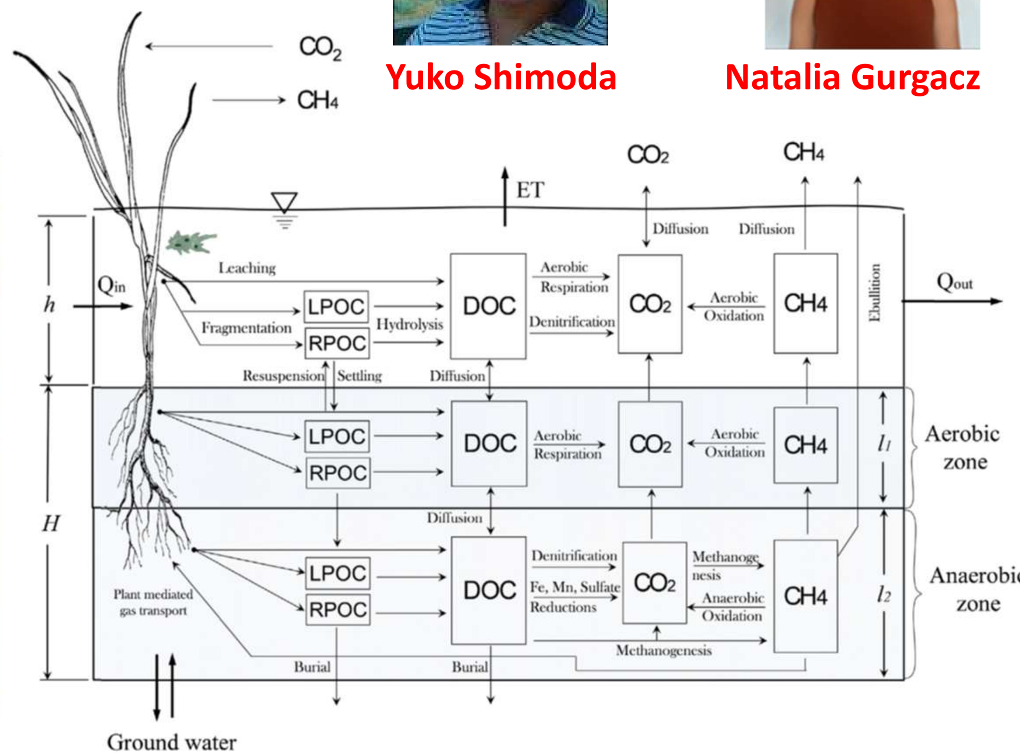
Process-based modelling for wetlands


Yuko Shimoda


Natalia Gurgacz

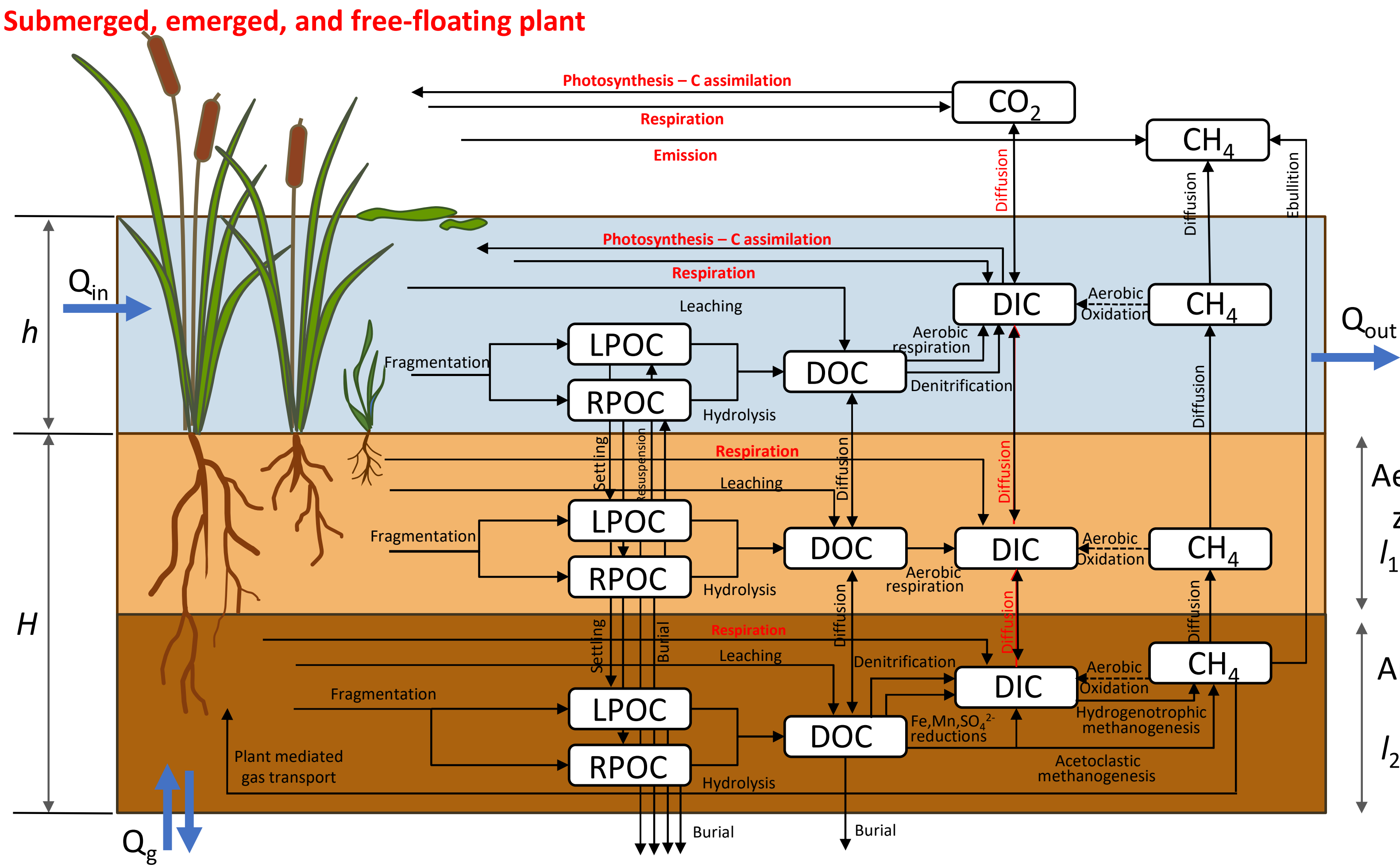


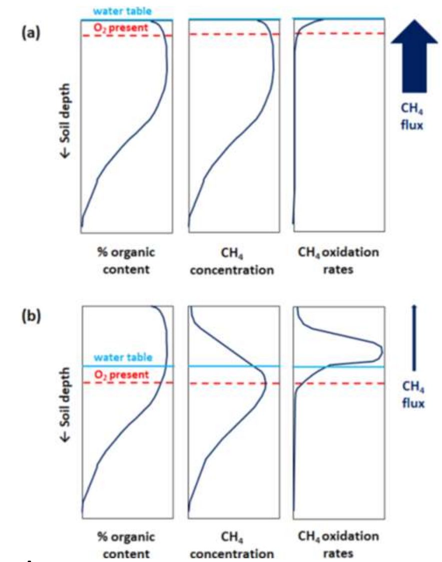
Wetland Eutrophication Model (WEM)



WetQual-C

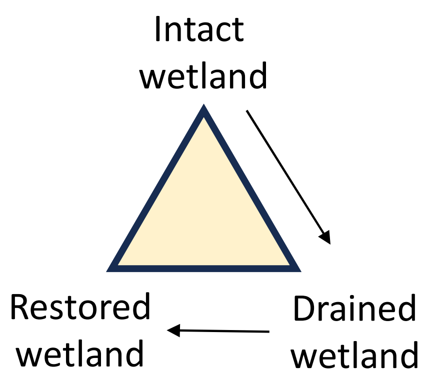
Process-based modelling for wetlands





Development of mechanistic models to understand functional transitions across restoration gradients.

Mineral wetlands in collaboration with OBJ 2 team



Peatland wetlands in collaboration with scientists from Canada and Europe

By examining <u>both</u> mineral and peatland wetlands, we can scale our understanding to the watershed level across our targeted Great Lake regions.

Alternative Models

McGill wetland model: evaluation of a peatland carbon simulator developed for global assessments

F. St-Hilaire[1,2], J. Wu[1,2], N. T. Roulet[1,2,3], S. Frolking[4], P. M. Lafleur[5], E. R. Humphreys[6], and V. Arora[7]

Journal of Geophysical Research: Biogeosciences

RESEARCH ARTICLE
10.1002/2016JG003438

Key Points:
- Using model-data fusion, we parameterized a hierarchy of biogeochemical models used to estimate CO_2 and CH_4 exchange in

Evaluation of a hierarchy of models reveals importance of substrate limitation for predicting carbon dioxide and methane exchange in restored wetlands

P. Y. Oikawa[1], G. D. Jenerette[2], S. H. Knox[3], C. Sturtevant[4], J. Verfaillie[3], I. Dronova[5], C. M. Poindexter[6], E. Eichelmann[3], and D. D. Baldocchi[3]

JGR Biogeosciences

RESEARCH ARTICLE
10.1029/2023JG007943

Special Collection:
Quantifying Nature-based Climate Solutions

Key Points:
- We present a process-based modeling

A New Coupled Biogeochemical Modeling Approach Provides Accurate Predictions of Methane and Carbon Dioxide Fluxes Across Diverse Tidal Wetlands

P. Y. Oikawa[1], D. Sihi[2], I. Forbrich[3,4], E. Fluet-Chouinard[5], M. Najarro[1], O. Thomas[1], J. Shahan[6], A. Arias-Ortiz[7], S. Russell[8], S. H. Knox[8,9], G. McNicol[10], J. Wolfe[11], L. Windham-Myers[12], E. Stuart-Haentjens[12], S. D. Bridgham[13], B. Needelman[14], R. Vargas[15], K. Schäfer[16], E. J. Ward[17,18], P. Megonigal[11], and J. Holmquist[11]

Implementation of nitrogen cycle in the CLASSIC land model

Ali Asaadi and Vivek K. Arora

Canadian Centre for Climate Modelling and Analysis, Environment Canada, University of Victoria, Victoria, B.C., V8W 2Y2, Canada

Correspondence: Vivek K. Arora (vivek.arora@canada.ca)

Global Change Biology WILEY

RESEARCH ARTICLE

Modeled production, oxidation, and transport processes of wetland methane emissions in temperate, boreal, and Arctic regions

Masahito Ueyama[1] | Sara H. Knox[2] | Kyle B. Delwiche[3] | Sheel Bansal[4] | William J. Riley[5] | Dennis Baldocchi[3] | Takashi Hirano[6] | Gavin McNicol[7] | Karina Schafer[8] | Lisamarie Windham-Myers[9] | Benjamin Poulter[10] | Robert B. Jackson[11] | Kuang-Yu Chang[5] | Jiquen Chen[12] | Housen Chu[5] | Ankur R. Desai[13] | Sébastien Gogo[14] | Hiroki Iwata[15] | Minseok Kang[16] | Ivan Mammarella[17] | Matthias Peichl[18] | Oliver Sonnentag[19] | Eeva-Stiina Tuittila[20] | Youngryel Ryu[21] | Eugénie S. Euskirchen[22] | Mathias Göckede[23] | Adrien Jacotot[24] | Mats B. Nilsson[18] | Torsten Sachs[25]

JGR Biogeosciences

RESEARCH ARTICLE
10.1029/2019JG005437

Key Points:
- We developed and tested a coupled carbon, nitrogen, and sulfur mechanistic model to assess GHG emissions in a wetland

A Mechanistic Analysis of Wetland Biogeocher in Response to Temperature, Vegetation, and Nutrient Input Changes

Chiara Pasut[1], Fiona H. M. Tang[1], and Federico Maggi[1]

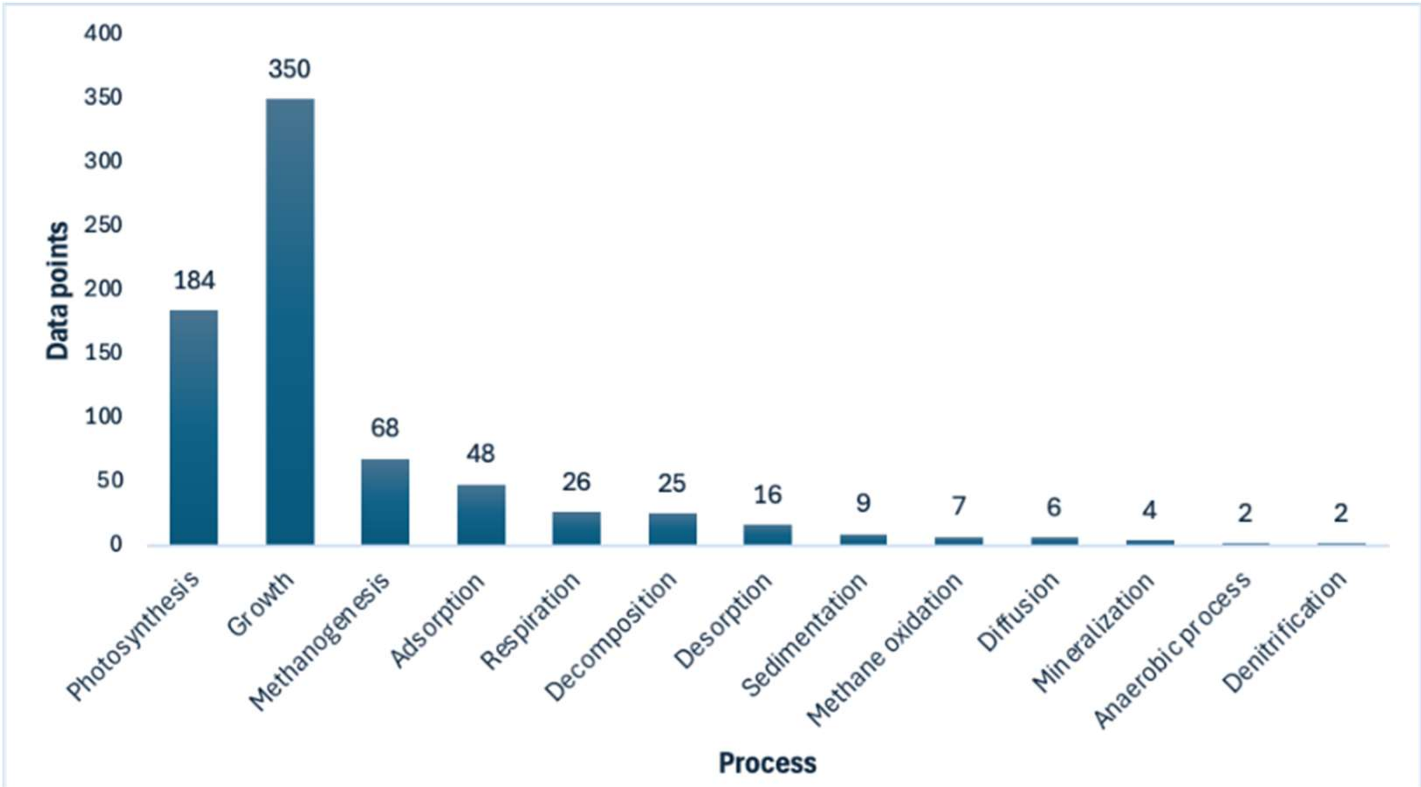
Natural Climate Solutions

Parameterization

Distribution of the parameter entries documented in the data repository across various wetland processes

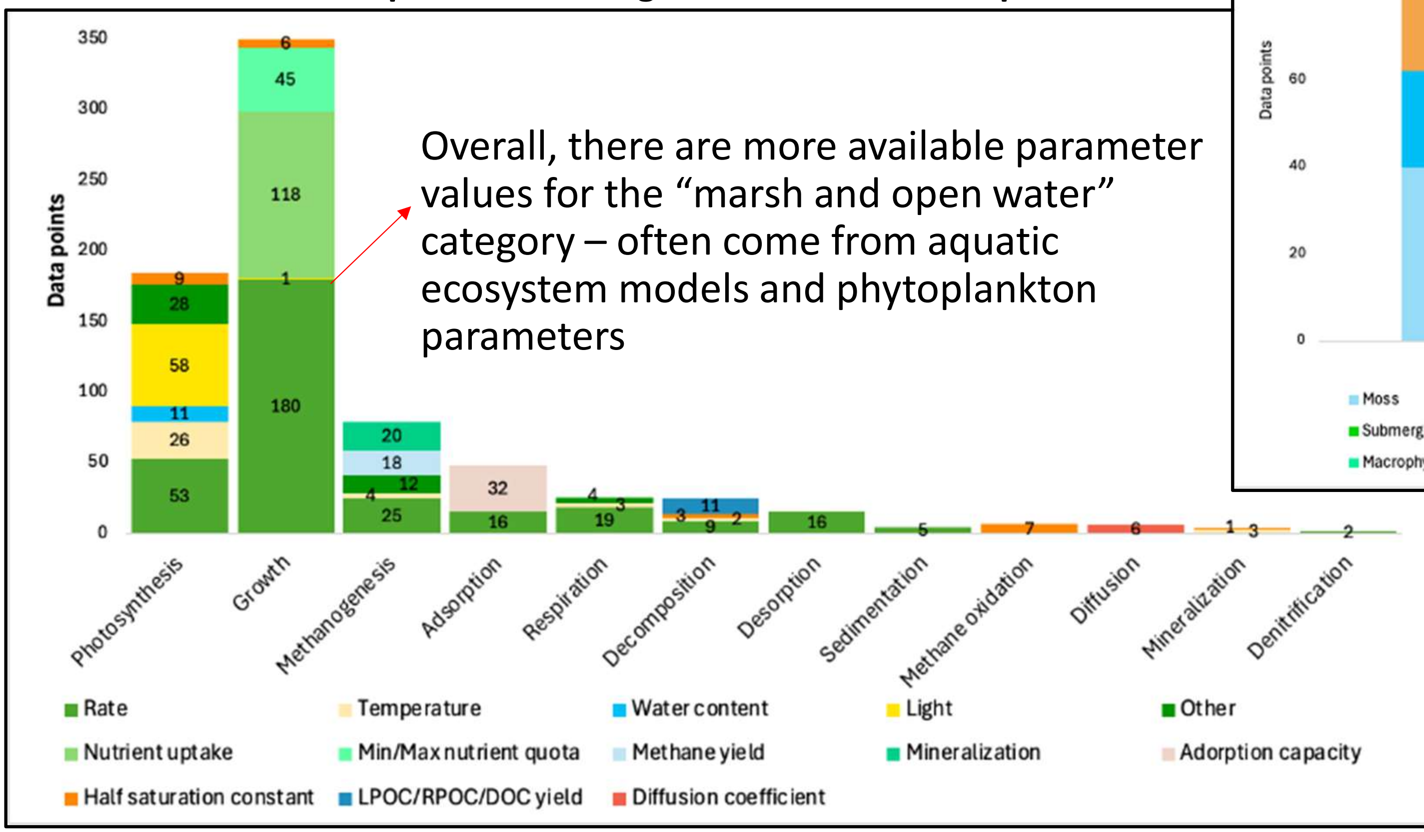
- Extensive data availability for photosynthesis and growth with 184 and 350 entries.
- Limited data on denitrification, sedimentation, and mineralization.

Availability of parameter data across wetland processes

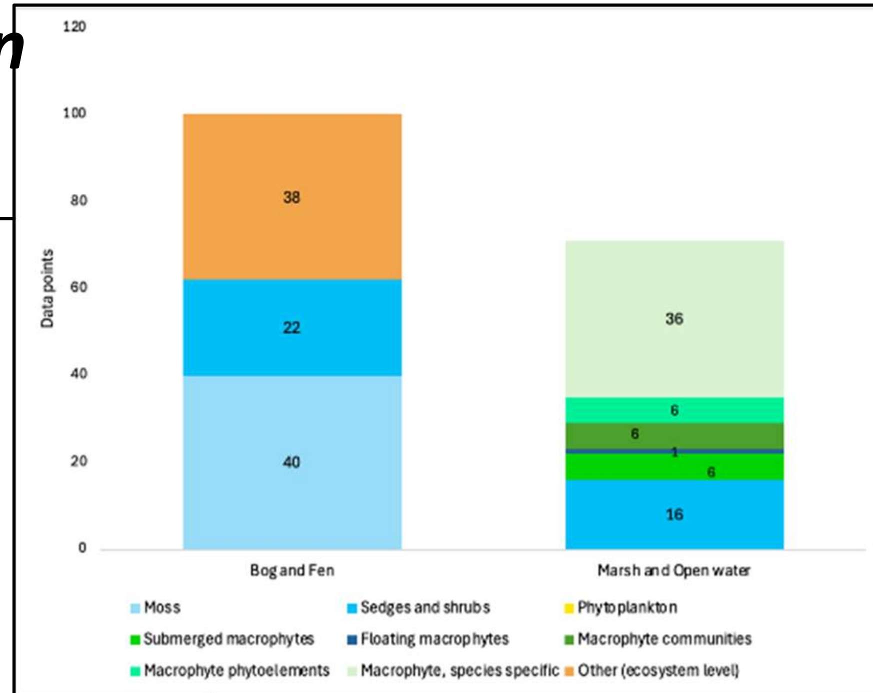


Parameterization

Distribution of parameter categories across wetland processes



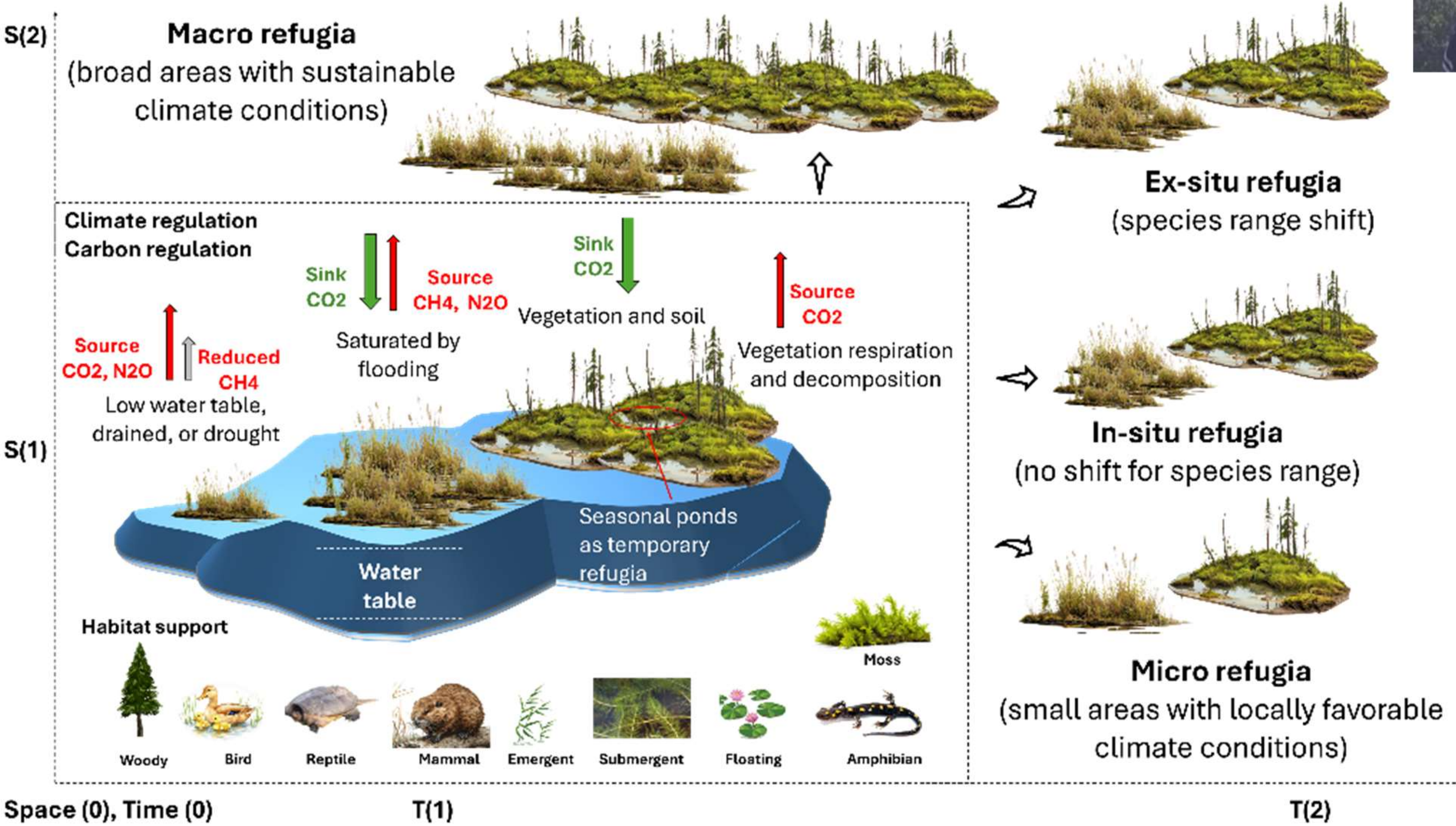
Overall, there are more available parameter values for the "marsh and open water" category – often come from aquatic ecosystem models and phytoplankton parameters



WETLANDS
Natural Climate Solutions

Wetlands and Biodiversity at a national level

Dynamic and dual role of wetlands in carbon sequestration and climate refugia.



Xin Wen

WETLANDS
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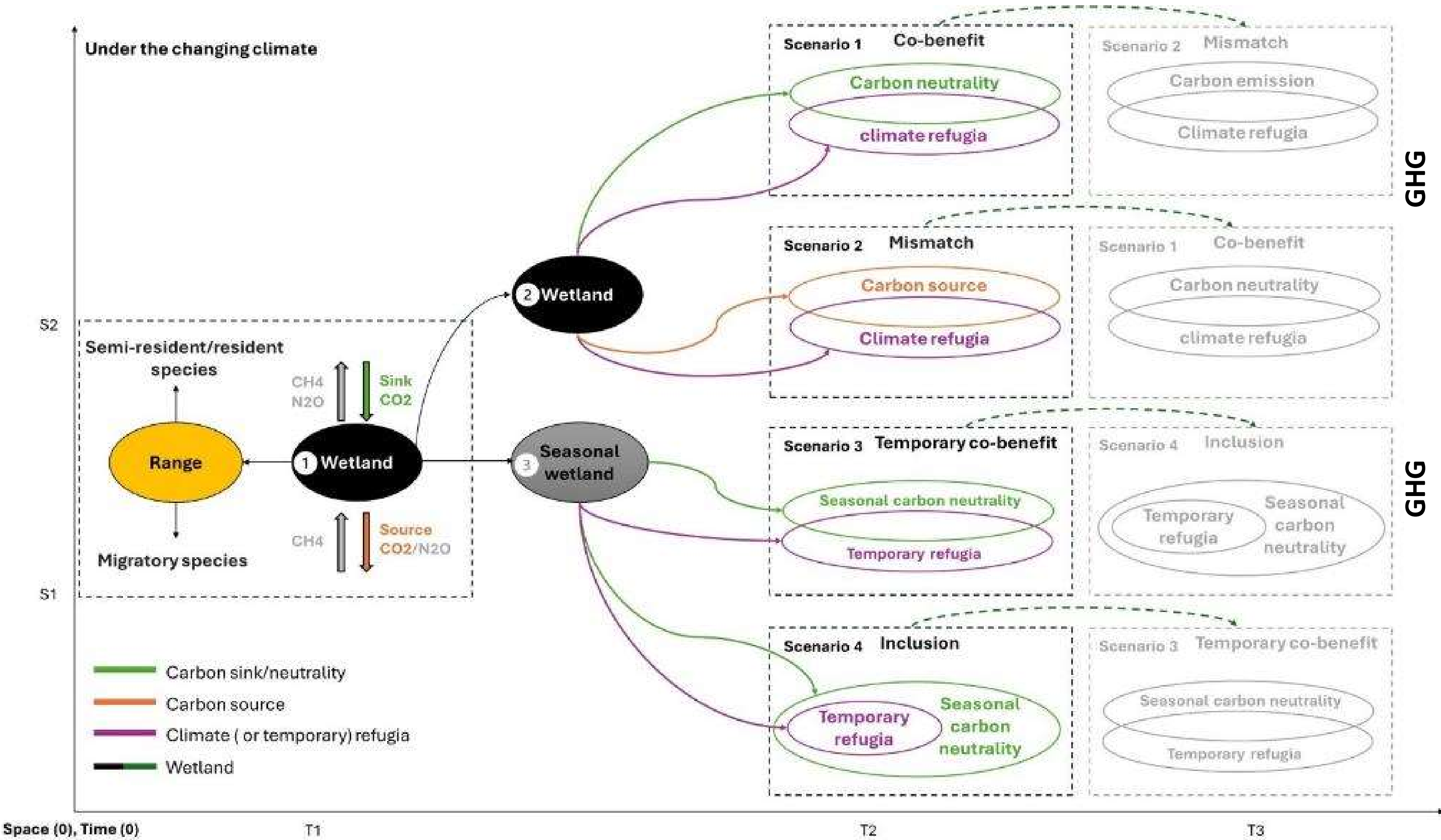
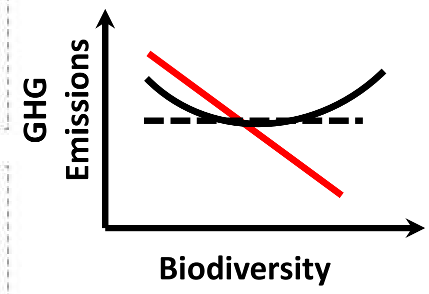
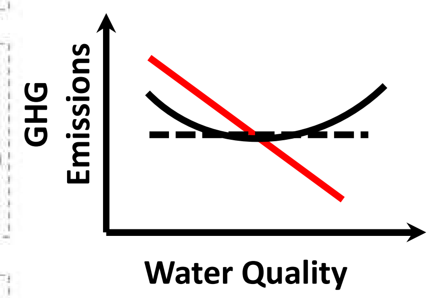
Wetlands and Biodiversity at a national level



Null (H_0) Hypothesis

Alternative (H_A) Hypotheses





WETLANDS
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Next Steps

- Integration of data collected across our network of wetland sites to inform our modelling tools.
- Address a multitude of questions related to the influence of hydrological connectivity on the fate and transport of carbon, nitrogen, and phosphorus for wetlands in agricultural landscapes.
- Connect these fate and transport patterns with other ecosystems services, including the integrity of our water resources and biodiversity.
- Develop web-based interactive/open-source modelling tools to explore the response of wetland hydrological connectivity and travel time to different climatic scenarios.

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Natural Climate Solutions

Objective 4. Co-Benefits

Develop Robust Estimates Of The Synergies (And Conflicts) Of Wetlands As NBS For Carbon Storage Versus Other Benefits

Cluster for Objective 4.

This cluster will bring their expertise in:
(1) measuring carbon storage, GHG mitigation, hydrological regulation, water purification and biodiversity benefits; and
(2) modelling ecosystem functions and benefits to enable exploration of synergies and conflicts among them.

Team members:
Irena Creed
James Patterson
Lauren Bortolotti
Share Clare
Pascal Badiou
Others … please join us!

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Natural Climate Solutions

Objective 4. Tasks

- **4.1.** Compile indicators to inform assessment of carbon and non-carbon wetland functions, service supply indicators, and benefits.
- **4.2.** Develop a rapid assessment tool to assess wetland's ability to regulate the atmosphere, mitigate floods/droughts, purify water, and enhance biodiversity.
- **4.3.** Identify highest priority data gaps for measuring indicators and fill them.
- **4.4.** Identify priority wetlands for protection or restoration to increase wetlands as nature-based solutions for climate change mitigation and co-benefits.

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Through an integrated synthesis of Objectives 1, 2, and 3,
this work aims to generate scalable tools
to inform wetland policy and management frameworks.

We need scalable tools to assess wetland functions and benefits

- Wetlands provide benefits.
- To harness these benefits nationally, we need tools that:
  - Go beyond **wetland-specific assessments**
  - Work at **jurisdictional scales**
  - Deliver **actionable data**
- Key questions we need to answer:
  - How do wetland functions vary across space and time?
  - Which wetlands deliver the greatest benefits?
  - Where should protection, restoration, or management be prioritized to maximize multiple functions and their benefits?

We are building principled, policy-relevant tools

To support multi-jurisdictional policies, tools must be:

- **Relevant** – focused on climate, biodiversity, and water security goals
- **Transparent** – built on open, reproducible methods
- **Observable** – grounded in indicators that can be measured with geospatial data
- **Transferable** – usable for wetlands across agricultural landscapes
- **Interoperable** – compatible with climate accounting, biodiversity tracking, and land-use planning systems

These principles ensure that assessments are scientifically credible **and** policy actionable.

We want to develop a shared conceptual framework across scales

To scale up assessments from individual wetlands to wetlandscapes,
we need a shared conceptual backbone that links:

- **Wetland structure**
- **Functions**
- **GIS and Remote sensing indicators**
- **Policy-relevant metrics**

This shared conceptual framework allows for consistent, scalable, and targeted assessments that support nature-based solution implementation under the CAAF program.

Who are we the intended users?

We are still considering this, and welcome feedback.

But based on our collective experience, we feel this planning tool will having the greatest impact serving municipalities and wetland conservation agencies (such as DUC).

We need to clarify the key terms that underpin wetland assessments – from wetland function, ecosystem service supply, and human benefits.

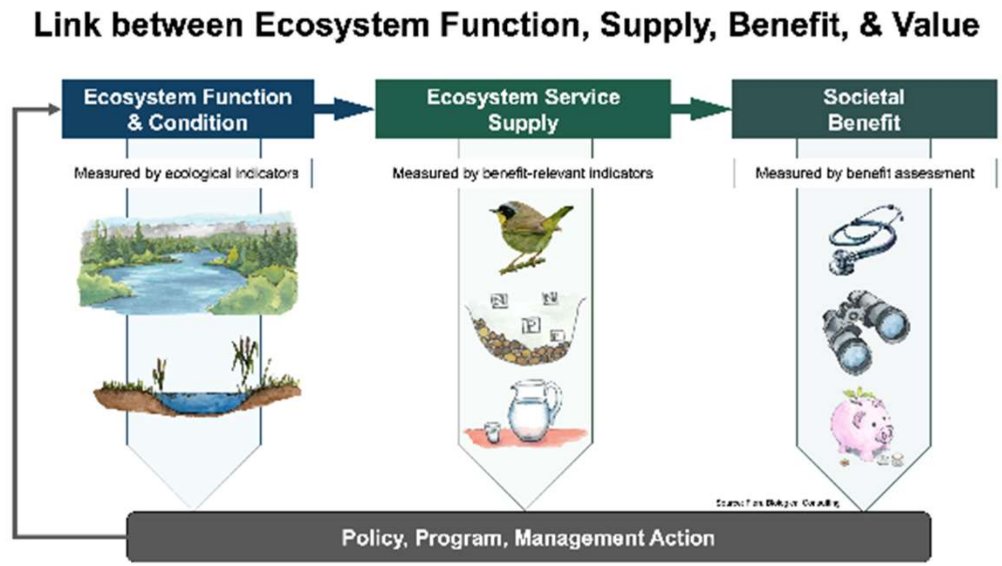
Why clarifying terms matters:

Critical for designing indicators, scaling models, and aligning models with policy goals.

Wetland Function (indicators)
The hydrological, biogeochemical, ecological processes that wetlands perform, independent of human use.
e.g., Photosynthesis, respiration

Wetland Service Supply (benefit-relevant indicators)
The capacity of a wetland to provide ecosystem services that are potentially beneficial to people.
e.g., Carbon sequestration

Wetland Social and Economic Benefit
The actual realization of human well-being outcomes from wetland services, shaped by access, demand, and policy.
e.g., Marketable carbon credits



We propose key features to guide the design of a tool
for assessing wetland functions and their associated benefits.

Core features of the wetland assessment tool

Dual planning approach
- Avoided Loss: Prevent degradation/loss of existing wetlands
- Intentional Gain: Restore/enhance degraded/loss wetlands to lift their function and benefit

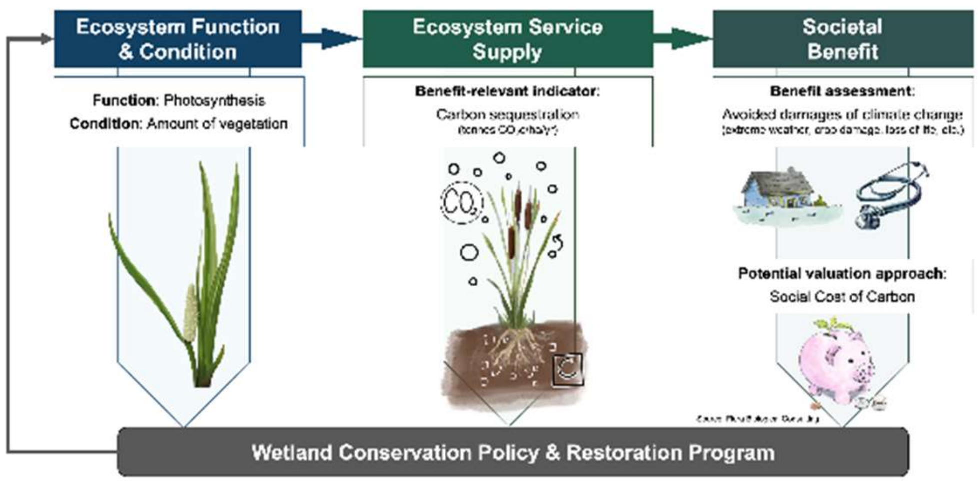
Centralized data repository
- Integrates environmental and socio-economic datasets
- Supports evidence-based, transparent decision-making

Scalable planning units
- Supports flexible application across neighborhoods, municipalities, watersheds, provinces

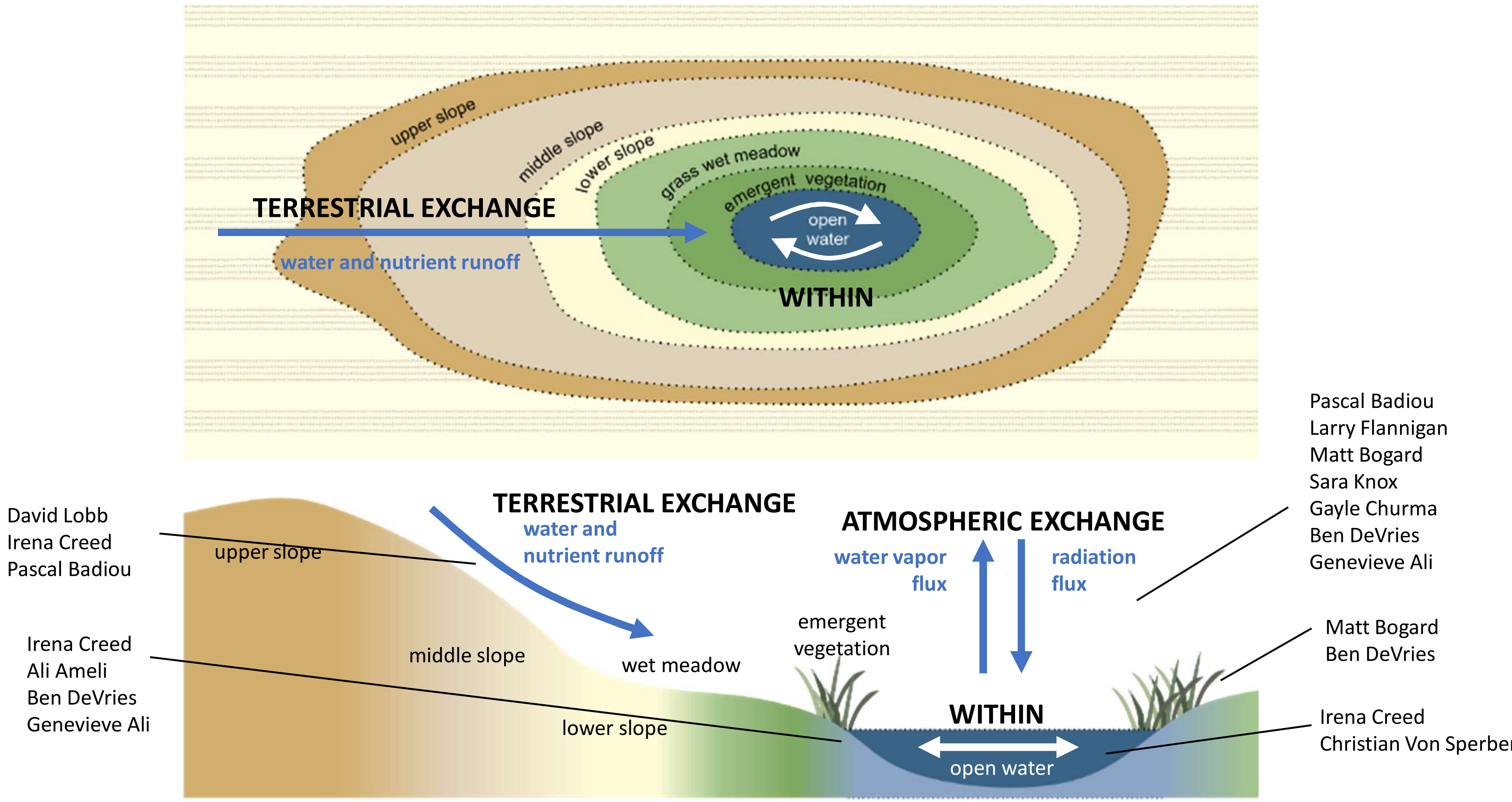
Dynamic calculator engine
- Real-time scoring and (re)calculation
- Adaptive to any selected planning unit

Function-to-benefit translation
- Functions: Measured using standardized and normalized ecological indicators
- Benefits: Translated into clear social and economic outcomes

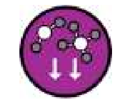
Today, I will focus on wetland's atmospheric regulation of carbon
– carbon storage and CO_2/CH_4 reduction –
and its functions, indicators, and resulting benefits.



Carbon function and benefit-relevant indicators



Practical tool for estimating climate function and benefit-relevant indicators, and benefits

function indicators	benefit-relevant indicator	benefit
Carbon Storage = ([WITHIN] * WITHIN LIFT + [EXCHANGE] * EXCHANGE LIFT) **[WITHIN]** = internal wetland carbon storage and GHG mitigation potential **[EXCHANGE]** = wetland exchange of carbon with the surrounding environment/contributing catchment **[LIFT]** = carbon gain (restoration and enhancement) lift potential Note: The LIFT score could be considered for use as a policy lever to prioritize restoration and enhancement initiatives.	Sequestration of atmospheric CO_2 and GHG emission reduction	

Practical tool for estimating climate function and benefit-relevant indicators, and benefits

function indicators

[WITHIN] = Carbon sequestered in wetland (autocthobnous)

Photosynthesis: Facilitates CO_2 uptake by emergent wetland vegetation
Indicator: **iNDVI**

Species: C/N ratio influences decomposition rate
Indicator: iNDVI

Soil mineral interactions: Clay binds carbon and forms aggregates, protecting organic C from rapid decomposition
Indicator: Soil texture

Redox potential: Regulates redox potential and oxygen availability for microbial activities that suppress decomposition and increase C storage but also increase CH4 Indicator: Inundation extent and period

Thermal regulation: Modulates microbial activity, decomposition rates, and plant metabolism
Indicator: Temperature

benefit-relevant indicator

Sequestration of atmospheric CO_2 and GHG emission reduction

benefit

Practical tool for estimating
climate function and benefit-relevant indicators, and benefits

function indicators

[EXCHANGE] Carbon mobilized into wetland (allochthonous)

Terrestrial-aquatic interface: Determines groundwater exchange, sediment erosion and deposition
Indicator: Perimeter to area ratio

Leaching: DOC (and nutrients) that influence microbial processes - respiration and denitrification

Erosion: Capture of eroded, C-rich sediments from agricultural runoff - upland soil properties and human disturbances

Drainage/Rewetting activities: changing hydrology influences carbon pools over time

BMP: Practices like buffer strips, no-till, cover cropping, amendment application, enhance C retention

Current and Legacy effects: Current and past agriculture activities affects current soil C dynamics – and different crops grown with different C:N ratio influences C cyanmics

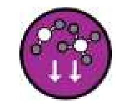
[LIFT] condition of wetland under which restoration or enhancement could maximize function

Drainage or degradation:
Amendments:

benefit-relevant indicator

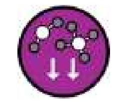
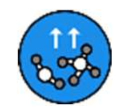
Sequestration of atmospheric CO_2 and GHG emission reduction

benefit



Practical tool for estimating climate function and benefit-relevant indicators, and benefits

Coupling the carbon and cooling benefits of wetlands

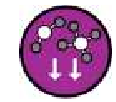
function indicators	benefit-relevant indicator	benefit
Carbon Storage = ([WITHIN] * WITHIN LIFT + [EXCHANGE] * EXCHANGE LIFT) **[WITHIN]** = internal wetland carbon storage and GHG mitigation potential **[EXCHANGE]** = wetland exchange of carbon with the surrounding environment **[LIFT]** = carbon gain (restoration and enhancement) lift potential	**Sequestration of atmospheric CO_2 and GHG emission reduction**	
Atmospheric cooling = ([WITHIN] * WITHIN LIFT + [EXCHANGE] * EXCHANGE LIFT) **[WITHIN]** = surface water area for evaporation and transpiration **[EXCHANGE]** = land surface available energy, energy fluxes, and surface roughness **[LIFT]** = temperature cooling (restoration and enhancement) lift potential	**Potential to drive evaporation and evapotranspiration to provide cooling and regulate local temperatures**	

Sara Knox: “The the wetland with the most cooling (CA-EM1) has the lower C uptake, so there may be trade-offs we need to consider. It would be good to explore the coupled biogeochemical and biophysical impacts of wetlands.”

With a plan for quantifying carbon functions and benefit supply,
next we want to examined the resulting carbon benefits.

Here, I want to share early work on estimating
the social and economic benefits that arise from the protection and restoration of wetlands.

Practical tool for estimating climate function and benefit-relevant indicators, and benefits

function indicators	benefit-relevant indicator	benefit
	Sequestration of atmospheric CO_2 and GHG emission reduction	

Carbon Storage = ([WITHIN] * WITHIN LIFT + [EXCHANGE] * EXCHANGE LIFT) X ([BENEFIT])

[WITHIN] = internal wetland carbon storage and GHG mitigation potential

[EXCHANGE] = wetland exchange of carbon with the surrounding environment/contributing catchment

[LIFT] = carbon gain (restoration and enhancement) lift potential

[BENEFIT] = Capacity to deliver carbon storage benefits to end users

Why do farmers drain wetlands?

Nuisance costs

1. **Lost revenue** due to missed farmable areas

2. **Overlap costs**
(added expenditures to avoid)

3. **Adjacency costs**
(lost revenue in farmable areas near near due to lower yields)

Why do farmers retain wetlands?

1. Wetland areas unsuitable for farming

2. Wetland drainage too costly

3. Wetlands provide (non-carbon) ecosystem services

Klotz, Boldt, Lloyd-Smith, Pattison-Williams and Brouwer. 2024. Producer Survey.
Klotz. In Prep. MA thesis, University of Alberta. Supervised by 2025 by Pattison-Williams, Lloyd-Smith and Adamowicz

Carbon benefit calculator

This is the benefit-relevant indicator!

1. Select the median carbon sequestration rates: **0.66 Mg C ha^{-1} yr^{-1}**

2. Select the 30-year time frame for sequestering OC: **2021-2050**

3. Determine the cost of restoring the wetland: **\$237-\$31,000 CAD ha^{-1}**
   We included direct restoration costs (e.g., cost of plugging the drain) and opportunity costs associated with alternative uses of the land (e.g., cost of lost crop yield).

4. Determine the benefit of restoring the wetland: **\$50 ton^{-1}, increasing \$15 ton^{-1} yr^{-1}**

5. Calculate **Benefit:Cost Ratio**
   If ratio = 1 breakeven in turns of benefits and costs.
   If ratio > 1 wetland restoration project justified based on carbon benefits alone.

Creed et al. 2022. Can Restoration of Freshwater Mineral Soil Wetlands Deliver Nature-Based Climate Solutions to Agricultural Landscapes? Front. Ecol. Evol. 10:932415.

FINDING 1.
It is better to protect rather than restore wetlands based on climate benefit.

Climate Target	Period	Tonnes	Present value of costs $/ha		Present value of costs $/tonne		Benefit: Cost Ratio	
			Protection	Restoration	Protection	Restoration	Protection	Restoration
2050	30	98.1	$8,472	$8,709 - $39,472	$86	$402	1.23	0.26 - 1.20

Based on 2022 price of carbon at $50 ton^{-1}, increasing $15 yr^{1}

Incentivize farmers to maintain the remaining intact wetlands on their land.

Creed et al. 2022. Can Restoration of Freshwater Mineral Soil Wetlands Deliver Nature-Based Climate Solutions to Agricultural Landscapes? Front. Ecol. Evol. 10:932415.

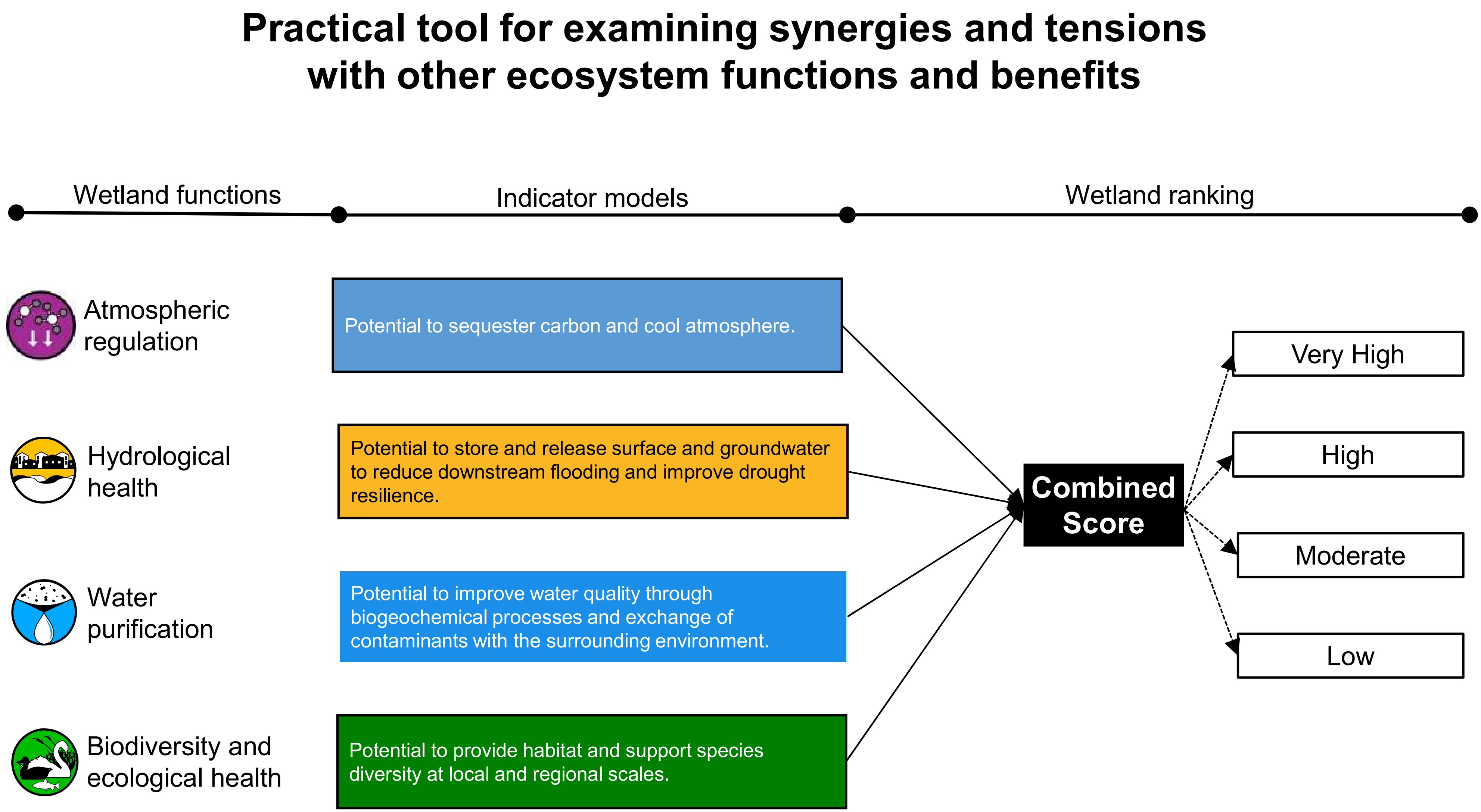
FINDING 2.
Climate benefits alone may not be enough to incentivize restoration of wetlands.

Climate Target	Period	Tonnes	Present value of costs $/ha		Present value of costs $/tonne		Benefit: Cost Ratio	
			Protection	Restoration	Protection	Restoration	Protection	Restoration
2050	30	98.1	$8,472	$8,709 - $39,472	$86	$402	1.23	0.26 - 1.20

Based on 2022 price of carbon at $50 ton^{-1}, increasing $15 yr^{1}

Increase the carbon benefit *or* stack other ecosystem benefits to create larger financial incentives.

Creed et al. 2022. Can Restoration of Freshwater Mineral Soil Wetlands Deliver Nature-Based Climate Solutions to Agricultural Landscapes? Front. Ecol. Evol. 10:932415.


Practical tool for examining synergies and tensions
with other ecosystem functions and benefits
Wetland functions
Indicator models
Wetland ranking
Atmospheric regulation
Potential to sequester carbon and cool atmosphere.
Hydrological health
Potential to store and release surface and groundwater to reduce downstream flooding and improve drought resilience.
Water purification
Potential to improve water quality through biogeochemical processes and exchange of contaminants with the surrounding environment.
Biodiversity and ecological health
Potential to provide habitat and support species diversity at local and regional scales.
Combined Score
Very High
High
Moderate
Low

Practical tool for estimating
climate function, benefit-relevant indicators, and benefits

function indicators	benefit-relevant indicator	benefit
Hydrological Health = **([WITHIN] × WITHIN LIFT + [EXCHANGE] × EXCHANGE LIFT) × ([BENEFIT])** **[WITHIN]** = internal capacity of wetland to provide water storage **[EXCHANGE]** = inflows and outflows of water from the surrounding environment/contributing catchment **[LIFT]** = flood/drought mitigation gain (restoration and enhancement) lift potential **[BENEFIT]** = capacity to deliver flood/drought mitigation benefits to end users	**Water storage and attenuation of flows**	 **Hydrological health**

Practical tool for estimating climate function, benefit-relevant indicators, and benefits

function indicators	benefit-relevant indicator	benefit
Water Purification = **([WITHIN] × WITHIN LIFT + [EXCHANGE] × EXCHANGE LIFT) × ([BENEFIT])**	**Water quality improvement through sequestration of nutrients and toxins**	 **Water purification**

[WITHIN] = internal capacity of wetland to remove or retain nutrients or toxins

[EXCHANGE] = inflows/outflows of nutrients/toxins with surrounding environment/contributing catchment

[LIFT] = nutrient and toxin sequestration (restoration and enhancement) lift potential

[BENEFIT] = capacity to deliver water quality benefits to end users

Practical tool for estimating
climate function, benefit-relevant indicators, and benefits

function indicators

Biodiversity and Ecological Health =
([WITHIN] × WITHIN LIFT + [EXCHANGE] × EXCHANGE LIFT) × ([BENEFIT])

[WITHIN] = internal wetland habitats/nesting/migration sites for amphibians, birds, mammals, reptiles

[EXCHANGE] = corridors/barriers to species movement from surrounding environment/contributing catchment

[LIFT] = species richness and diversity (restoration and enhancement) lift potential

[BENEFIT] = capacity to deliver biodiversity and ecological health benefits to end users

benefit-relevant indicator

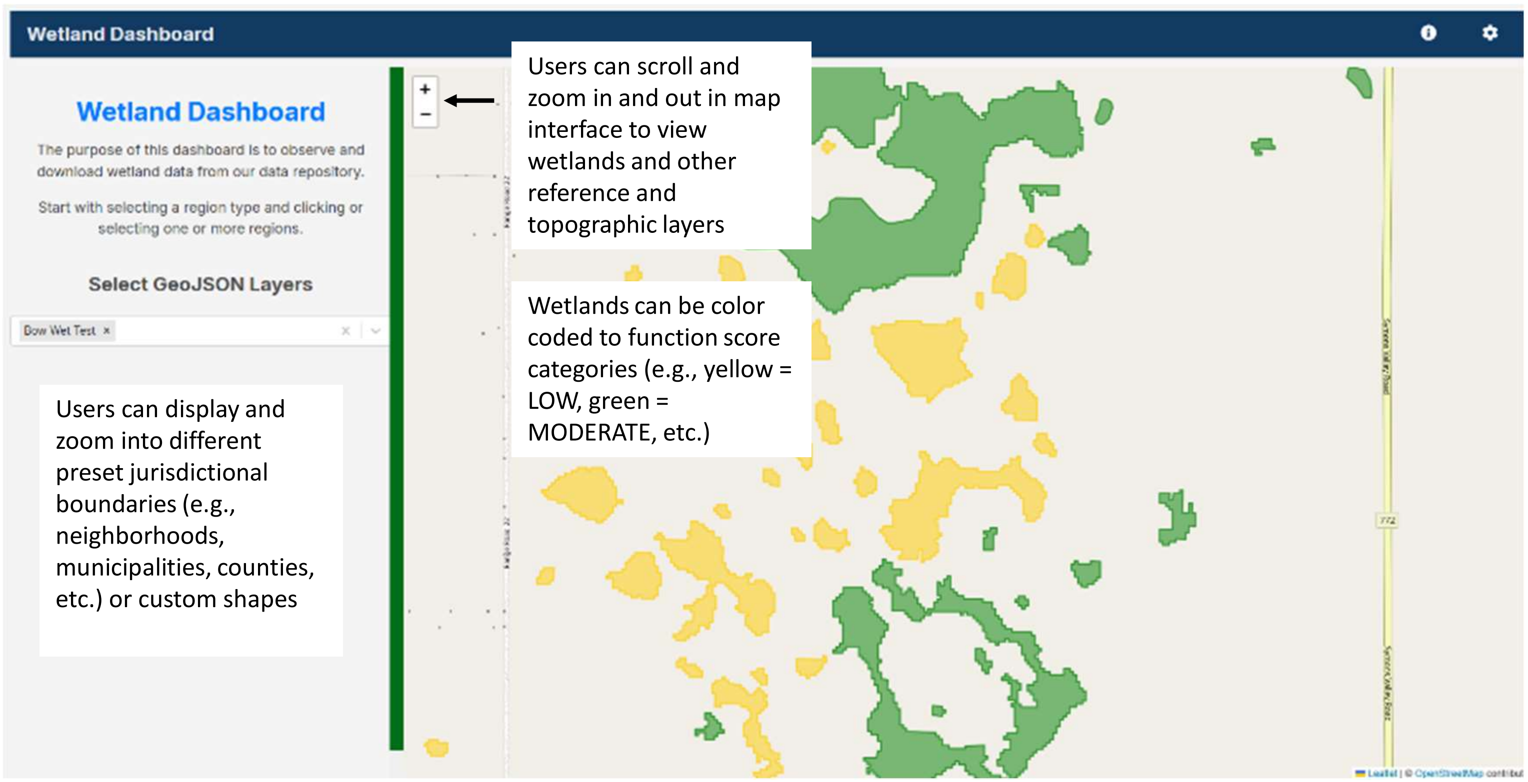
Species richness and diversity

benefit

Biodiversity and ecological health

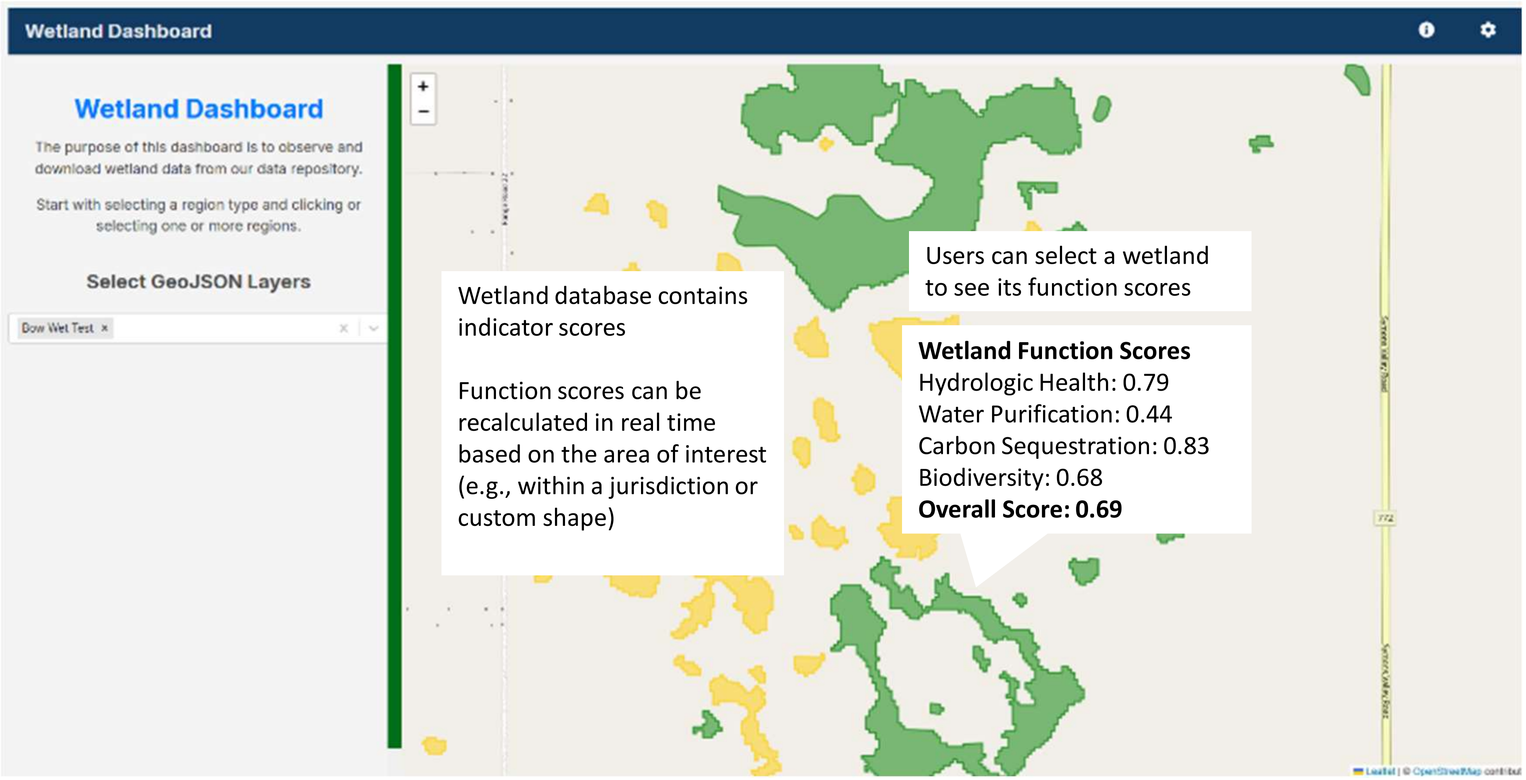
We are developing an App to automate calculations
of wetland functions and benefit-supplies at multiple scales.

Wetland Function App—Under Development

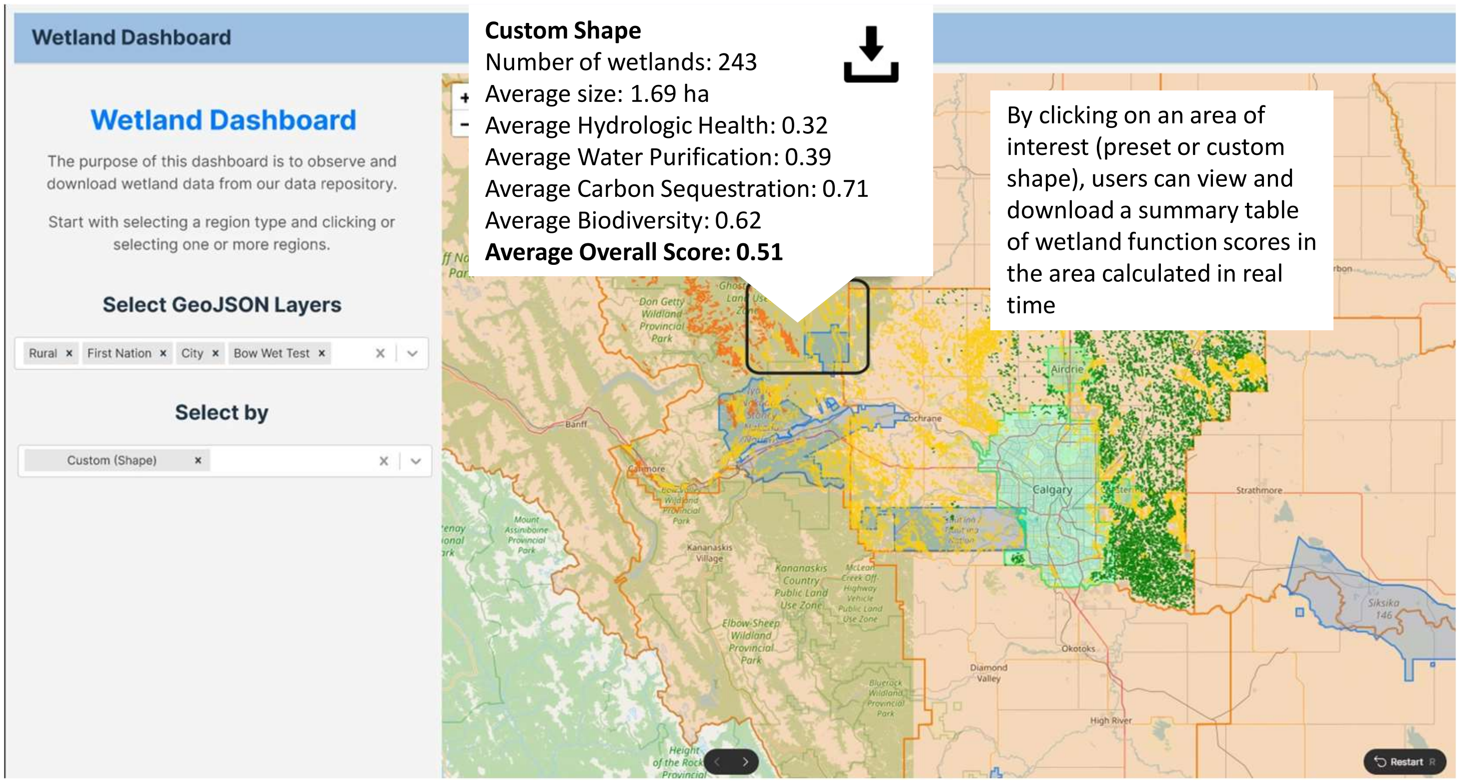


Setting and Info buttons

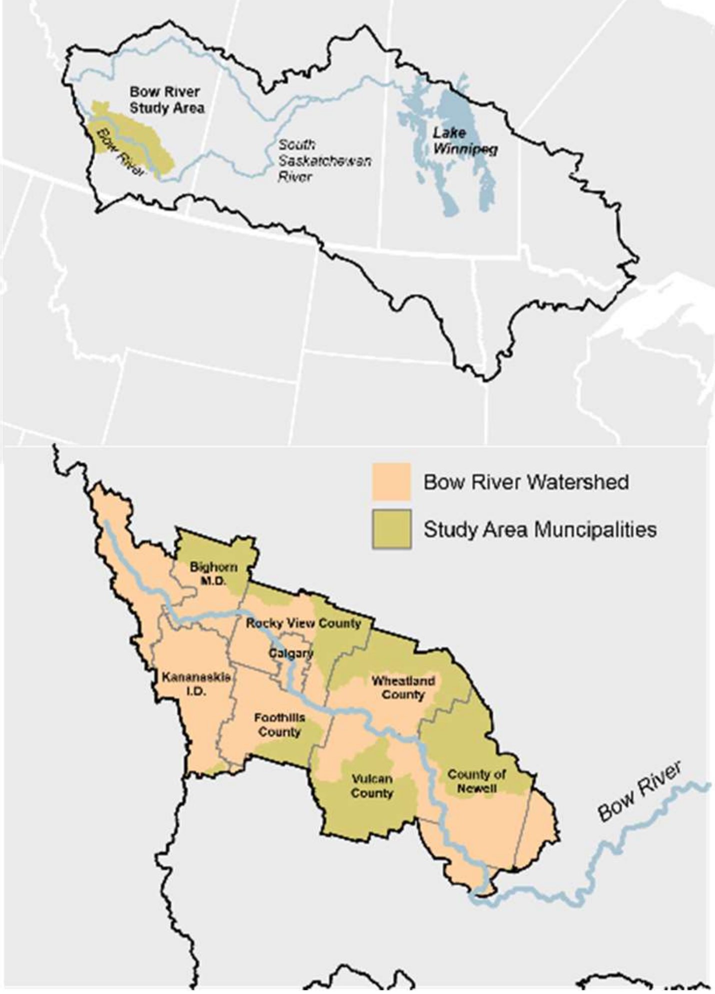
Wetland Function App—Under Development

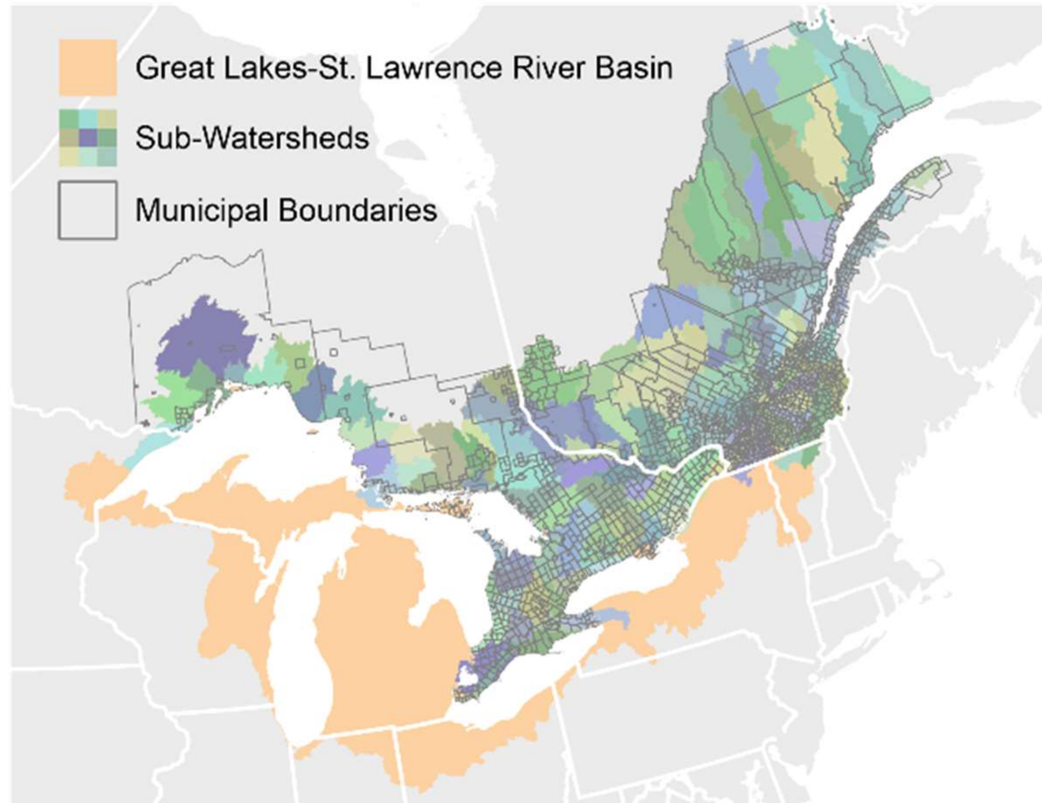


Wetland Function App—Under Development

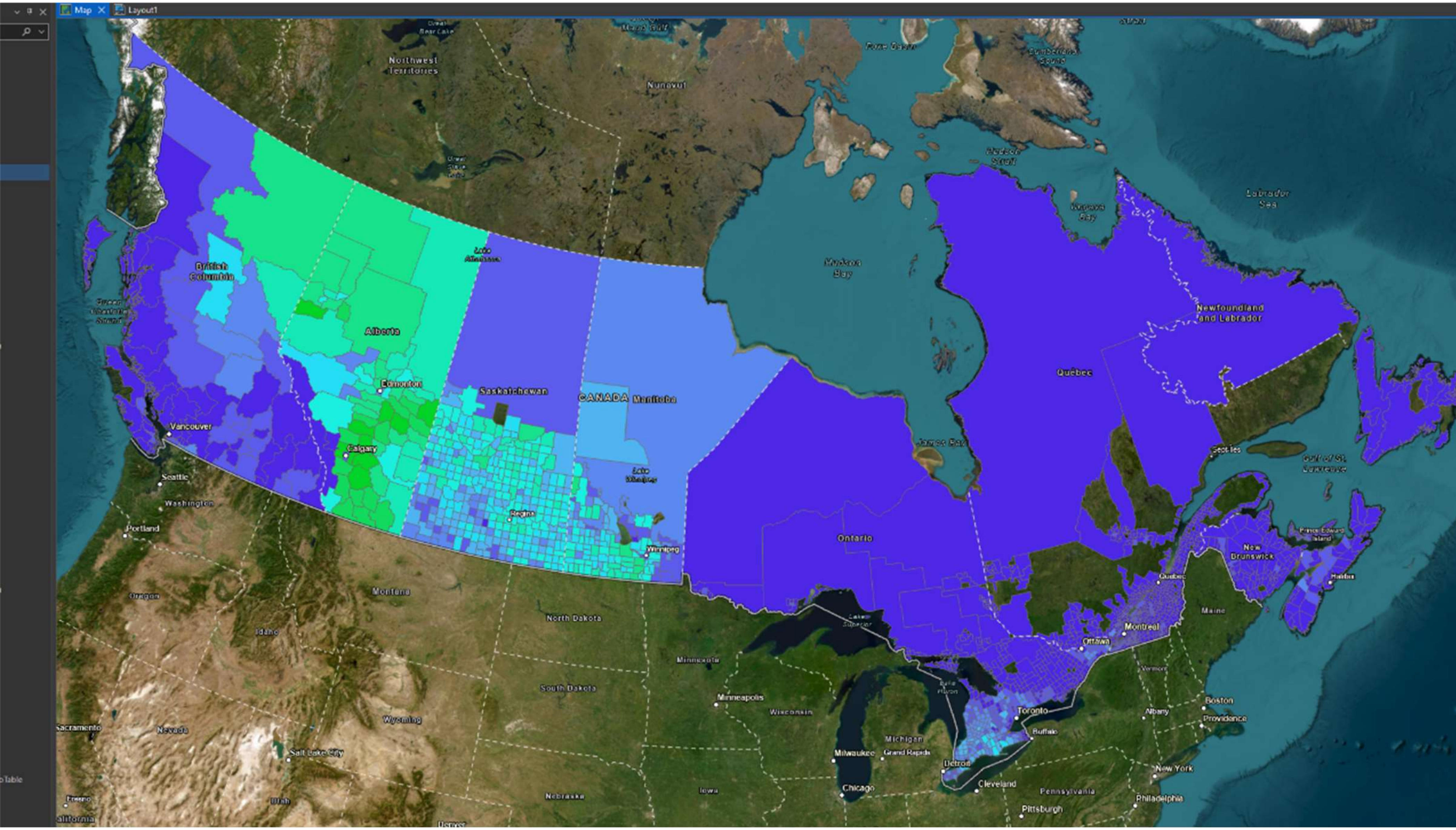


We have selected the bow river watershed in the west, and are in the process of selecting one in the east)



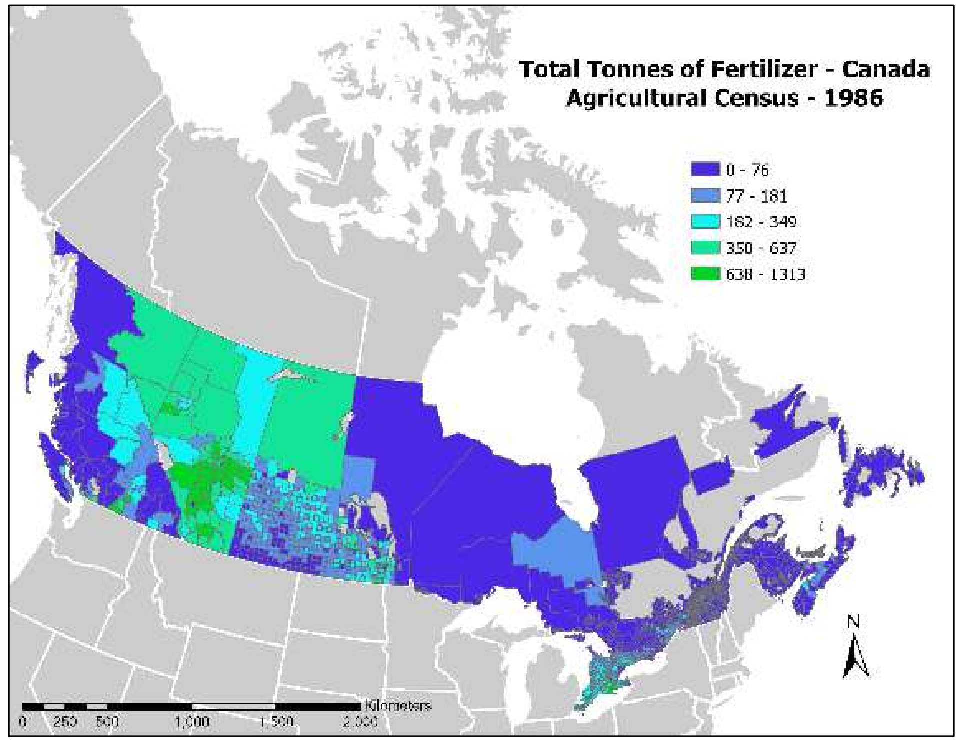


We are seeking recommendations for a pilot watershed in the GLSLR, especially in QUEBEC.


Map
Layout1
Northwest Territories
Nunavut
Hudson Bay
Labrador Sea
British Columbia
Alberta
Saskatchewan
CANADA
Manitoba
Edmonton
Calgary
Vancouver
Regina
Winnipeg
Ontario
Québec
Newfoundland and Labrador
James Bay
Sept-Îles
New Brunswick
Prince Edward Island
Halifax
Quebec
Montreal
Ottawa
Toronto
Buffalo
Detroit
Cleveland
Seattle
Washington
Portland
Oregon
Idaho
Montana
North Dakota
South Dakota
Minnesota
Minneapolis
Wisconsin
Michigan
Milwaukee
Grand Rapids
Chicago
Wyoming
Nevada
Sacramento
Salt Lake City
Utah
Nebraska
Iowa
Maine
Boston
Providence
Albany
New York
Pennsylvania
Philadelphia
Pittsburgh

Agricultural Census Data (1961 – 2021)

- Track reported agricultural data by Aggregated Census subdivisions.
  - 602 to 1338 variables depending on the year
- Some consistent variables over time include:
  - Farm count
  - Farm area
  - Farm capital
  - Land and Buildings (Market Value)
  - Machinery and equipment
  - Livestock (Poultry, cattle, pigs)
  - Agricultural products sold
  - Cropland area
  - Fertilizer area (starting from 1981)
  - Irrigation area (starting from 1981)



Collaboration between/within objectives

1. Open invitation for WNbS Network members to participate.
2. Ongoing collaborations with OBJ1 (mapping), OBJ2 (measuring), and OBJ3 (modelling).
3. Emerging collaborations with extension projects (e.g., we are compiling the data needed for wetland benefit-supply to support social and economic analysis in the pilot watersheds).
4. Inviting collaborations with local beneficiaries (e.g., municipalities), but also with international networks that are pursuing similar tool development.

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Forward-looking requests and opportunities

E.g., What would we do if we had more resources?

E.g., what other grants are we applying for to pursue additional opportunities?

Additional resources would enable us to create the data repository, extract indicators and models, and build the full App for the two pilot watersheds.

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Anticipated impacts

There is a need for evidence-based decision making.

Evidence synthesis is “the process of identifying, compiling, and combining relevant knowledge from multiple sources so it is readily available for decision makers”. (S. Cooke)

OBJ4’s tool is a form of evidence synthesis to inform decisions related to wetlands as natural climate solutions.

This type of interdisciplinary **evidence synthesis** activity is hard.

We need time to develop consensus on terms, approaches, tools, and audiences.

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- **Objective 5**

Use The Authoritative And Robust Estimates Of OC Accumulation And GHG Fluxes To Inform Policy And Practice Tools To Incentivize The Use Of Wetlands As NBS For Multiple Benefits In Agricultural Landscapes

Guillaume Peterson St. Laurent, Senior Policy Advisor
Canadian Wildlife Service, Environment and Climate Change Canada

Nature Smart Climate Solutions Fund

Embracing the power of nature to fight climate change

Natural Climate Solutions For Mitigation

In December 2020, the Natural Climate Solutions Fund (NCSF) was announced ($ 5 billion over 10 years) to reduce greenhouse gas (GHG) emissions reaching 7-10 megatonnes (Mt) CO_{2e} annually in 2030 and up to 16-20 Mt CO_{2e} by 2050.

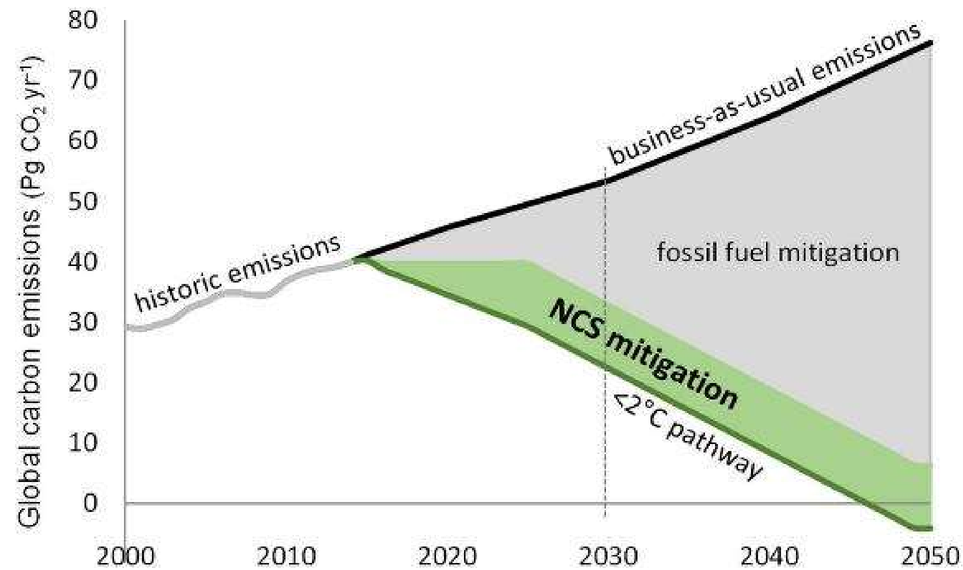
2 Billion Trees Program
Lead: Natural Resources Canada (NRCan)

Nature Smart Climate Solutions Fund (NSCSF)
Lead: Environment and Climate Change Canada (ECCC)

Agricultural Climate Solutions Fund
Lead: Agriculture and Agri-food Canada (AAFC)

Nature Smart Climate Solution Fund

$1.4 billion,
10-year fund (2021-2031)
led by ECCC to support
natural climate solution projects
that will contribute to reducing
5-7 Mt of GHG emissions annually in 2030
to 2050.



Griscom et al. 2017. PNAS. 114 (44): 11645-11650.

NSCSF Objectives

1. **Improve knowledge** about natural climate solutions in Canada
2. **Support projects** through contribution agreements that will:
   - Stop major releases of carbon stored in ecosystems and facilitate ongoing sequestration by reducing the rates of conversion in carbon-rich ecosystems (**Avoided Conversion**).
   - Optimize ecosystem capacity to sequester and store carbon by restoring ecosystems and changing land management practices (**Restoration and Improved Management**).
   - Achieve biodiversity and human well-being **co-benefits.**
   - Advance the federal commitment to **reconciliation** by providing dedicated support to enable Indigenous peoples to play a meaningful leadership role in natural climate solutions (with, but not only through, the Indigenous-led Natural Climate Solutions (ILNCS) program).
3. **Encourage the integration of natural climate solutions into existing land use and management policies and programs for longer term changes and at larger scale.**

NSCSF Funding Streams

- **Emissions Reduction Activities**
  - Projects that will contribute to Canada's 2030 emissions reduction targets by reducing rates of land conversion, increasing rates of restoration and improving land management – site-based and policy projects.
- **Indigenous-Led Natural Climate Solutions**
  - Through the Indigenous-led Natural Climate Solutions stream, funding supports First Nations, Inuit and Métis Nations, communities and organizations to build capacity and to undertake on-the-ground activities supporting ecosystem protection, restoration and improved land management.
- **Science for Delivery and Accountability**
  - Funding to improve state of knowledge on natural climate solutions in Canada and identify where and how best to implement GHG mitigations to support Canada's GHG emissions reduction target while gaining biodiversity benefits.

Science for Delivery and Accountability

1. Baselines and projections
2. Short-term needs to inform implementation
3. Long-term "Learning and Knowledge Hubs"

Targeted ecosystems and type of information for Science for Delivery and Accountability

Ecosystems and NSCSF activities

- Coastal wetlands: avoided conversion & restoration
- Croplands: tree planting on agricultural land
- Forests: avoided conversion & enhanced management
- Freshwater mineral wetlands: avoided conversion & restoration
- Grasslands: avoided conversion & restoration
- Peatlands: avoided conversion & restoration

Categories of data/information

1. Historical baselines: development of historical baselines for rates of land use change for one or multiple ecosystems

2. Projections: development of projections of land use change that draw on both historical data as well as expected future socio-economic, behavioral, policy, drivers of land use change and other relevant data.

3. GHG quantification: capacity building for GHG quantification, including the development or improvement of methods for (1) monitoring (2) quantification of mitigation outcomes, and (3) assessment of leakage

4. Implementation & policy: Support (1) the development of data and information that can inform the implementation of NSCSF and/or (2) the direct or indirect improvement of existing and/or development of new policy, tools or programs supporting NCS implementation.

Questions

- For general questions on NSCSF, please contact:
  ec.fscan-nscsf.ec@ec.gc.ca

- For more specific questions (especially on science), feel free to contact me:
  Guillaume.petersonst-laurent@ec.gc.ca

Nature Smart Climate Solutions Fund

April 09, 2025

Natural Climate Solutions For Mitigation

In December 2020, the Natural Climate Solutions Fund (NCSF) was announced ($ 5 billion over 10 years) to reduce greenhouse gas (GHG) emissions reaching 7-10 megatonnes (Mt) CO_{2e} annually in 2030 and up to 16-20 Mt CO_{2e} by 2050

2 Billion Trees Program
Lead: Natural Resources Canada (NRCan)

Nature Smart Climate Solutions Fund (NSCSF)
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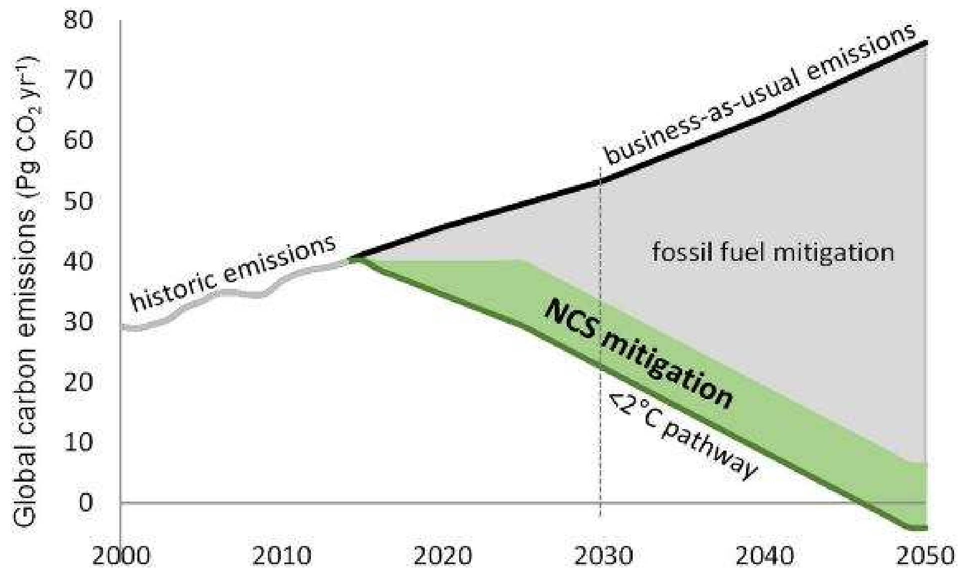
Agricultural Climate Solutions Fund
Lead: Agriculture and Agri-food Canada (AAFC)

e Nature Smart Climate Solution Fund

$1.4 billion, ten-year fund (2021-2031) led by ECCC **to support natural climate solution projects that will contribute to reducing 5-7 Mt of GHG emissions annually** in 2030 to 2050



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   - Optimize ecosystem capacity to sequester and store carbon by restoring ecosystems and changing land management practices (**Restoration and Improved Management**)
   - Achieve biodiversity & human well-being **co-benefits**
   - Advance the federal commitment to **reconciliation** by providing dedicated support to enable Indigenous peoples to play a meaningful leadership role in natural climate solutions (with, but not only through, the Indigenous-led Natural Climate Solutions (ILNCS) program)

3. Encourage the integration of natural climate solutions into existing land use and management **policies** and **programs** for longer term changes and at larger scale

NSCSF Funding Streams

- **Emissions Reduction Activities**
  - Projects that will contribute to Canada's 2030 emissions reduction targets by reducing rates of land conversion, increasing rates of restoration and improving land management – site-based and policy projects.

- **Indigenous-Led Natural Climate Solutions**
  - Through the Indigenous-led Natural Climate Solutions stream, funding supports First Nations, Inuit and Métis Nations, communities and organizations to build capacity and to undertake on-the-ground activities supporting ecosystem protection, restoration and improved land management.

- **Science for Delivery and Accountability**
  - Funding to improve state of knowledge on natural climate solutions in Canada and identify where and how best to implement GHG mitigations to support Canada's GHG emissions reduction target while gaining biodiversity benefits.

Science for Delivery and Accountability

1. Baselines and projections
2. Short-term needs to inform implementation
3. Long-term "Learning and Knowledge Hubs"

Targeted ecosystems and type of information for Science for Delivery and Accountability

Ecosystems and NSCSF activities

- Coastal wetlands: avoided conversion & restoration
- Croplands: tree planting on agricultural land
- Forests: avoided conversion & enhanced management
- Freshwater mineral wetlands: avoided conversion & restoration
- Grasslands: avoided conversion & restoration
- Peatlands: avoided conversion & restoration

Categories of data/information

1. Historical baselines: development of historical baselines for rates of land use change for one or multiple ecosystems
2. Projections: development of projections of land use change that draw on both historical data as well as expected future socio-economic, behavioral, policy, drivers of land use change and other relevant data.
3. GHG quantification: capacity building for GHG quantification, including the development or improvement of methods for (1) monitoring (2) quantification of mitigation outcomes, and (3) assessment of leakage
4. Implementation & policy: Support (1) the development of data and information that can inform the implementation of NSCSF and/or (2) the direct or indirect improvement of existing and/or development of new policy, tools or programs supporting NCS implementation.

Questions?

ec.fscan-nscsf.ec@ec.gc.ca

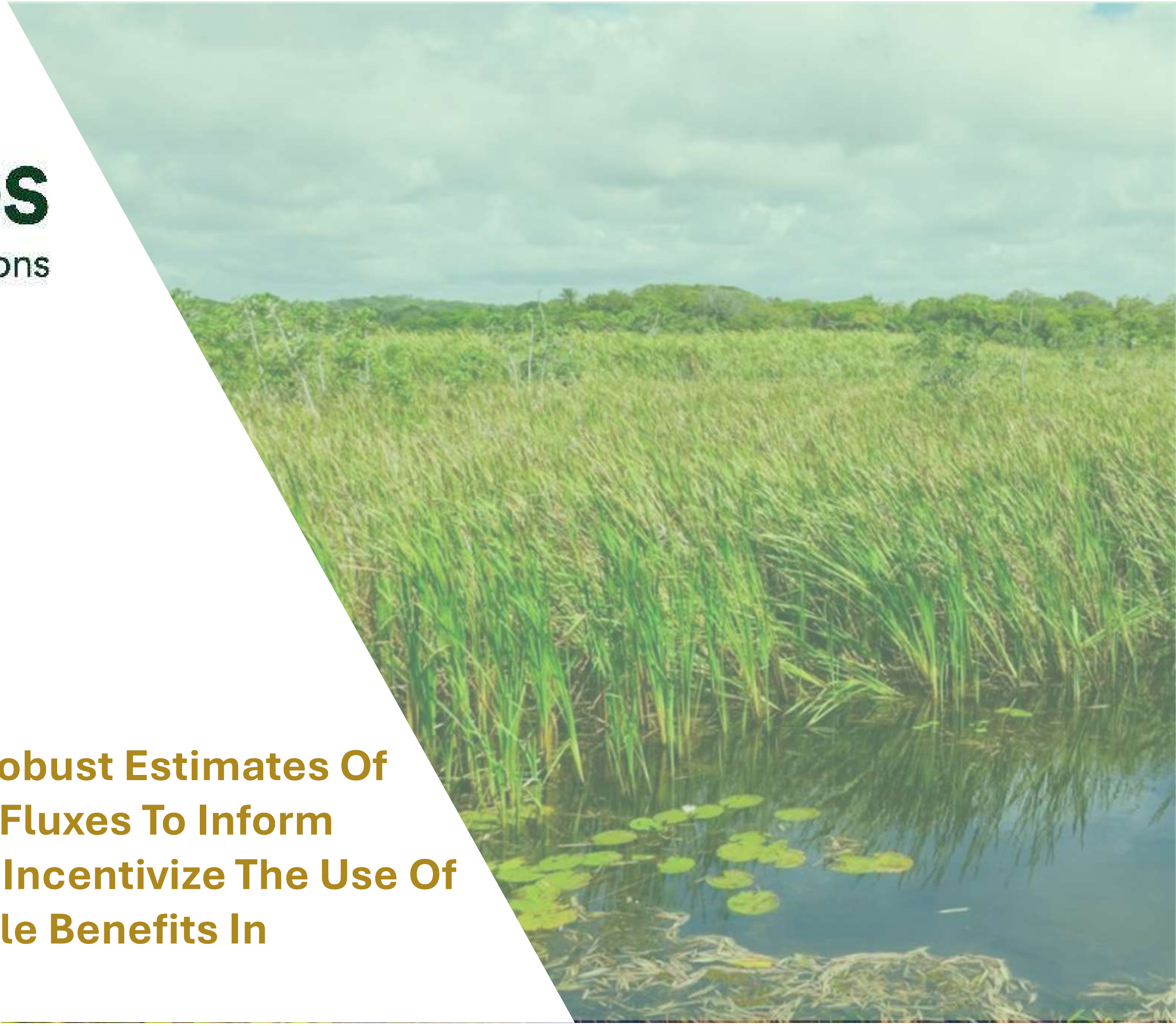
For more specific questions (especially on science), feel free to contact me: Guillaume.petersonst-laurent@ec.gc.ca

WETLANDS

Natural Climate Solutions

- **Objective 5**

Use The Authoritative And Robust Estimates Of OC Accumulation And GHG Fluxes To Inform Policy And Practice Tools To Incentivize The Use Of Wetlands As NBS For Multiple Benefits In Agricultural Landscapes



Objective 5.4. Socioeconomic Analysis (aka Extension Projects)

April 9, 2025

Living and working at ᐊᓯᓂᐢᑲᐤ ᓰᐲᓯᐢ (asiniskaw sipisis - Stoney Creek) in Treaty 6 territory.
This territory provided a travelling route and home to the Maskwacis Nêhiyawak, Niitsitapi, Nakoda, and Tsuut'ina Nations, the Métis, and other Indigenous peoples.

Clusters for LWW & GLSLRB Projects

Prairies:

(Lloyd-Smith, Pattison-Williams, Creed)

[Jan 1, 2023 – March 31, 2025]

Ontario/Quebec:

(DeVries, Ali, Creed, Brouwer, He, Tamini, Pattison-Williams)

[Jan 1, 2024 – March 31, 2027]

WETLANDS
Natural Climate Solutions

<u>Objective 1.</u> Evaluate methods of mapping wetlands and estimating historical rates of land use change and conversion of wetlands in the LWW & GLSLRB

<u>Objective 2.</u> Create an inventory of wetlands and identify historical rates of land use change and conversion of wetlands in the LWW & GLSLRB

<u>Objective 3.</u> Identify the main **socio-economic drivers** of wetland conversion and projecting how these **drivers might change the rates of wetland conversion**, and **the resulting GHG emissions, over time** in the LWW & GLSLRB

- 3.1The main drivers of wetland conversion are identified and described based on existing data and literature
- 3.2. Design and implementation of bilingual surveys (English/French) as required by the areas of interest to explore the economic behavioral perspectives of landowners and farmers
- 3.3. Quantification & mapping wetlands ES values in agricultural landscapes / cost model

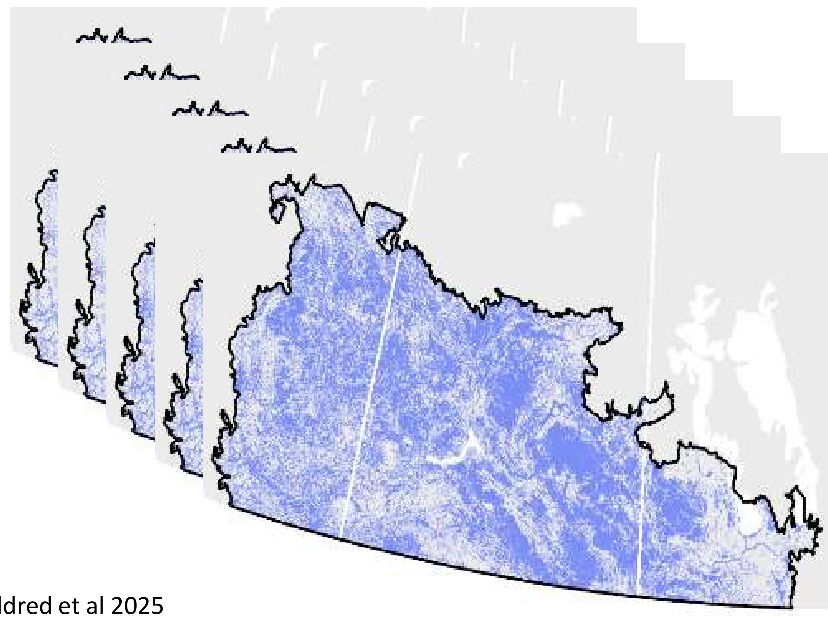
<u>Objective 4.</u> Cost-effectiveness and cost-benefit analysis of restoration and/or conservation of wetlands on agricultural lands as NBCS in the LWW & GLSLRB

- 4.1 Identify future wetland conservation/restoration policy scenarios and estimate their costs
- 4.2 Develop spatial optimization method minimizing costs for wetlands as NbCS in the GLSLRB
- 4.3 Assess potential role of leakage of wetlands associated GHG emissions
- 4.4 Build an integrated decision-making tool that connects ecosystem function models with ES models

Progress
1.0 Evaluate Methods of Mapping

Prairie Pothole Region:

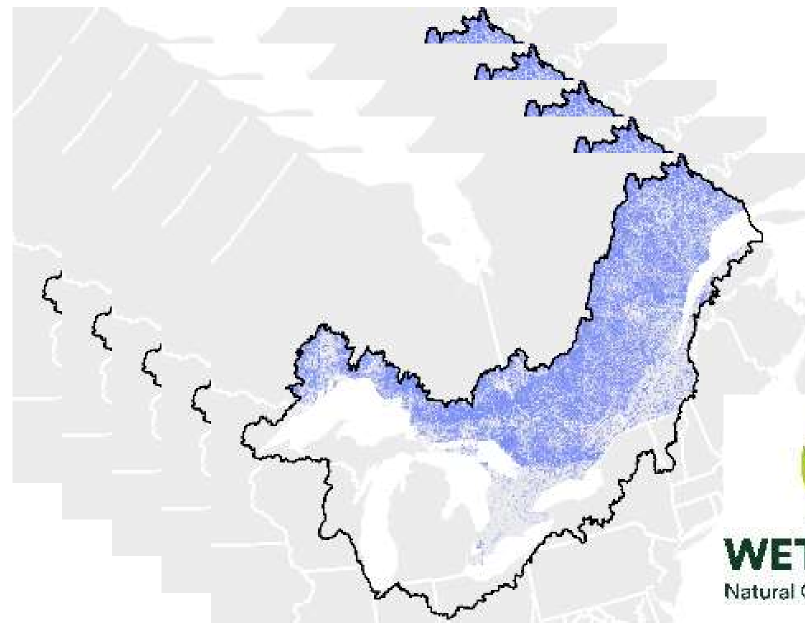
We generated annual 1993-2020 30-m wetland inventories in the Prairie Pothole Region from overlays of DSW maps with lakes and rivers removed in August 2023



Source: Aldred et al 2025

Great Lakes-St. Lawrence River Basin

We generated annual 1993-2020 30-m wetland inventories in the Great Lakes-St. Lawrence River Basin from overlays of DSW maps with lakes and rivers removed in March 2025

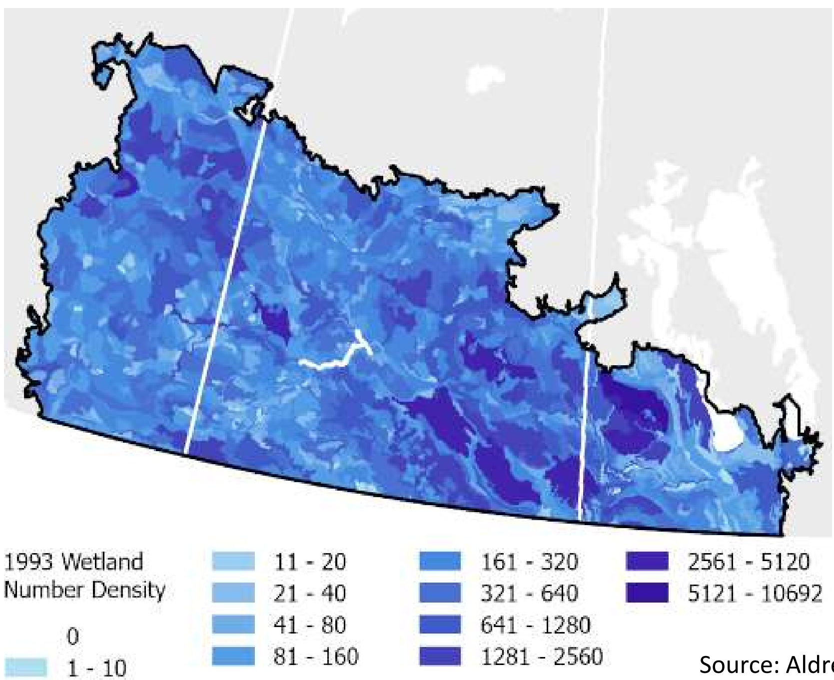


WETLANDS
Natural Climate Solutions

Progress
2.0 Inventory of Wetlands

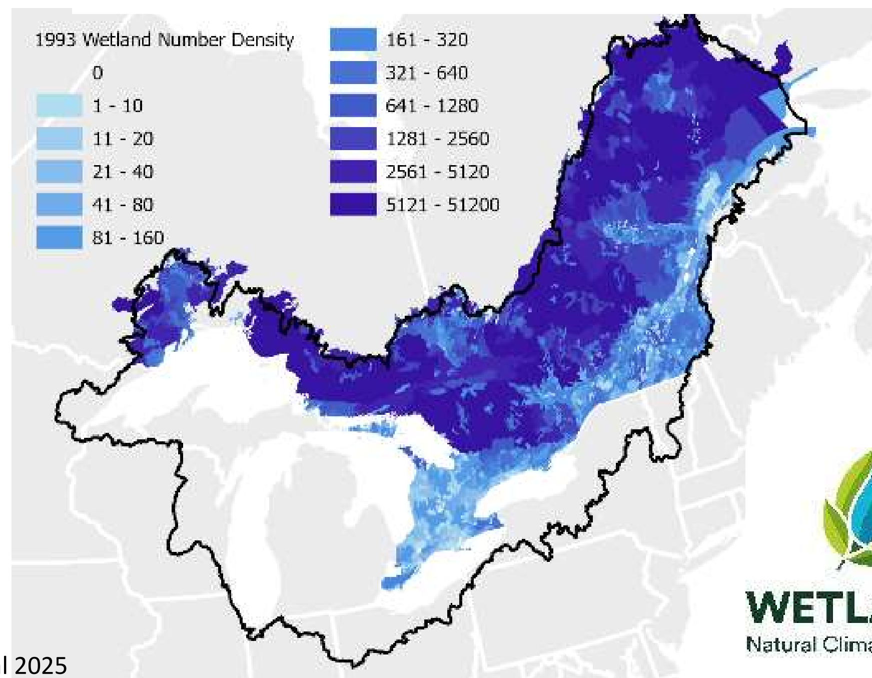
Prairie Pothole Region:

From these inventories we generated wetland area and number density maps at the scale of SLC polygons within the Prairie Pothole Region



Great Lakes-St. Lawrence River Basin

…and in the Great Lakes-St. Lawrence River Basin



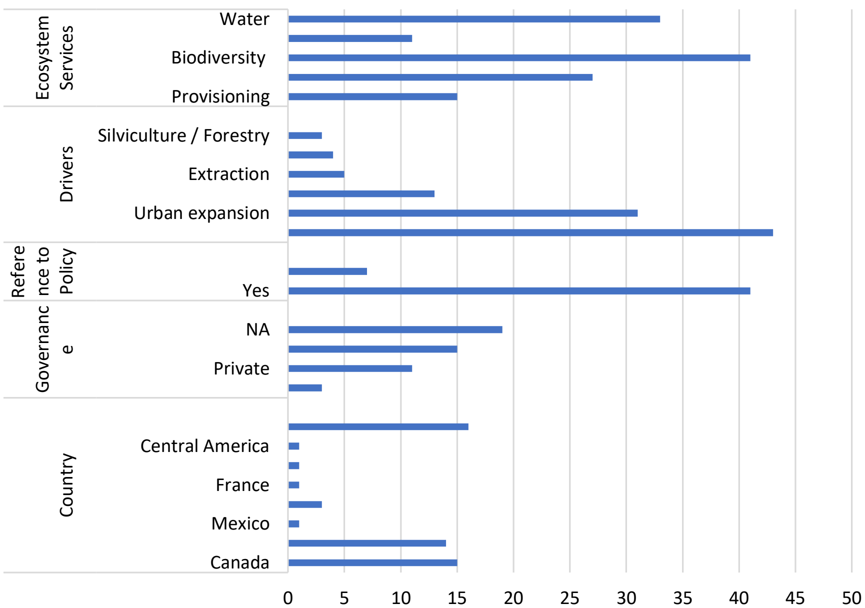
Source: Aldred et al 2025

WETLANDS
Natural Climate Solutions

Progress
3.1 Drivers of Wetland Conversion

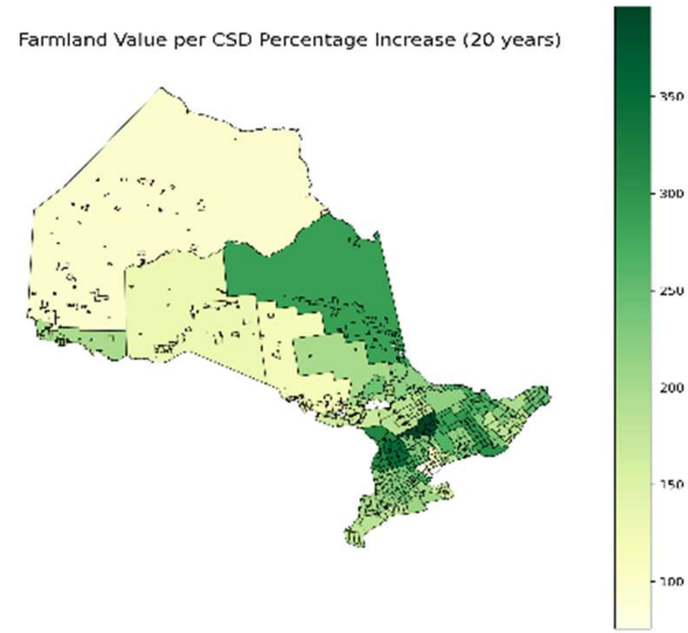
Lake Winnipeg Watershed:

Systematic Review



Source: Pattison-Williams, et al. 2025 (in preparation)

Great Lakes St. Lawrence Watershed



Source: Census of Agriculture
Spatial resolution: census division
Years: 2001, 2006, 2011, 2016, 2021

WETLANDS
Natural Climate Solutions

Progress
3.2 Provincial Farm Survey (Approach)

Farm Level Information
- to gather information on farm characteristics.

Wetlands on Farm
- to understand how producers view and manage wetlands on their property.

Choice Experiment
- to understand farmers' preferences over contract attributes and willingness to participate in conservation programs.

Wetland Policy
- to understand producers' knowledge of wetland policy and the impact of policy on decision-making.

Environmental Attitudes
- to understand producers' attitudes toward the environment.

Demographic Information
- to gather information about farmer characteristics.

WETLANDS
Natural Climate Solutions

Progress
3.2 Provincial Farm Survey (Collaboratively)

	Alberta	Saskatchewan	Manitoba	Ontario	Quebec
Number of respondents	201	212	188	201	200
Male (% of respondents)	90	91.5	93.1	87.6	78
Age (average)	57.5	59.5	54.2	58.5	56.7
Farm Receipts (% of respondents)					
Under $10,000	3.0	3.3	0.5	1.0	5
$10,000 to $24,999	0.5	0	0	1.0	5
$25,000 to $49,999	1.5	0.9	0	2.5	5.5
$50,000 to $99,999	3.0	4.3	2.7	5.0	7
$100,000 to $249,999	11.4	11.3	6.9	19.9	13
$250,000 to $499,999	12.4	14.2	10.1	18.9	21
$500,000 to $999,999	16.9	19.8	23.4	20.4	20
$1,000,000 to $1,999,999	24.9	22.2	25.5	24.4	17
$2,000,000 and over	26.4	24.1	30.9	7.0	6.5
Farm Size (average, acres)	4416.2	4524.5	3841.7	800.3	585.85
Percent Wetland (average)	5.1	5.8	5.4	3.6	4.4

Source: Farm Survey 2024 (results in preparation)

WETLANDS
Natural Climate Solutions

Progress
3.2 Provincial Farm Survey (Collaboratively)

Wetlands and Nature-Based Climate Solutions
There is interest in offering multiple voluntary wetland conservation contracts to producers as part of a **carbon sequestration and storage program**. Wetlands in agricultural landscapes provide society with a number of benefits, including sequestering and storing carbon. Wetland carbon sequestration can play a key role in mitigating the effects of climate change and meeting Canada's climate commitments. We would like to better understand landowner willingness to conserve wetlands on their land to increase carbon sequestration.
Wetlands and Agricultural Water Management
There is interest in offering multiple voluntary wetland conservation contracts to producers as part of an **agricultural water management program**. Wetlands in agricultural landscapes provide society with a number of benefits, including water storage and filtration of agricultural chemicals and fertilizers from runoff. Wetlands can play an important role in reducing flooding downstream from your fields in wet years, holding water in dry years, improving local water quality, ad contribute to broader agricultural water management goals in your area. We would like to better understand landowner willingness to conserve wetlands on their land to improve agricultural water management.
Wetlands and Wildlife Habitat
There is interest in offering multiple voluntary wetland conservation contracts to producers as part of a **wetland wildlife habitat program**. Wetlands in agricultural landscapes provide society with a number of benefits, including providing habitat for wildlife. Wetlands provide imortant naturalized spaces and food sources for a wide range of bird and mammal species and contribute to improved recreation opportunities for people. Wetland habitat can play an important role in ensuring there is enough space for wildlife to thrive in agricultural landscapes. We would like to better understand landowner willingness to conserve wetlands on their land to increase wildlife habitat.
Wetland Conservation (Control)
There is interest in offering multiple voluntary wetland conservation contracts to producers as part of a **wetland conservation program**. Wetlands in agricultural landscapes provide society with a number of public benefits. We would therefore like to better understand landowner willingness to conserve wetlands on their land.

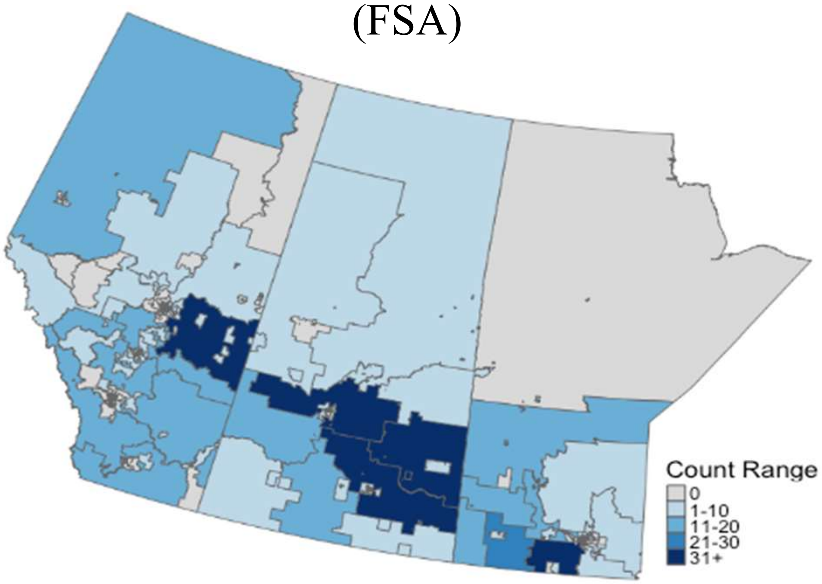
Source: Farm Survey 2024 (results in preparation)

WETLANDS
Natural Climate Solutions

Progress
3.2 Provincial Farm Survey (AB, SK, MB, ONT, QUE)

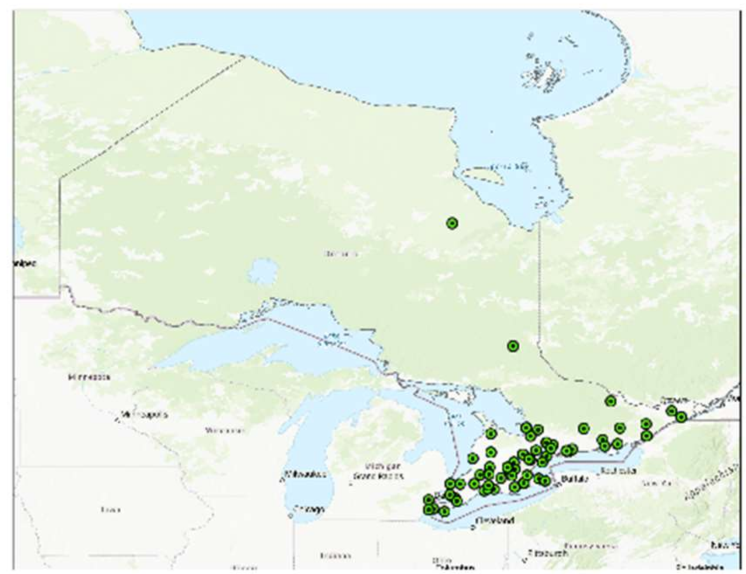
Lake Winnipeg Watershed

Distribution of respondents by postal code (FSA)



Source: Klotz et al. (2025) (results in preparation)

Great Lakes St. Lawrence Watershed



Source: Amiri et al. (2025) (results in preparation)

WETLANDS
Natural Climate Solutions

Progress
3.2 Provincial Farm Survey (Results)

Lake Winnipeg Watershed **Great Lakes St. Lawrence Watershed**

	Alberta	Saskatchewan	Manitoba	Quebec
Drainage (% of respondents)	24	25	30	36
Retention (% of respondents)	66	68	51	75
Restoration (% of respondents)	10	11	12	11

Source: Klotz et al. (2025) (results in preparation)

Reasons for drainage	1. Increasing farmable acres (AB, SK, MB) (2nd in Quebec) 1. Low yields near wetlands (QC)
Reasons for Retention	1. Drainage too costly/not worth it (AB, SK, MB) 1. Wildlife habitat (QC)
Reasons for Restoration	1. Wildlife habitat (MB, SK) 1. Low yields near wetlands (AB) 1. Private benefits (QC)

Source: Amiri et al. (2025) (results in preparation)

WETLANDS
Natural Climate Solutions

Econometric Model

- Under a random utility framework, the utility an individual receives from participating in a program can be separated into an observable (V_{ij}) and unobservable component (ε_{ij}). Utility of program j for individual i is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

- Assuming a linear in parameters functional form

$$V_{ij} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}$$

Where x_{ij} are the attributes for alternative j and person i and β_j is the marginal utility from alternative j

- The probability that person i chooses alternative j is given by

$$Prob_{ij} = \frac{\exp(V_{ij})}{\sum_{k=1}^{J} \exp(V_{ik})} \quad j = 1, \ldots, J$$

- The marginal willingness to accept for program attribute j is

$$MWTA = \frac{\beta_j}{-\beta_{payment}}$$

Progress
3.2 Provincial Farm Survey (Quebec Results)

	(1)
VARIABLES	Wetland_drainage
Men	-0.171
	(0.300)
Farm_size	-0.000228
	(0.000221)
Experience	-0.0150
	(0.171)
Farming_income	0.0997
	(0.0707)
Black_soil	0.773
	(0.496)
Dark_brown_soil	0.938**
	(0.467)
Brown_soil	0.766*
	(0.449)
High_degree	0.459
	(0.350)
High_Knowledge_Wetlands_Policies	0.479
	(0.344)
High_Knowledge_env_issues	-0.247
	(0.315)
Wetland_share	0.0178
	(0.0122)
Constant	-1.785*
	(1.081)
Observations	103

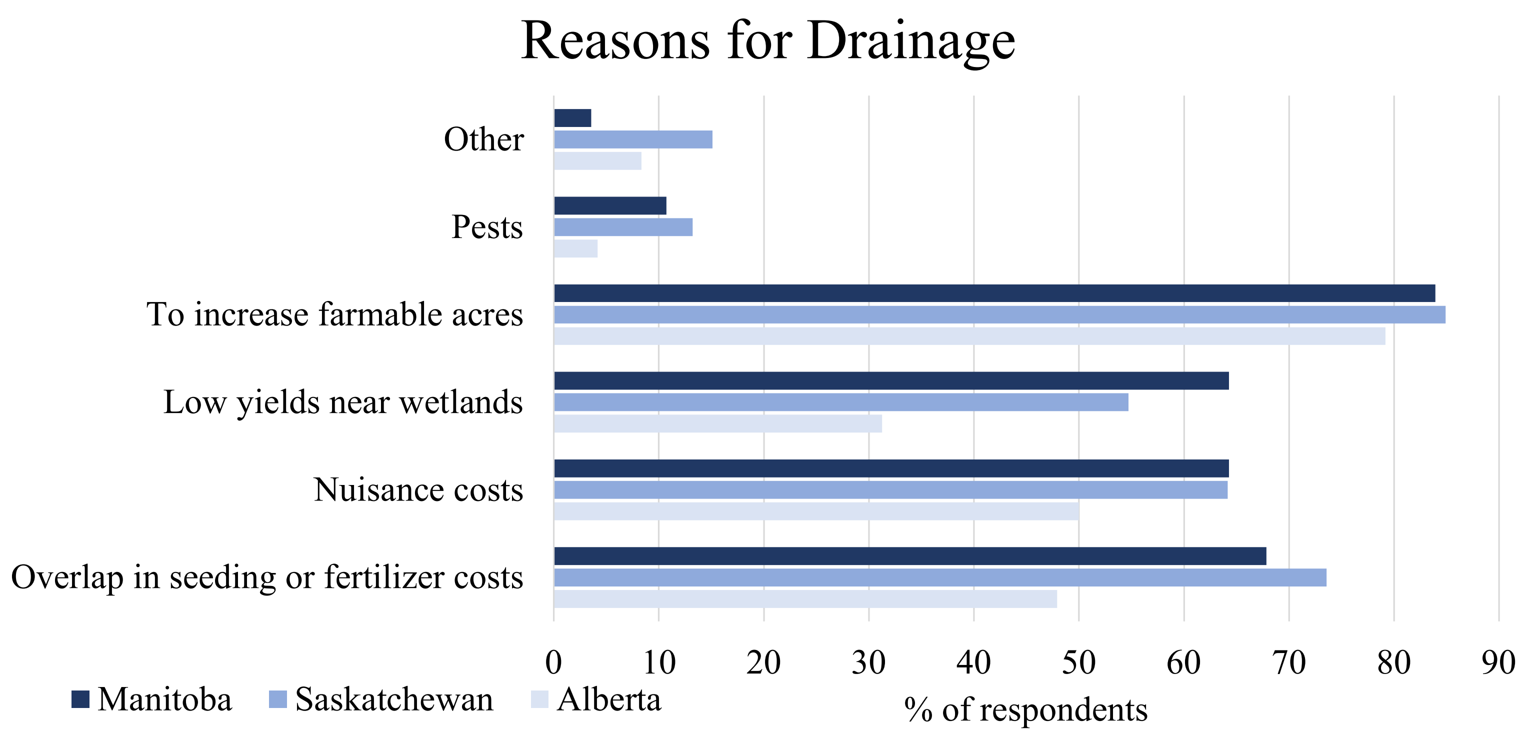
	(1)
VARIABLES	Wetland_retention
Men	-0.311
	(0.372)
Farm_size	6.46e-05
	(0.000261)
Experience	-0.513**
	(0.226)
Farming_income	0.0479
	(0.0833)
Black_soil	0.514
	(0.517)
Dark_brown_soil	1.288**
	(0.544)
Brown_soil	0.592
	(0.440)
High_degree	-0.737*
	(0.425)
High_Knowledge_Wetlands_Policies	0.645
	(0.493)
High_Knowledge_env_issues	1.028***
	(0.351)
Wetland_share	-0.0247*
	(0.0127)
Constant	2.414*
	(1.263)
Observations	103

	(1)
VARIABLES	Wetland_restoration
Men	-0.791**
	(0.392)
Farm_size	0.000331
	(0.000323)
Experience	0.541*
	(0.291)
Farming_income	-0.0879
	(0.0988)
Black_soil	5.232
	(546.2)
Dark_brown_soil	5.373
	(546.2)
Brown_soil	5.127
	(546.2)
High_degree	0.453
	(0.530)
High_Knowledge_Wetlands_Policies	0.208
	(0.500)
High_Knowledge_env_issues	-0.231
	(0.451)
Wetland_share	0.00281
	(0.0174)
Constant	-8.305
	(546.2)
Observations	103

Source: Amiri et al. (2025) (results in preparation)

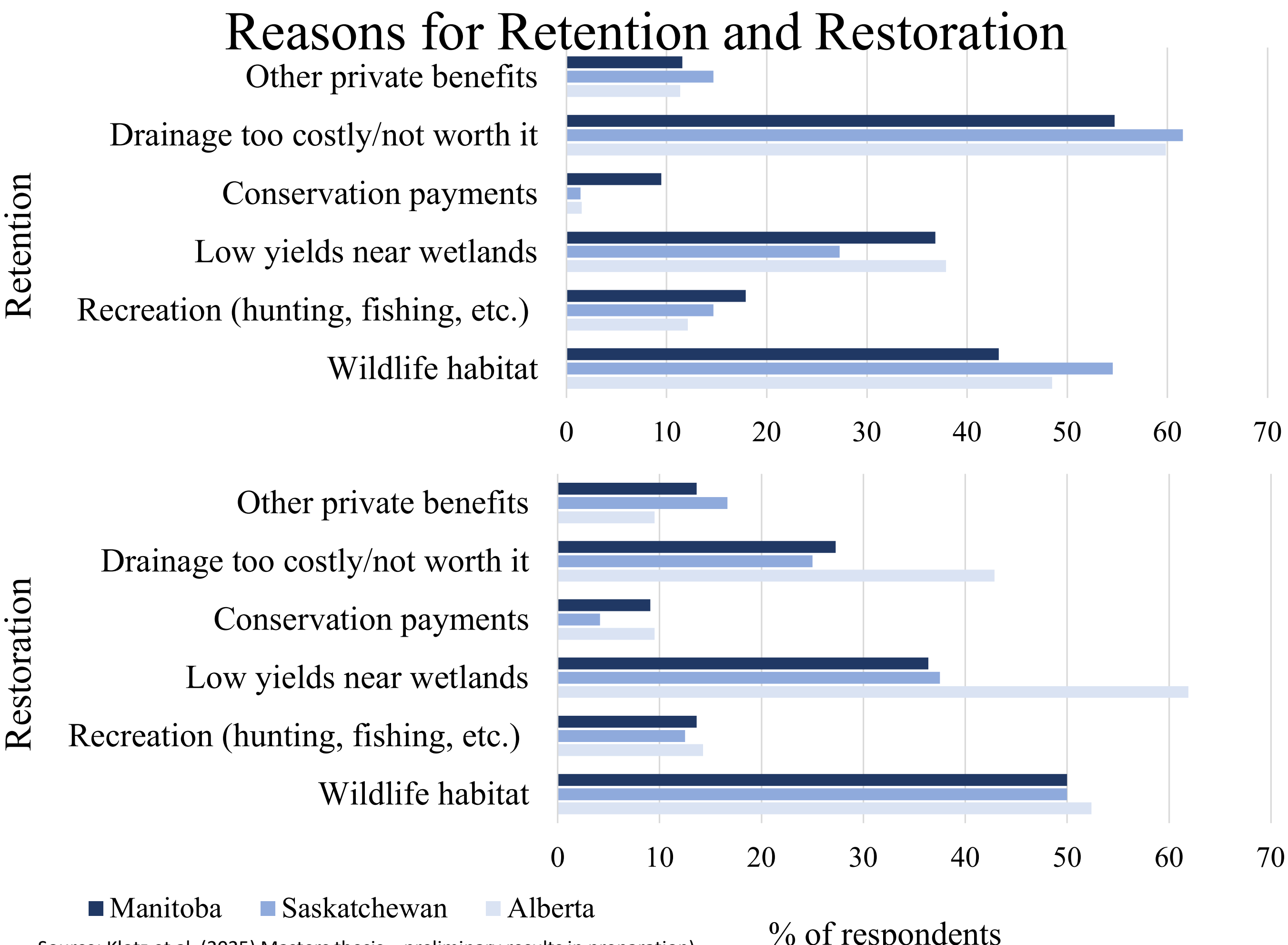
Progress
3.2 Provincial Farm Survey (LWW Results)

24% of Alberta producers, 25% of Saskatchewan producers and 30% of Manitoba producers had drained wetlands on their property.



Source: Klotz et al. (2025) Masters thesis – preliminary results in preparation)

Progress
3.2 Provincial Farm Survey (LWW Preliminary Results)



66% of Alberta producers, 68% of Saskatchewan producers and 51% of Manitoba producers had retained wetlands on their land.

10% of Alberta producers, 11% of Saskatchewan producers and 12% of Manitoba producers had restored wetlands on their property.

Source: Klotz et al. (2025) Masters thesis – preliminary results in preparation)

Progress
3.2 Provincial Farm Survey (LWW Results)

Multinomial Logit Model

	Full Sample	**Retention**	**Restoration**
Payment	-0.002 ***	-0.002 ***	-0.002 ***
	(0.000)	(0.000)	(0.000)
Size	-3.353	-6.028	-1.213
	(2.975)	(3.814)	(4.246)
Penalty	166.298 ***	155.247 ***	172.847 ***
	(24.625)	(32.091)	(34.078)
Duration 5	-329.843 ***	-326.298 ***	-317.146 ***
	(40.187)	(54.629)	(54.122)
Duration 10	-320.427 ***	-274.325 ***	-349.543 ***
	(39.175)	(48.149)	(62.216)
Duration 25	-103.043 **	-1.640	-202.868 ***
	(34.189)	(48.294)	(60.951)
Activity	-247.819 ***	-230.394 ***	-240.441 ***
	(29.936)	(35.927)	(43.243)
Contract (ASC)	670.315 ***	742.030 ***	616.204 **
	(171.476)	(188.189)	(191.666)
Restoration	52.402 *	-	-
	(23.924)	-	-

Significance levels: 0.001 ***; 0.01 **; 0.05 *; 0.1 .

Continued on next slide

Source: Klotz et al. (2025) Masters thesis – preliminary results in preparation)

Progress
3.2 Provincial Farm Survey (LWW Preliminary Results)

	Full Sample	Retention	Restoration
Treatment: carbon	-59.540	-45.450	-70.981
	(83.907)	(89.189)	(90.990)
Treatment: water	-59.784	-17.795	-99.718
	(83.113)	(87.505)	(89.254)
Treatment: habitat	-56.553	-27.924	-83.291
	(83.984)	(88.781)	(92.172)
Alberta	56.293	37.166	73.730
	(76.264)	(79.271)	(82.793)
Saskatchewan	78.683	41.668	114.719
	(73.799)	(77.796)	(81.083)
Age	36.930	24.809	46.247
	(61.968)	(65.224)	(67.600)
Farm receipts	-21.005	-33.180 .	-6.811
	(18.725)	(20.097)	(21.026)
Farm size (1000 acres)	2.115	3.216	0.871
	(7.172)	(7.758)	(7.863)
Percent wetland	-3.623	-3.276	-3.963
	(5.674)	(5.788)	(5.820)
Drained wetlands	197.114 **	143.112 *	245.302 **
	(67.483)	(71.648)	(76.194)

Significance levels: 0.001 ***; 0.01 **; 0.05 *; 0.1 .

Source: Klotz et al. (2025) Masters thesis – preliminary results in preparation)

Progress
3.2 Provincial Farm Survey (LWW PRELIMINARY Results)

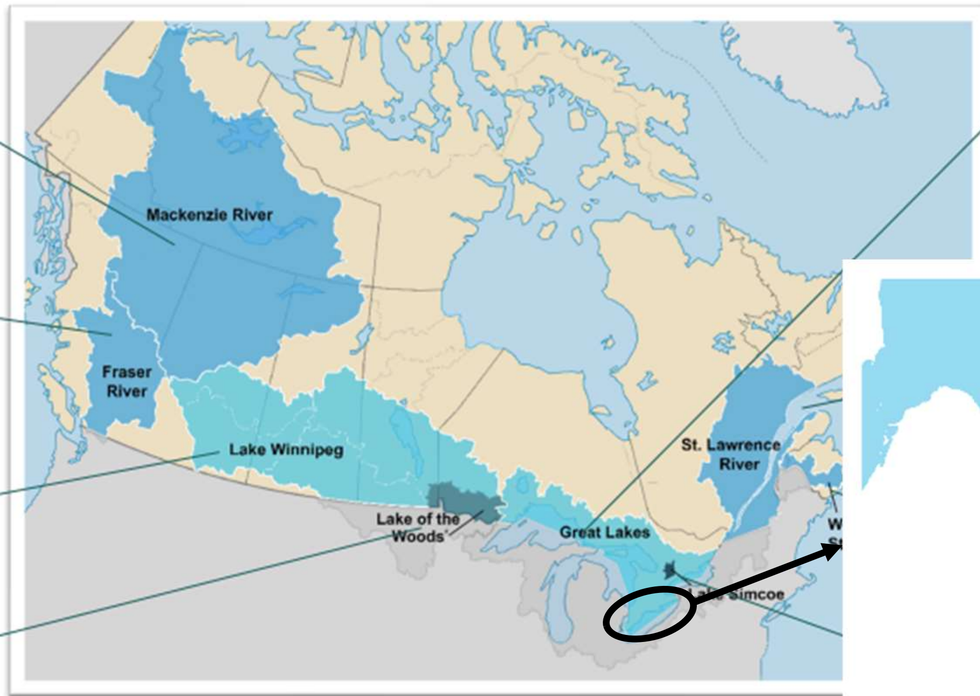
- Few farmers that had retained or restored wetlands were motivated to do so by conservation payments.
  - Implication: programs currently available are not incentivizing many farmers to conserve wetlands.
- Producers are more likely to participate in wetland retention programs than restoration programs.
  - Implication: stronger incentives may be necessary to incentivize participation in restoration programs.
- Producers are not sensitive to size of wetland area under contract.
- Annual payment amount, whether activity is permitted in the basin and whether there is a penalty for early contract termination significantly influence willingness to accept.
- Producer preferences differ based on the duration of the contract being offered. However, for retention contracts, preferences do not differ significantly between a 25- and 40-year contract.
  - Implication: average willingness to accept is the same for a 25- and 40-year retention contract.
- Past investment in drainage activities has a negative influence on producers' likelihood of participating in a conservation program. The impact is stronger for restoration contracts.
  - Implication: programs may be costlier to implement in areas where there has been more drainage.

Source: Klotz et al. (2025) Masters thesis – preliminary results in preparation)

Progress 3.3 Quantification and mapping wetlands ES values in agricultural landscapes

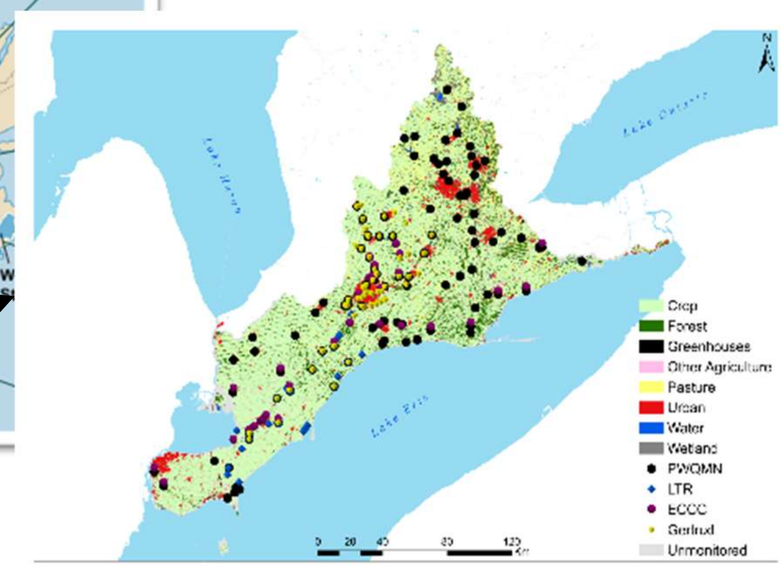
Significant efforts on the ecosystem services provided by the Great Lakes and Lake Winnipeg, which together host over 90% of Canada's agricultural wetlands.

Great Lakes:
Toxic and nuisance algae caused by nutrient pollution; contaminated and degraded Areas of Concern; Great Lakes coastal wetlands and nearshore health is under threat due to the impacts of climate change and other stressors; and toxic chemicals.



Lake Winnipeg:
Toxic and nuisance algae caused by nutrient pollution; climate change impacts

Lake of the Woods:
Nutrient pollution and the impacts of toxic and nuisance algae



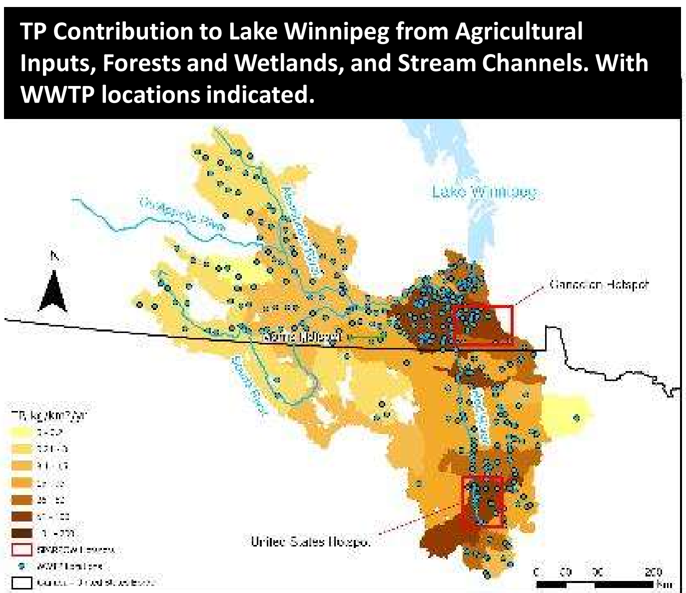
WETLANDS
Natural Climate Solutions

Source: Archontitsis et al. (2025) (in preparation)

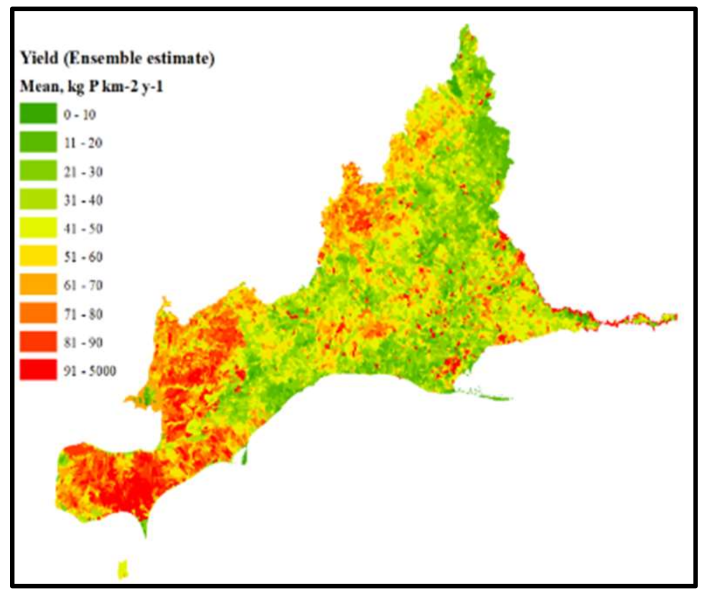
Progress 3.3 Quantification and mapping wetlands ES values in agricultural landscapes

Delineation of the Role Wetlands in Mitigating Nutrient Export and Eutrophication Problems

Lake Winnipeg



Lake Erie



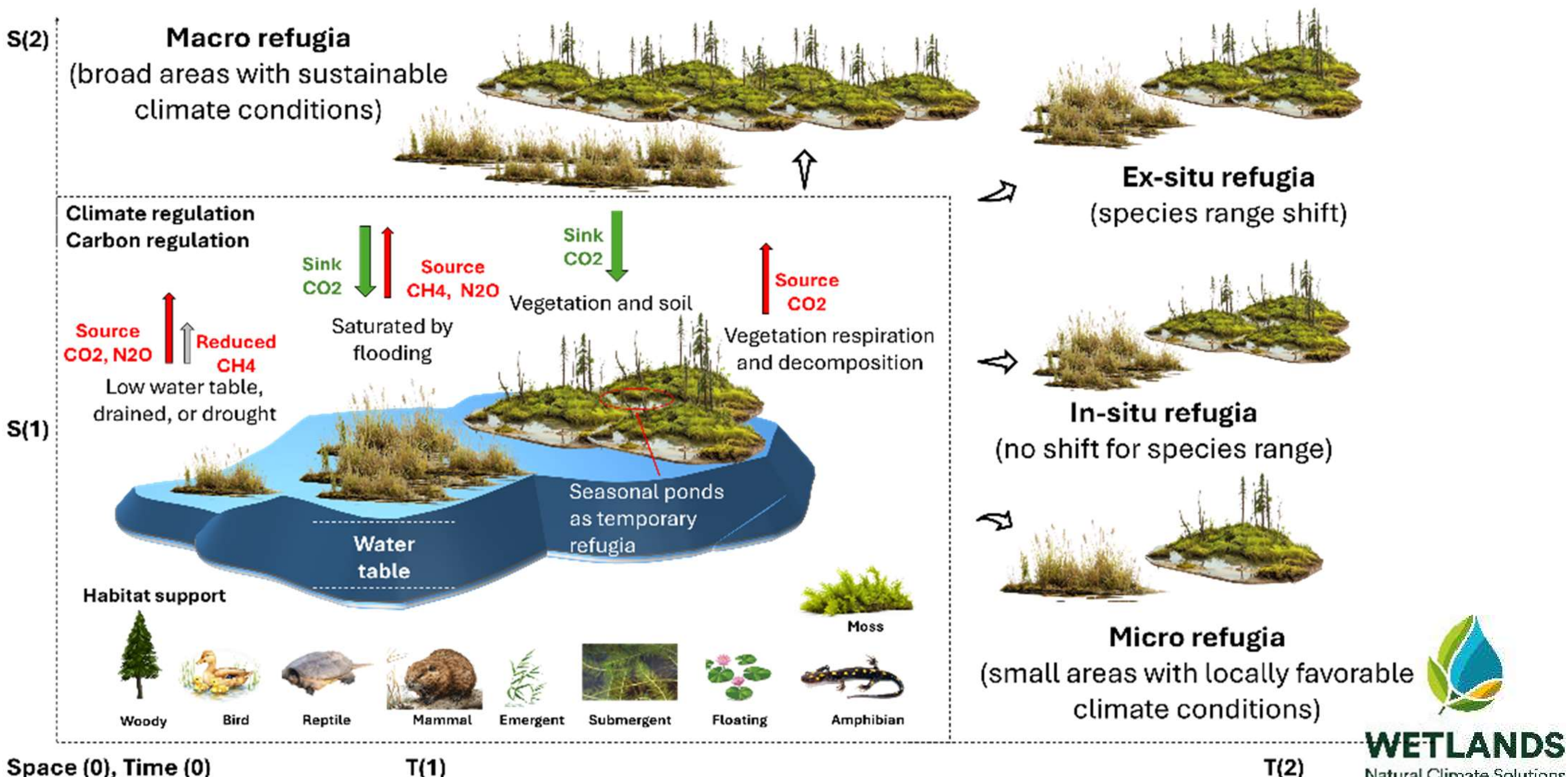
Source: Archontitsis et al. (2025) (in preparation)

WETLANDS
Natural Climate Solutions

Progress 3.3 Quantification and mapping wtlands ES values in agricultural landscapes

Wetlands and Biodiversity at a National level

Dynamic and dual role of wetlands in carbon sequestration and climate refugia.



Source: Archontitsis et al. (2025) (in preparation)

Progress
4.1 Wetland Policy Scenarios and Costs

Lake Winnipeg Watershed

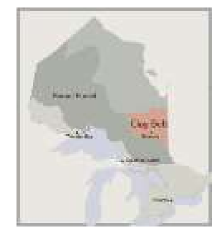
REGION	Initial number of legislative documents containing *'wetland'*	Initial number of recorded cases containing *'wetland'*	Relevant Legislation Included	Relevant Policies/Programs Included	Final Scan Tally	Average Relevance
Federal-Prairie CANADA	27	81	23	15	38	*2.24*
ALBERTA	6	338	9	19	28	*2.11*
SASKATCHEWAN	12	29	10	10	20	*2.05*
MANITOBA	32	12	19	8	27	*1.70*

1. Scan of policies and ranking
2. Perspectives and awareness of policies from survey
3. Integration

Source: Pattison-Williams et al. (2025) in preparation

Great Lakes St. Lawrence Watershed
Key Informant Interviews

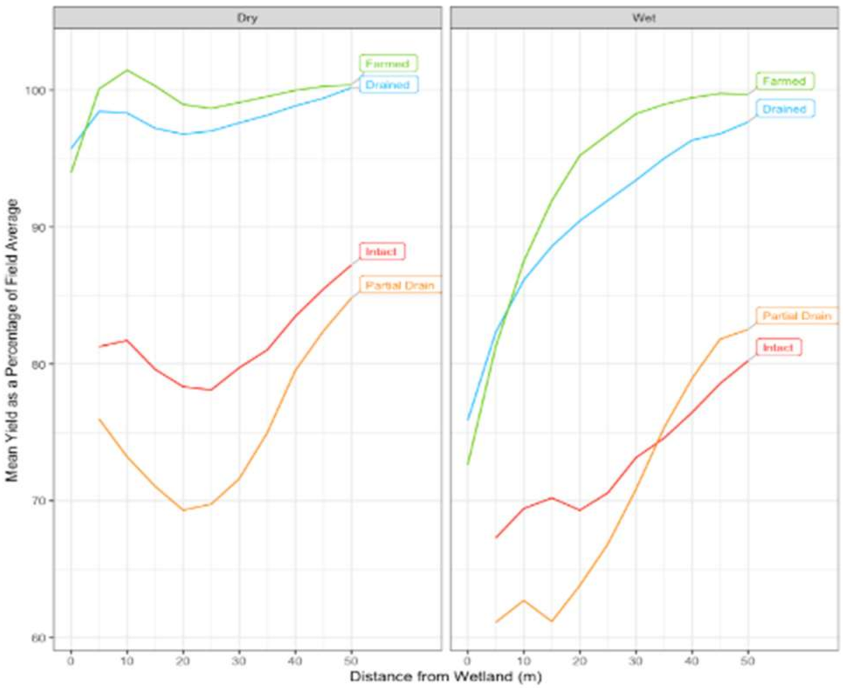
- Identify policy scenarios for addressing carbon emissions from peatland conversion to agriculture in Ontario
  - Compile available literature on land use change trends in Ontario related to agriculture
  - Refine/validate identified drivers through interviews with key stakeholders
  - Link drivers of change to IPCC Shared Socioeconomic Pathways
- Findings:
  - Urban pressures on agriculture in southern Ontario induce expansion into Northern Clay Belt
  - Expansion impacted by lack of infrastructure, distance to markets, policies on Crown Land, and Indigenous land claims
- Questions:
  - What are the major drivers of land use change in Ontario?
  - Does the importance of drivers differ between the nort and the south?
  - What are the major obstacles to the expansion of agriculture into the Northern Clay Belt



WETLANDS
Natural Climate Solutions

Progress 4.2 Improving costs of wetland conservation estimates

Lake Winnipeg Watershed



Source: Boldt et al. (2025)

Great Lakes St. Lawrence Watershed

- Met-analysis cost effectiveness for NbS
  - Identify criteria for prioritization of preservation/restoration of wetlands based on cost-effectiveness
    - Compile a database of studies on the costs of wetland preservation/restoration and effectiveness of P removal
    - Assess factors affecting the costliness (per ha) and cost-effectiveness (per kg of P removed) of wetland preservation/restoration
    - Hypothesis:
      - Wetlands that are the least costly to preserve/restore may not necessarily be the most cost-effective in achieving the desired environmental goal
  - Questions:
  - What are the magnitudes of the costs of restoration/preservation of wetlands?
    - What is the effect of time, size, latitude, restoration, preservation, and other factors on cost-effectiveness?
  - Main results:
    - The most cost-effective wetlands in P retention are not necessarily the ones with the lowest per-hectare costs of preservation/conservation (size and location play a

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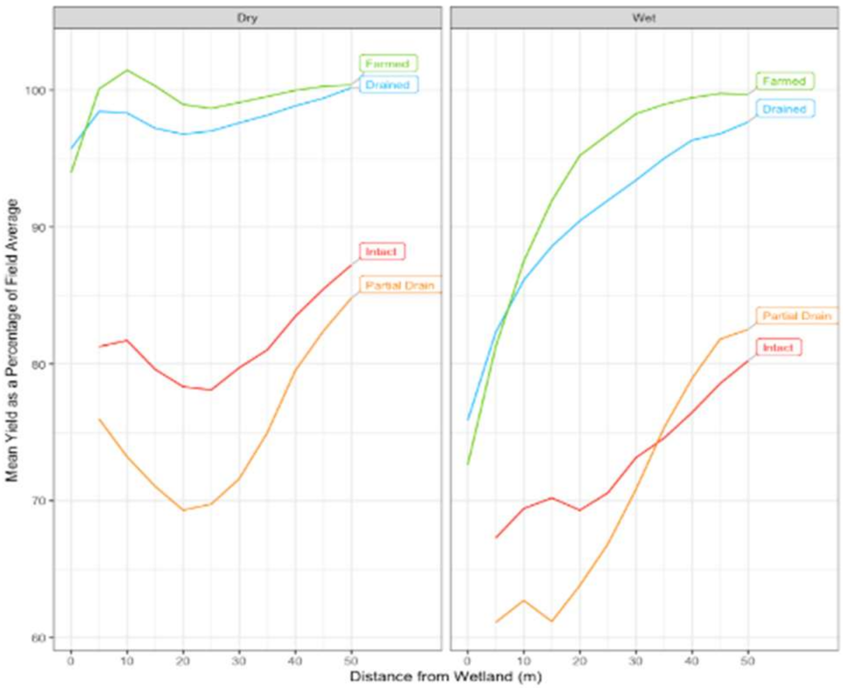
Progress 4.2
Economic model development (LWW)

Lake Winnipeg Watershed



Source: Boldt et al. (2025)

Manuscript

- Use precision agriculture data to estimate the effects of wetlands on crop yields within the basin itself as well as in the adjacent buffer areas.
  - Focus is on yield effect differences across soil zones, wet/dry years, wetland impact code, and crop types.
- Ongoing collaboration with Water Security Agency to ground future wetland scenarios on wetland policy under development
- Field-level model coded in R
- Manuscript in *Agricultural Systems* "Agronomic and economic effects of wetlands on crop yields using precision agriculture data"

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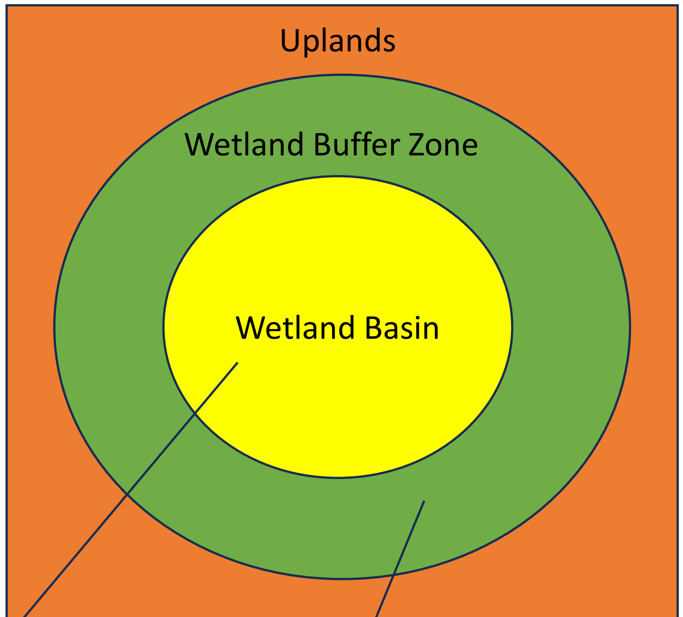
Agronomic and economic effects of wetlands on crop yields using precision agriculture data (*Agricultural Systems*)

BACKGROUND
Prairie wetland drainage is driven by financial incentives for agricultural production, including nuisance, overlap, and opportunity costs.

RESEARCH QUESTION
How do the agronomic effects of wetlands and their buffer zones affect crop yields and farm financial performance?

DATA AND STUDY AREA
We use precision yield and wetland map data from 16 fields over 7 years in the Black soil zone and 20 fields over 4 years in the Dark Brown soil zone of Saskatchewan, Canada.



Yields inside farmed wetlands are lower than the rest of the field. Drainage tends to improve yields.

Wetland yield effects extend more than 50m into the field and can be mitigated by drainage.

The costs of wetland yield effects exceed overlap, nuisance, and opportunity costs at the farm level. These costs provide further incentives for wetland drainage.

Full wetland drainage within the study area would increase the net benefits of farming by \$17-\$33 per cultivated acre relative to full wetland restoration.

The effects of wetland drainage on yields and farm profits vary by soil zone, crop type, annual precipitation, and use of sectional control technology.

Boldt, L., Lloyd-Smith, P., Belcher, K., Pattison-Williams, J., Bergen, G., Blechinger, K., and Paulson, I.

Progress
4.3 Leakage Analysis

Lake Winnipeg Watershed

- Exploratory Report complete
- Linkages with biophysical and policy mapping
- Refining theoretical approach

Great Lakes St. Lawrence Watershed

- FY26 and FY27

Source: Pattison-Williams et al. (2025) in preparation

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Progress
4.2 Minimizing Costs of Wetlands
4.4 Maximizing Benefits of Wetlands
4.5 Integrated Decision-Making Tool

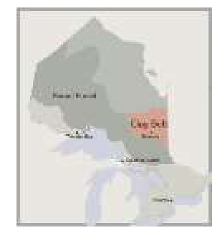
Lake Winnipeg Watershed

NEXT STEPS (to April 30 2025)

- Finalize models and report
- Finalize leakage and report

Great Lakes St. Lawrence Watershed

NEXT STEPS



- Conjoint work about DCE analysis from the different surveys with economists involved;
- Conjoint work (already engaged) on Task 3.3. (Quantification and spatial mapping of the economic values of wetland ecosystem services)
- Conjoint work (already engaged) on objective 4 (Cost-effectiveness and cost-benefit analysis of restoration and/or conservation of wetlands)

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Collaboration between/within objectives

ECCC CAAF (Objective 1) and NSCSF extensions projects are collaborating on wetland inventory and conversion data/maps (standardized and leading-edge approaches).

Our approach to mapping and quantifying wetland conversions allows for some degree of quantification of change drivers. However, we can only identify proximal drivers through this approach, whereas the research being done by the socio-economic team could allow for a more in-depth

Continual consideration for leakage engagement

Great Lakes and Prairies Component survey collaboration

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Action-Oriented opporunities

Publication of Manuscripts Integrating Science and Economics:

- Economic Analysis:
  - Evaluating biophysical impacts (e.g., carbon sequestration, phosphorus reduction) using the cost-effectiveness framework
- Policy Analysis, wetlands with a specific focus on
- Scenario Analysis
  - Comparative analysis of the wetland/peatland conversion scenarios: Great Lakes vs. The Prairies

Comparative / Transferability Analysis of results WTA results between projects

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Forward-looking requests and opportunities

What would we do if we had more resources?

- Integration of deep learning and AI tools into our wetland conversion workflow.
  - This could help to build more robust models and repeatable measurements of change across large areas. However, these models typically require large training datasets and are computationally demanding.
- Policy & Incentives:
  - Exploring cost-sharing programs, regulatory streamlining, and potential government investment in environmental benefits.
- Resources for future publication time – LWW completed now.
- Carbon Markets & Wetland Restoration:
  - Examining market-based valuation methods, cost-benefit analysis for farmers, government subsidies for ecosystem services, and regulatory barriers.

What other grants are we applying for to pursue additional opportunities?

- we have been working on this in other regions through an ongoing NSERC Discovery Grant, and it will be the topic of a future DG application to be submitted this fall.

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Anticipated impacts

What knowledge/processes/products can we take to influence the narrative about natural climate solutions or affect change?

- creating more robust and accurate wetland change/conversion product

What continuous improvement measures are being offered?

What automated/repeatable/robust measurements are being offered?

- Our approach is nearly fully automated. Training data are derived from existing wetland inventories and changes are determined based on multi-annual Mann-Kendall trend tests on the resulting probabilities.
- *Increased knowledge of incentives for wetland conservation, targeted by province and agricultural groups*
- *Informing discussion of wetland policy awareness among producers and targeted information sharing*

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Acknowledgements

UNIVERSITY OF WATERLOO

UNIVERSITY OF TORONTO

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UNIVERSITÉ DE SHERBROOKE

UNIVERSITY OF ALBERTA

UNIVERSITY OF SASKATCHEWAN

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Canada

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Welcome to the Third Annual General Meeting
Wetlands as Natural Climate Solutions

April 9 and 10, 2025

Day 2. Thursday, April 10 (ET time)

11:00-11:15 PM:	Highlights from Day 1 (Irena)
11:15-11:30 PM:	OBJ5.1. Data Repository (Irena)
11:30–12:00 PM:	OBJ5.2. National GHG Inventory Report (Pascal to introduce Doug)
12:00-12:30 PM:	OBJ5.3. Farmer Holos Model (Pascal to introduce Roland)
12:30-1:00 PM:	Lunch Break
1:00-1:15 PM:	Network’s Action Science: Select topics and rapporteurs (Pascal)
1:15-1:45 PM:	Breakout Groups: Identify topics
1:45-2:15 PM:	Network’s Action Science; Finalize topics and indicate interests (Irena)
2:15–2:30 PM:	Plans for AGM#4 (In Person) (Pascal & Irena)
2:30-4:00 PM:	Flex Breakout Groups: Flesh out topics

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Highlights from Day 1

Our Core Themes (cross-cutting)

1. **Coordinate and engage** the Project Team, International Science Advisory Group, Partner Steering Committee, and stakeholders through workshops to guide strategic direction and implementation.

2. **Support decision-making** in the face of uncertainty by advancing tools, frameworks, and dialogues that help navigate complexity and risk.

3. **Mobilize knowledge** by translating research insights into accessible formats and actionable recommendations for diverse audiences.

4. **Amplify education and outreach** efforts to increase public awareness, build capacity, and inspire action on climate and sustainability goals.

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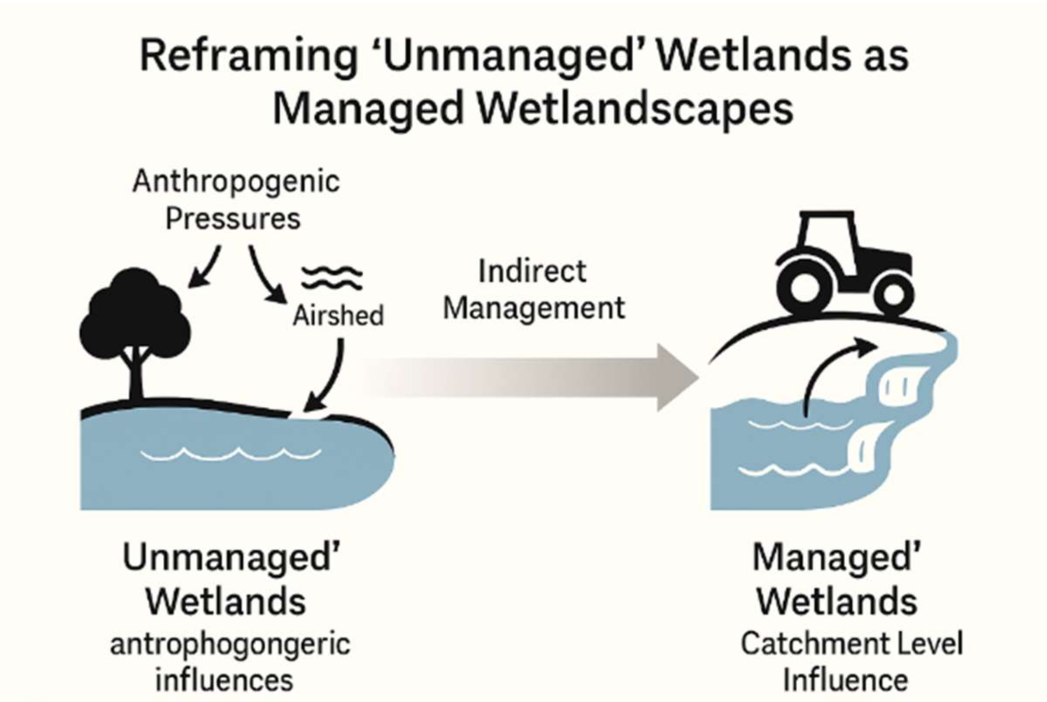
Seven Highlights:

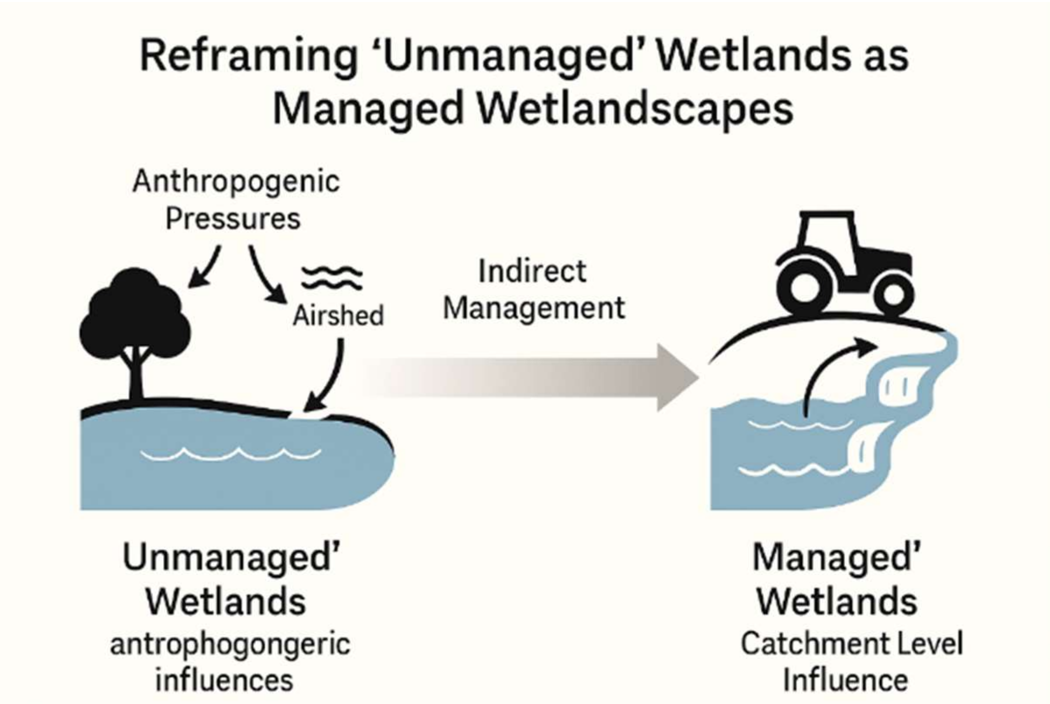
Major high-impact opportunities for synthesis, perspectives, editorials, and opinion pieces that emerged, organized thematically with attention to novelty, relevance, and potential for wide scientific or policy impact.



Highlight #1.
Reframing "Unmanaged" Wetlands as Managed Wetlandscapes

Why it's high impact:

- Canada and other nations currently exclude many wetlands from their National Greenhouse Gas Inventories (GHGIs), classifying them as "unmanaged."
- This distinction rests on a narrow interpretation of direct human manipulation.
- However, wetlands within agricultural landscapes are routinely influenced—via drainage, nutrient runoff, cropping regimes, hydrological fragmentation, and atmospheric deposition.
- This binary "managed/unmanaged" framing breaks down further when wetlands are understood not as isolated features but as part of interconnected wetlandscapes—dynamic, cascading systems shaped by upstream land use and downstream connectivity.
- Failing to recognize this interconnectedness results in underestimated climate mitigation potential.

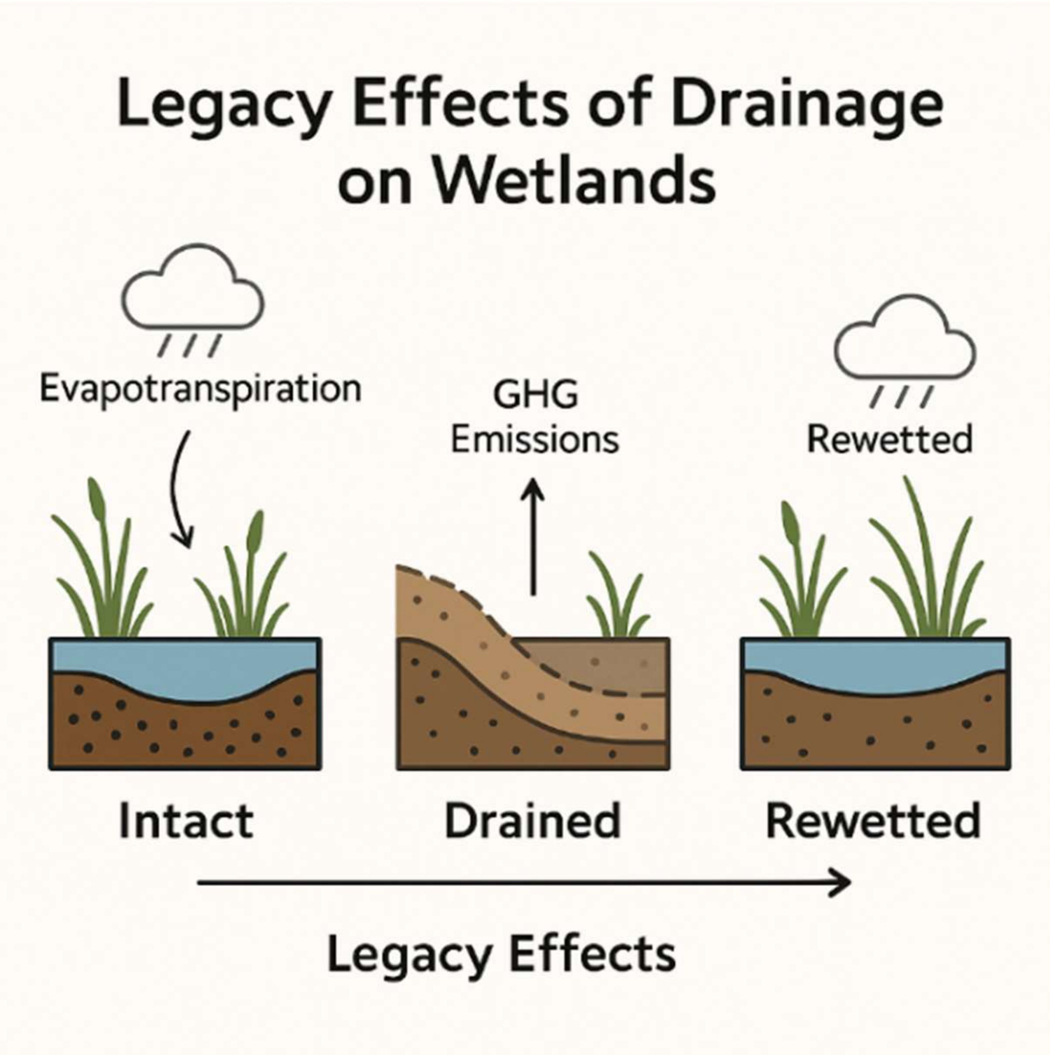


Highlight #1.
Reframing "Unmanaged" Wetlands as Managed Wetlandscapes

Opportunity:
An *opinion or perspective article* advocating for a new classification and management framework that:

- Acknowledges catchment-level management as valid forms of influence.
- Promotes a gradient approach to management status (e.g., direct, indirect, passive).
- Repositions wetlands as part of functionally connected wetlandscapes, emphasizing ecological feedbacks and cumulative impacts.
- Links this reframing to opportunities for national carbon accounting, policy reform, and nature-based solution funding mechanisms.
- This synthesis could reshape IPCC guidance, while improving alignment with how wetlands actually function in landscapes.

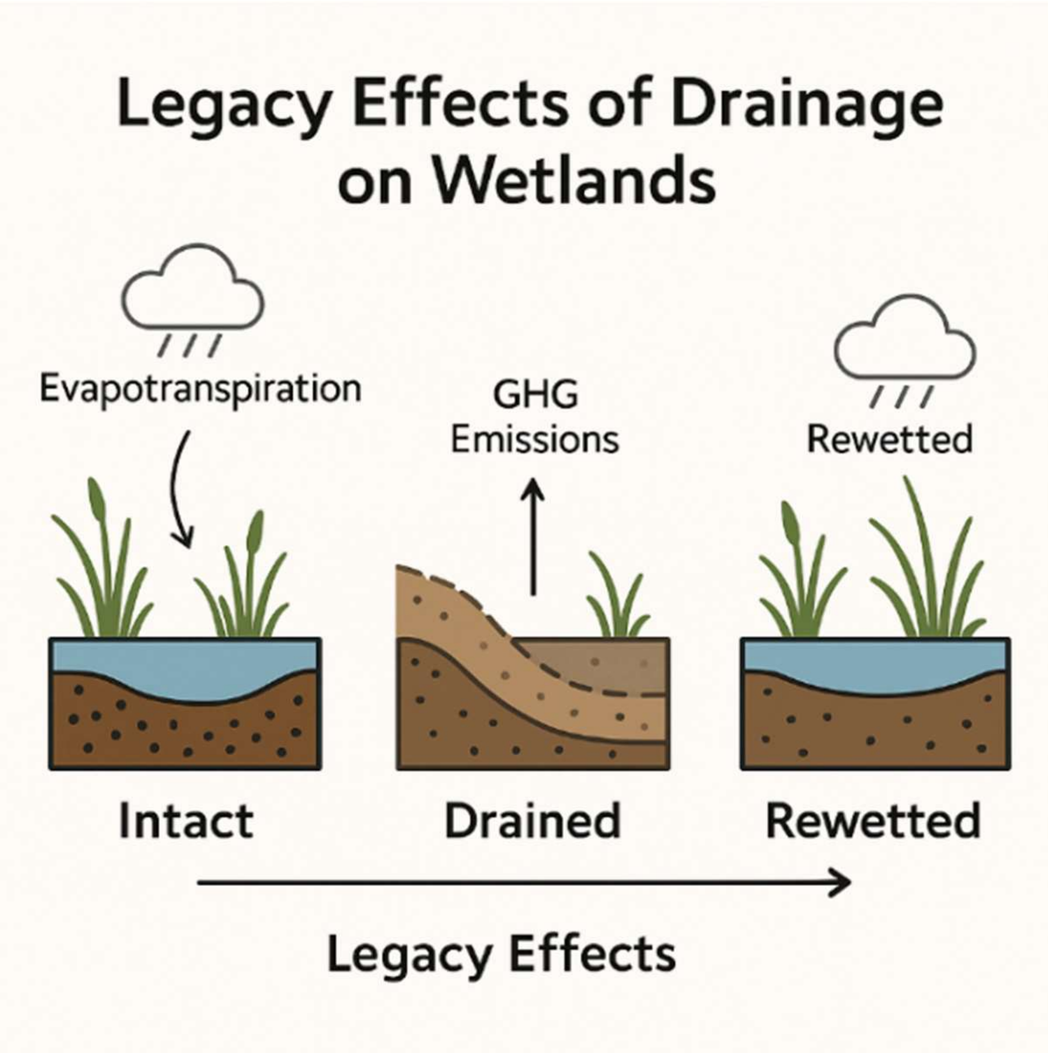
Source: OBJ 1 presentation



Highlight #2.
Buried Signals: Legacy Effects of Drainage on Wetland Carbon Stocks and Restoration Trajectories

Why It's High-Impact:

- Global investments in wetland restoration are accelerating, yet many initiatives overlook the "carbon debt" from historic drainage.
- Chronosequence and long-term monitoring data reveal that past land use leaves lasting imprints—not only on carbon stocks, but also on GHG emissions.
- This means wetlands with similar vegetation or hydrology today may differ radically in climate value, depending on their drainage legacies.
- These blind spots complicate restoration planning, distort carbon crediting schemes, and lead to mismatched expectations around climate mitigation timelines.



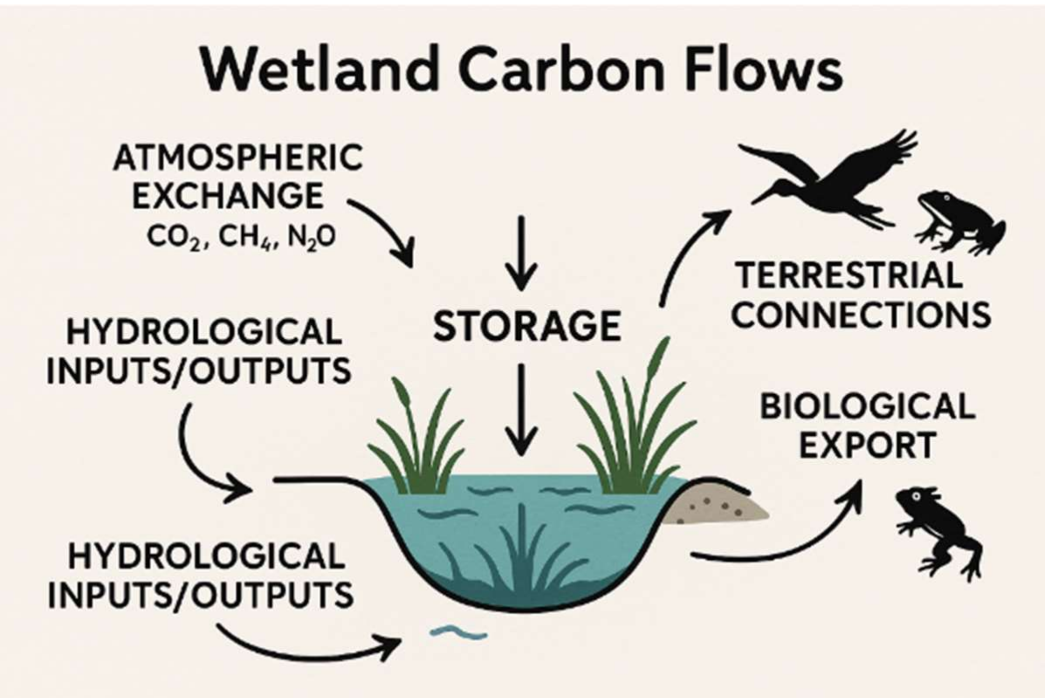
Highlight #2.
Buried Signals: Legacy Effects of Drainage on Wetland Carbon Stocks and Restoration Trajectories

Opportunity:

This paper would:

- Synthesize evidence from chronosequence studies, soil profile analyses, and rewetting experiments to:
- Trace how legacy drainage alters soil carbon composition, methane fluxes, and vertical/horizontal C redistribution
- Highlight time lags and hysteresis effects in post-restoration carbon recovery
- Evaluate how these legacy effects bias climate modeling and offset accounting
- Propose a decision-support typology for planners and restoration practitioners:
    - When do legacy effects matter most?
    - How should baseline carbon estimates be adjusted?
    - What monitoring strategies are needed to detect long-term responses?

Source: OBJ 1, 2, 3



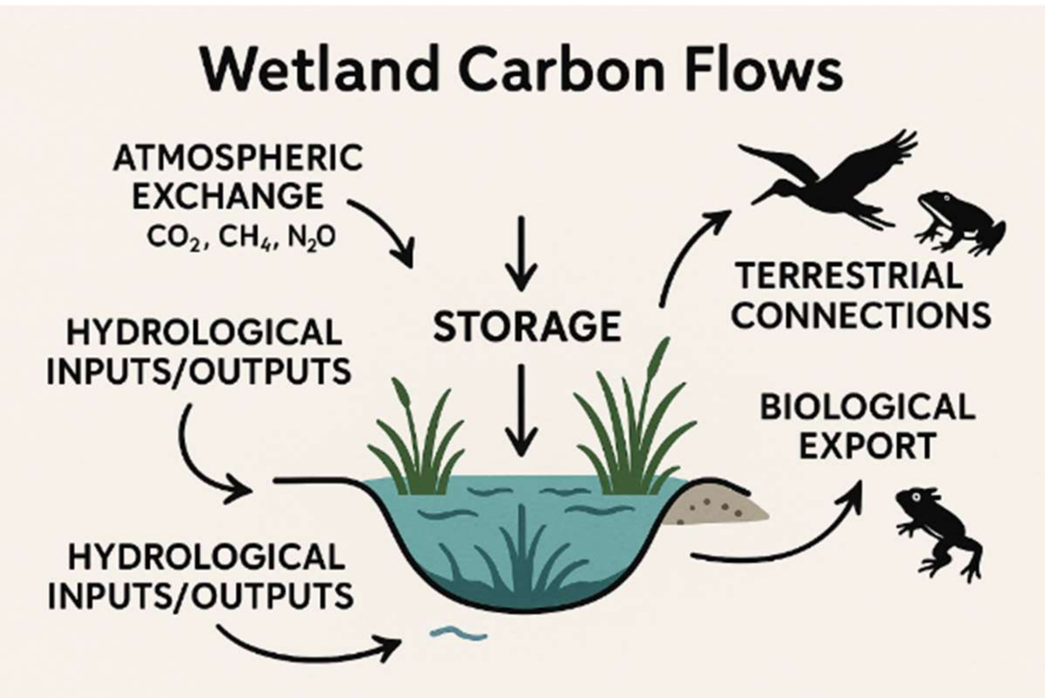
Highlight #3.
Closing the Carbon Budget: Toward a Full Accounting of Wetland Inflows, Storage, and Exports

Why it's high impact:

Wetlands are often framed as carbon sinks—but most assessments focus narrowly on vertical gaseous fluxes (CO_2, CH_4, N_2O), missing other critical components. In reality, wetlands function as carbon nodes embedded in landscapes, with multidirectional flows of carbon via:

- Atmospheric exchange (gas fluxes)
- Hydrological inputs/outputs (runoff, drainage, groundwater)
- Terrestrial connections (litterfall, sedimentation, erosion)
- Biological exports (e.g., migratory birds, aquatic insects, amphibians carrying carbon beyond system boundaries)

There is currently no integrated framework or tool that captures these cross-boundary carbon flows, leaving major gaps in our understanding of wetland carbon budgets and weakening our ability to include them in GHG inventories, carbon markets, and restoration ROI models.



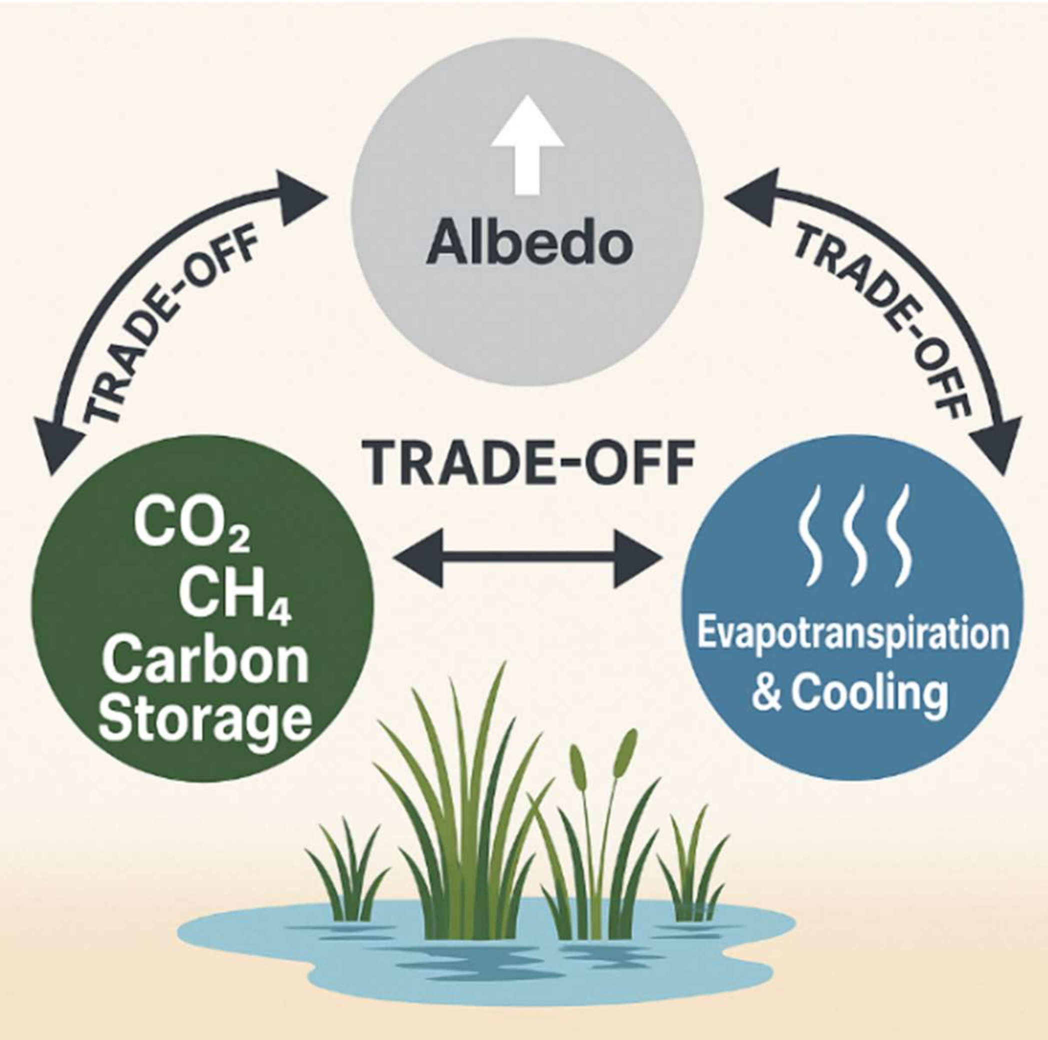
Highlight #3.
Closing the Carbon Budget: Toward a Full Accounting of Wetland Inflows, Storage, and Exports

Opportunity:

A perspective paper or conceptual synthesis that:

- Maps the knowns and unknowns in wetland carbon accounting across all major inflow and outflow pathways (air, water, land, biota).
- Proposes a framework for a “4D Wetland Carbon Calculator”, capable of integrating multiple data types (e.g., flux towers, hydrological models, remote sensing, wildlife telemetry).
- Calls for novel methods (e.g., isotopic tracing, organismal tagging, lateral flux measurements) to quantify underrepresented flows—especially biologically mediated export.
- Highlights policy implications for offset eligibility, national reporting, and ecosystem service valuation.
- This piece could help redirect monitoring priorities, tool development, and conservation investments.

Source: OBJ 1 and 2 presentations.

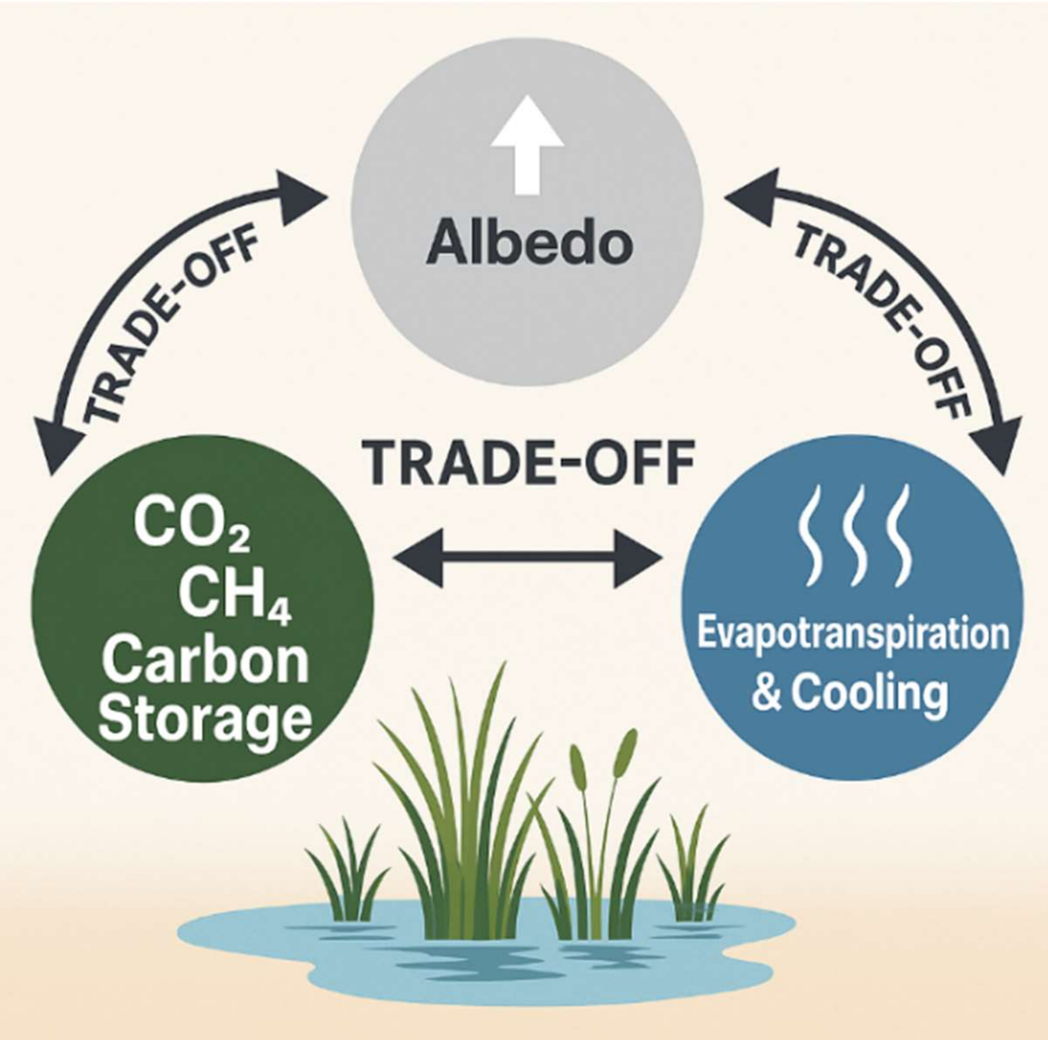


Highlight #4.
Beyond Carbon: Reconciling Climate Cooling and Carbon Storage Trade-Offs in Wetland Ecosystems

Why This Matters

- Current wetland climate mitigation policies are predominantly carbon-centric—favoring strategies that maximize carbon sequestration.
- Yet, recent field studies and modeling efforts highlight a critical disconnect: the ecosystems that store the most carbon may not deliver the greatest cooling benefits, particularly through evapotranspiration and albedo modulation.
- This raises a challenge: Are we optimizing the wrong metric in restoration and conservation planning?

- This perspective could illuminate how cooling potential and carbon storage can be decoupled across wetland types and climatic zones—exposing a major blind spot in global climate assessments and climate-smart wetland management.



Highlight #4.
Beyond Carbon: Reconciling Climate Cooling and Carbon Storage Trade-Offs in Wetland Ecosystems

Opportunity

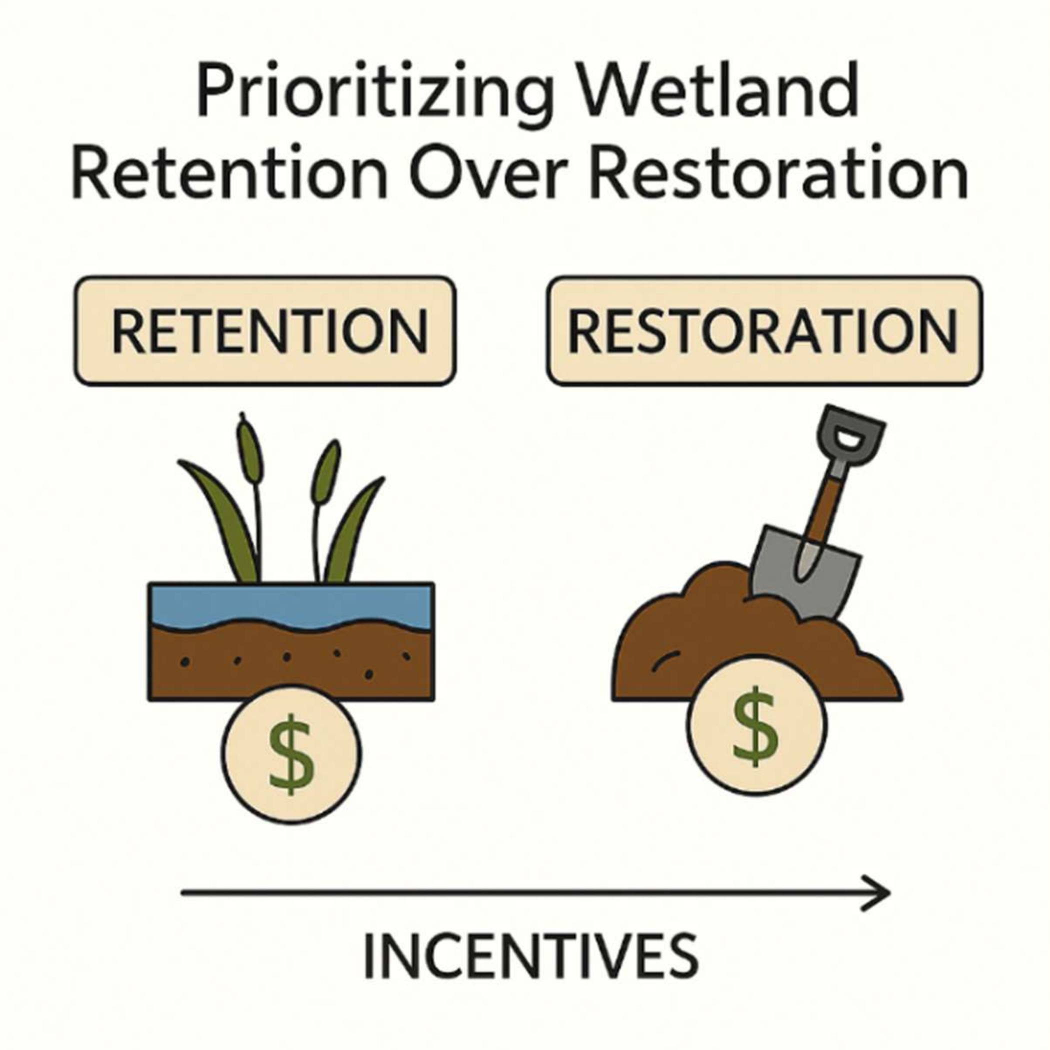
A synthesis paper that challenges the dominant carbon-storage paradigm in wetland offsetting schemes, IPCC inventories, and Nature-Based Solutions

A conceptual synthesis and framework that maps functional trade-offs between:

- Carbon sequestration
- Evapotranspiration-driven cooling
- Surface albedo effects

This paper would argue for a recalibration of how we define and measure “climate benefit.”

Source: OBJ 2



Highlight #5.
Rethinking Incentives: Prioritizing Wetland Retention Over Restoration

Why it's high impact:
Wetland policies and funding programs across Canada (and globally) have traditionally emphasized restoration—the re-establishment of wetlands that have been drained or degraded.

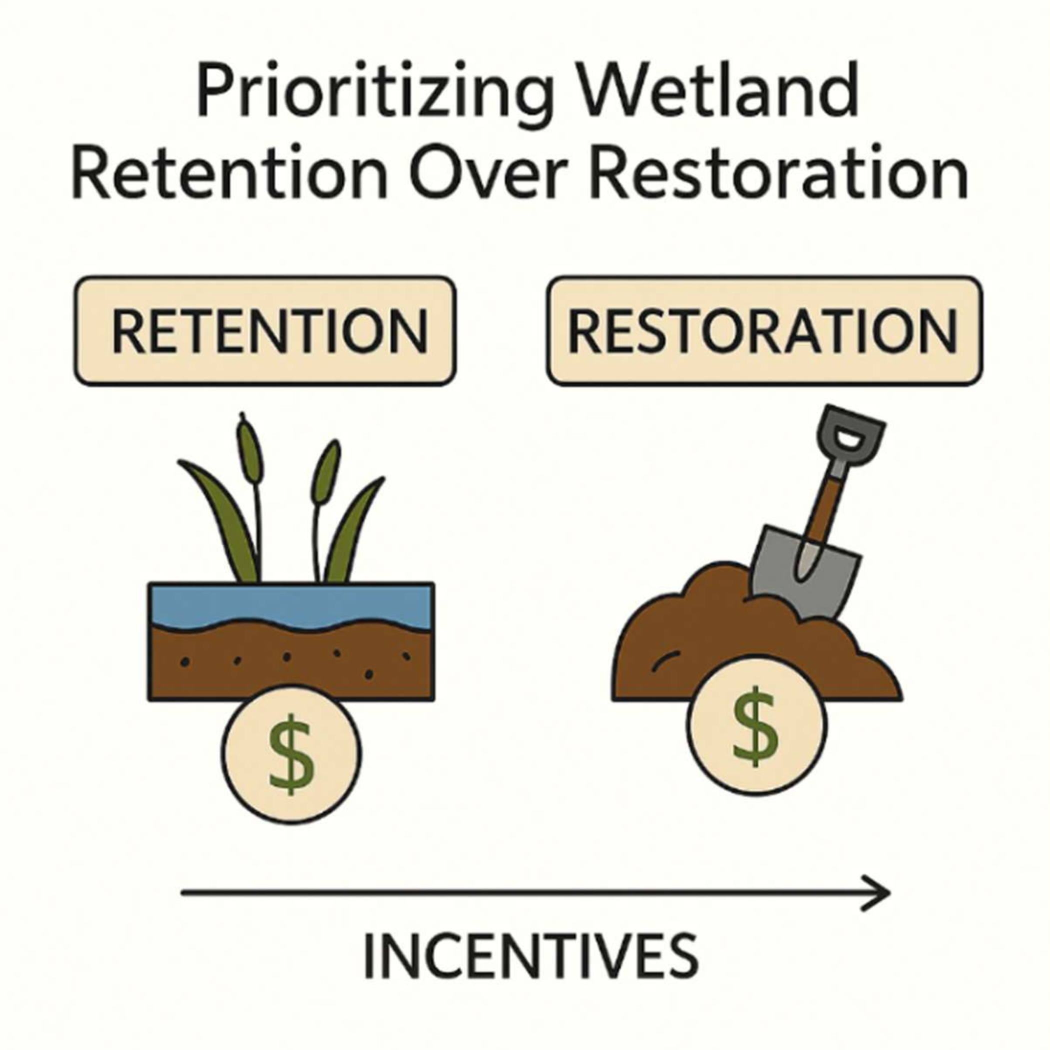
However, a growing body of evidence shows that retaining existing wetlands—especially small, unprotected ones on private lands—is often more cost-effective, ecologically efficient, and socially acceptable than restoring lost ones.

Despite this, most public and private incentive programs (e.g., payment for ecosystem services, offset credits, government subsidies) still prioritize restoration over retention, due in part to:

- Restoration offering more visible, "marketable" results,
- Institutional inertia,
- Limited recognition of the hidden value of unconverted wetlands,
- Challenges in proving "additionality" for retention.

But on-the-ground evidence tells another story:

- Farmers and landowners are more likely to engage with and support programs focused on retention—especially when framed around flexibility, stewardship, and co-benefits (e.g., flood reduction, biodiversity, cultural value).
- Reverse auctions and behavioral experiments indicate higher uptake and satisfaction with retention-based programs.
- Avoided emissions from wetland loss are immediate, while restoration benefits often take decades to recover (if at all, especially in carbon terms).

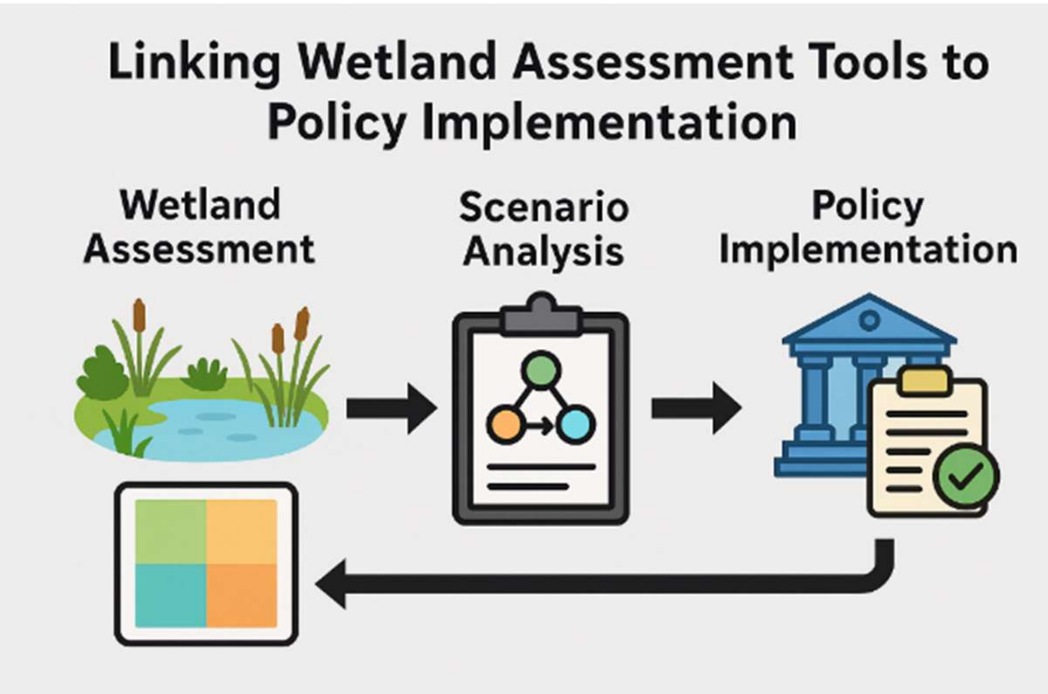


Highlight #5.
Rethinking Incentives: Prioritizing Wetland Retention Over Restoration

Opportunity:
An editorial, policy perspective, or commentary that:

- Compares the ecological return on investment (ROI) of wetland retention vs. restoration, using cost–benefit frameworks, empirical studies, and modeled scenarios.
- Highlights behavioral evidence showing stronger landowner buy-in and longer-term engagement with retention-first approaches.
- Argues for shifting incentive structures—including carbon offset markets, agri-environmental payments, and conservation subsidies—to better support retention, especially of:
    - Small, isolated wetlands on agricultural land
    - Wetlands with high carbon stocks and low restoration potential
    - Functionally connected wetlands in “wetlandscapes”
- Proposes criteria for prioritizing retention, including permanence, connectivity, carbon density, and vulnerability.

Source: OBJ 4 and 5



Highlight #6.
Beyond Carbon: Building a Multi-Functional Wetland Assessment Framework for Policy and Planning

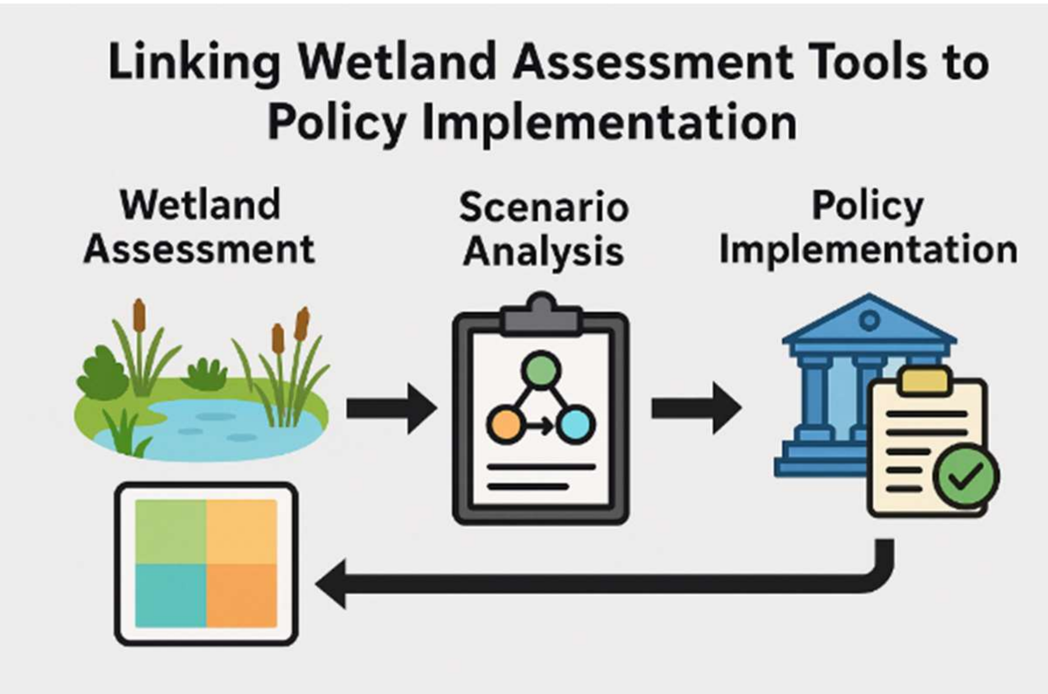
Why it's high impact:
Wetlands are multi-functional ecosystems that simultaneously regulate climate (carbon sequestration, methane emissions), support biodiversity (habitat, migration corridors), and manage water (flood retention, nutrient filtering, groundwater recharge).

But most current tools — including policy instruments, restoration prioritization frameworks, and carbon market protocols — focus on only one dimension at a time.

This siloed approach leads to:

- Fragmented decision-making, where biodiversity-rich sites may be overlooked due to low carbon scores;
- Missed co-benefit opportunities in restoration or offset planning;
- Poorly optimized scenarios in municipal and watershed-scale land-use decisions.

Meanwhile, practitioners — from conservation authorities to provincial planners — are asking for tools that can integrate multiple ecosystem functions into clear, spatially explicit, and scenario-friendly formats.



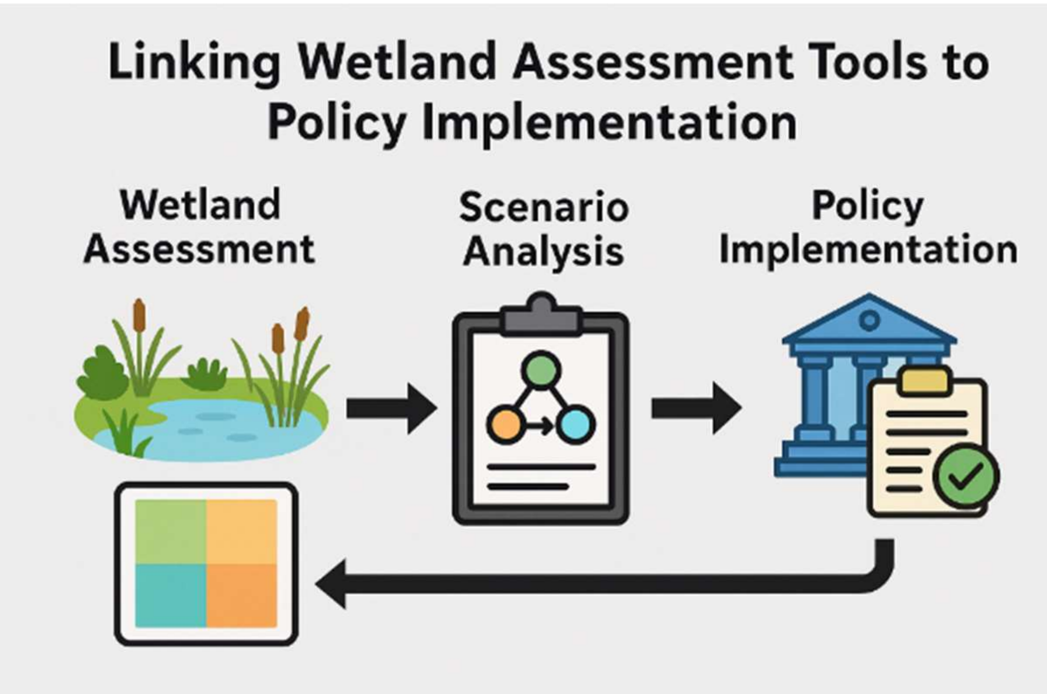
Highlight #6.
Beyond Carbon: Building a Multi-Functional Wetland Assessment Framework for Policy and Planning

Opportunity:
A perspective or framework paper proposing a multi-functional wetland assessment system that:

- Scores wetland units (existing or potential) across two core axes: Ecosystem functions and socioeconomic relevance (e.g., cost-benefit, restoration feasibility, cultural values)
- Can be deployed at local to national scales using open-access data and modular indicators;
- Enables scenario modeling for planners: e.g., "Which wetlands give us the best combined benefit under future climate or development scenarios?";
- Offers a flexible architecture that can evolve over time with additional data streams (e.g., new remote sensing, community science, economic valuation).

This tool isn't just for ecologists—it becomes a bridge between disciplines, making wetland science accessible and usable by:

- Watershed planners and municipalities (e.g., for zoning, green infrastructure planning),
- Climate mitigation agencies (e.g., to target nature-based solutions),
- Offset markets and regulators (e.g., to score projects beyond carbon),
- Conservation NGOs (e.g., to identify multi-benefit hotspots).



Highlight #6.
Beyond Carbon: Building a Multi-Functional Wetland Assessment Framework for Policy and Planning

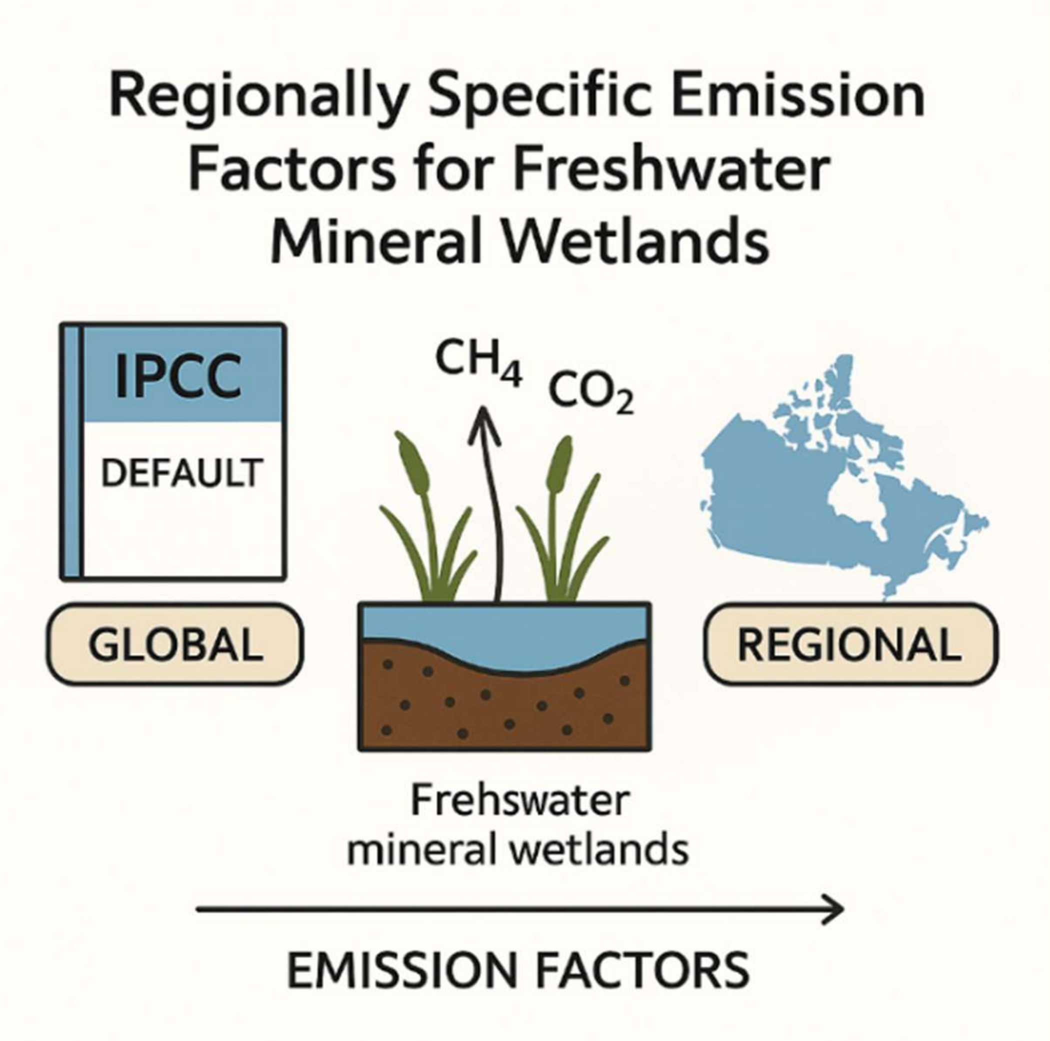
Why this matters now:

Canada is investing heavily in Nature-Based Solutions (NBS) and climate-resilient infrastructure but lacks spatially explicit tools to guide where and how to invest.

Municipalities and provincial ministries face increasing pressure to integrate climate, biodiversity, and water goals — often with conflicting maps and indicators.

This framework would support evidence-based decision-making, turning wetland planning into a multi-benefit optimization problem, rather than a one-metric-at-a-time exercise.

Source: OBJ4 and OBJ5 presentations



Highlight #7.
Getting the Numbers Right: Regionally Specific Emission Factors for freshwater mineral wetlands

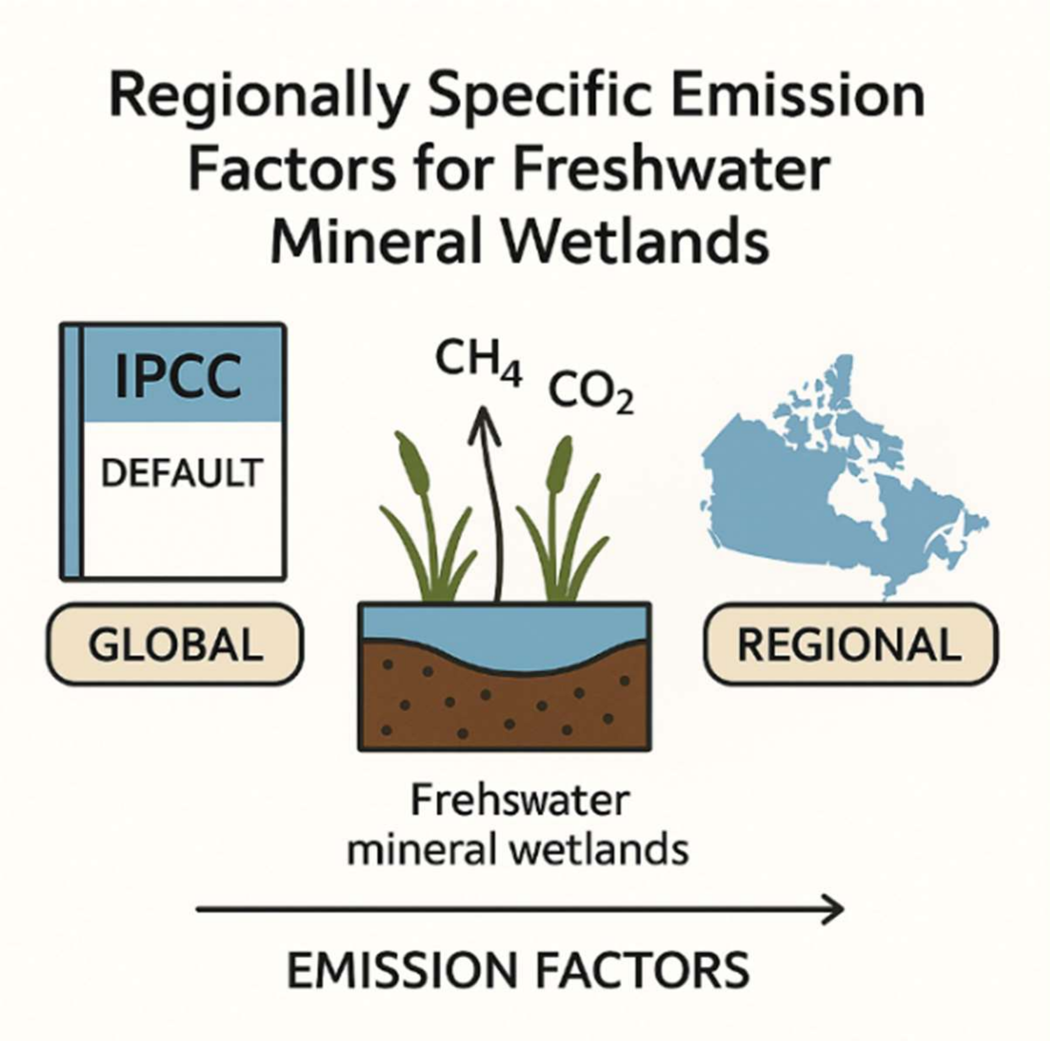
Why it's high impact:
Canada currently relies heavily on default emission factors (EFs) provided by the Intergovernmental Panel on Climate Change (IPCC) for its national greenhouse gas inventory (GHGI).

However, the IPCC's default for "mineral wetlands" is often:

- Based on limited global datasets,
- Overly conservative or generic, and
- Misaligned with Canadian-specific conditions, especially for freshwater mineral wetlands.

As a result, Canada's GHG accounting may overestimate methane (CH_4) and underestimate carbon dioxide (CO_2) uptake from certain wetland types.

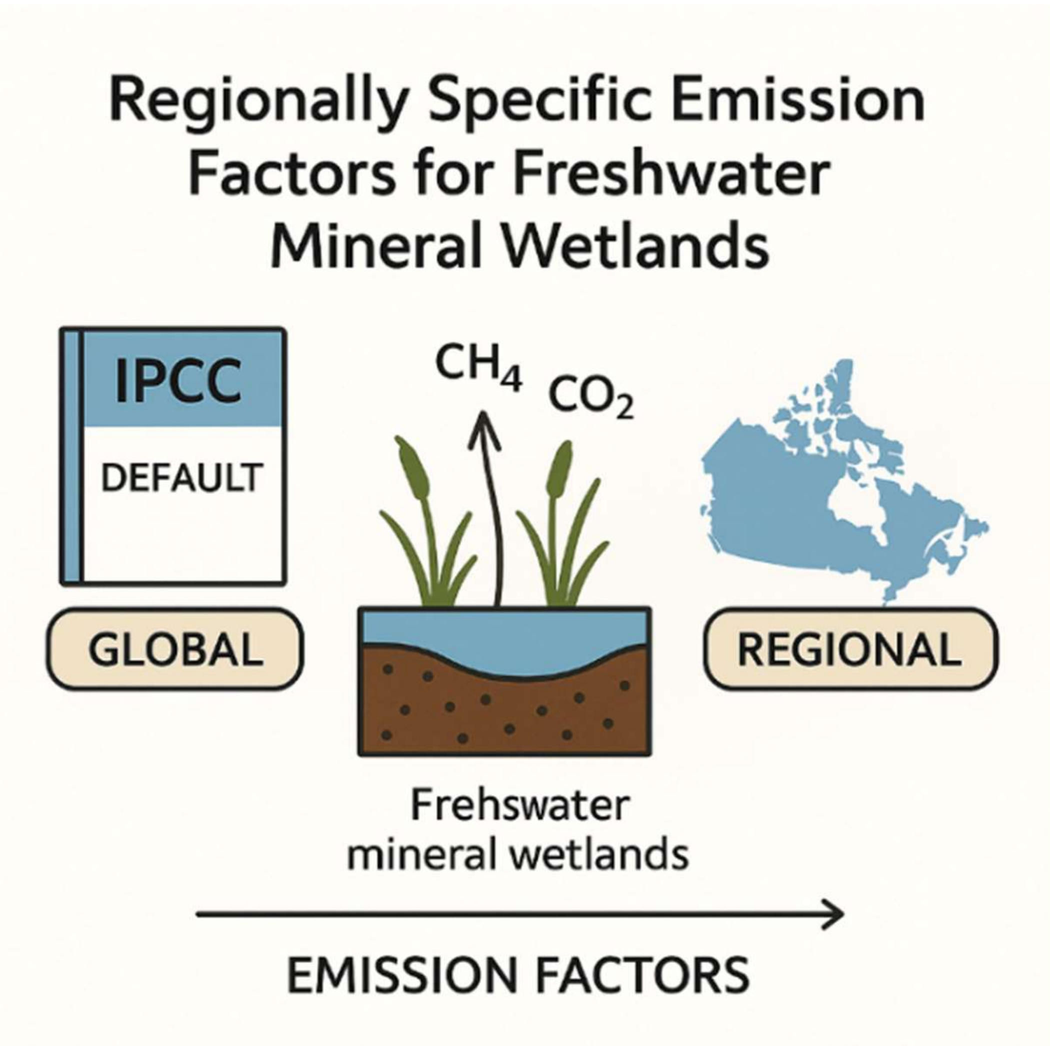
This distorts not only national reporting but also investment decisions in wetland restoration, inclusion in carbon offset protocols, and eligibility for climate financing.



Highlight #7.
Getting the Numbers Right: Regionally Specific Emission Factors for freshwater mineral wetlands

Opportunity:
A data-rich synthesis or commentary that:

- Compiles and compares empirical emission data from Canadian wetlands using:
  - Flux towers, chamber studies, static and eddy covariance methods
  - Seasonal datasets, especially winter and shoulder-season fluxes
  - Public sources like AmeriFlux, FLUXNET Canada, and project-specific repositories (e.g., Ducks Unlimited Canada, Wetland BMPs)
- Analyzes how site-specific variables (e.g., vegetation type, water table, salinity, legacy drainage) affect EFs.
- Proposes regionally stratified emission factors for freshwater mineral wetlands.
- Recommends a pathway for integrating refined EFs into:
  - Canada's national inventory (via ECCC)
  - International IPCC Tier 2 and Tier 3 methodologies
  - Carbon market protocols for avoided wetland conversion and restoration



Highlight #7.
Getting the Numbers Right: Regionally Specific Emission Factors for freshwater mineral wetlands

Policy Relevance:

- Accurate, regionally tailored emission factors are essential for:
- Credible climate reporting
- Quantifying the mitigation potential of wetland conservation
- Designing cost-effective nature-based solutions under Canada's Emission Reduction Plan (ERP)
- Improving offset methodologies for voluntary and compliance markets

Source: Advanced by Pascal Badiou, who explicitly called for this synthesis; echoed by others discussing challenges with default IPCC factors and the need for better field-calibrated baselines. Strong alignment with work underway in Objectives 1, 2, 3, and 5.

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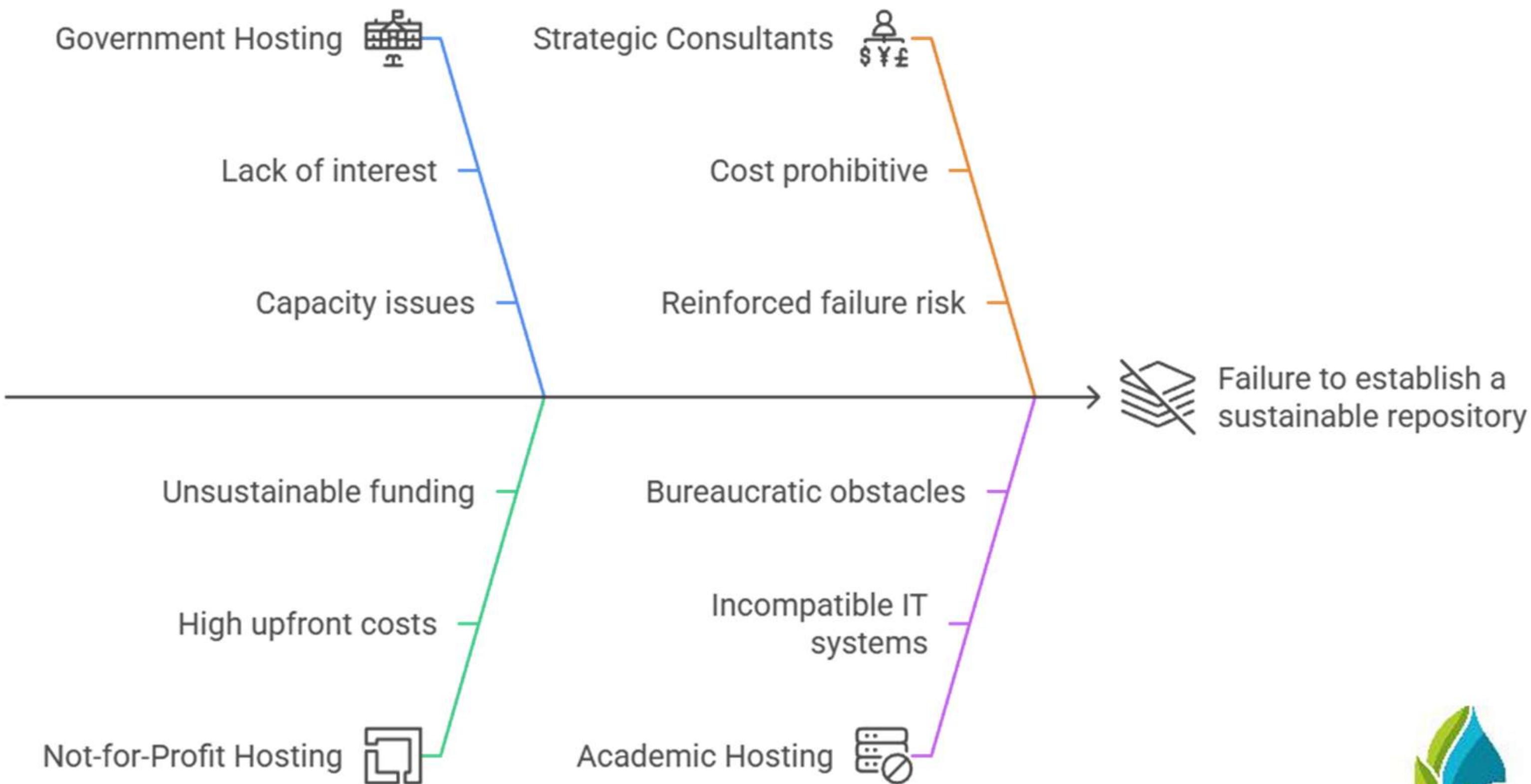
Objective 5.1. Data Repository

Challenges in Establishing a Sustainable Repository



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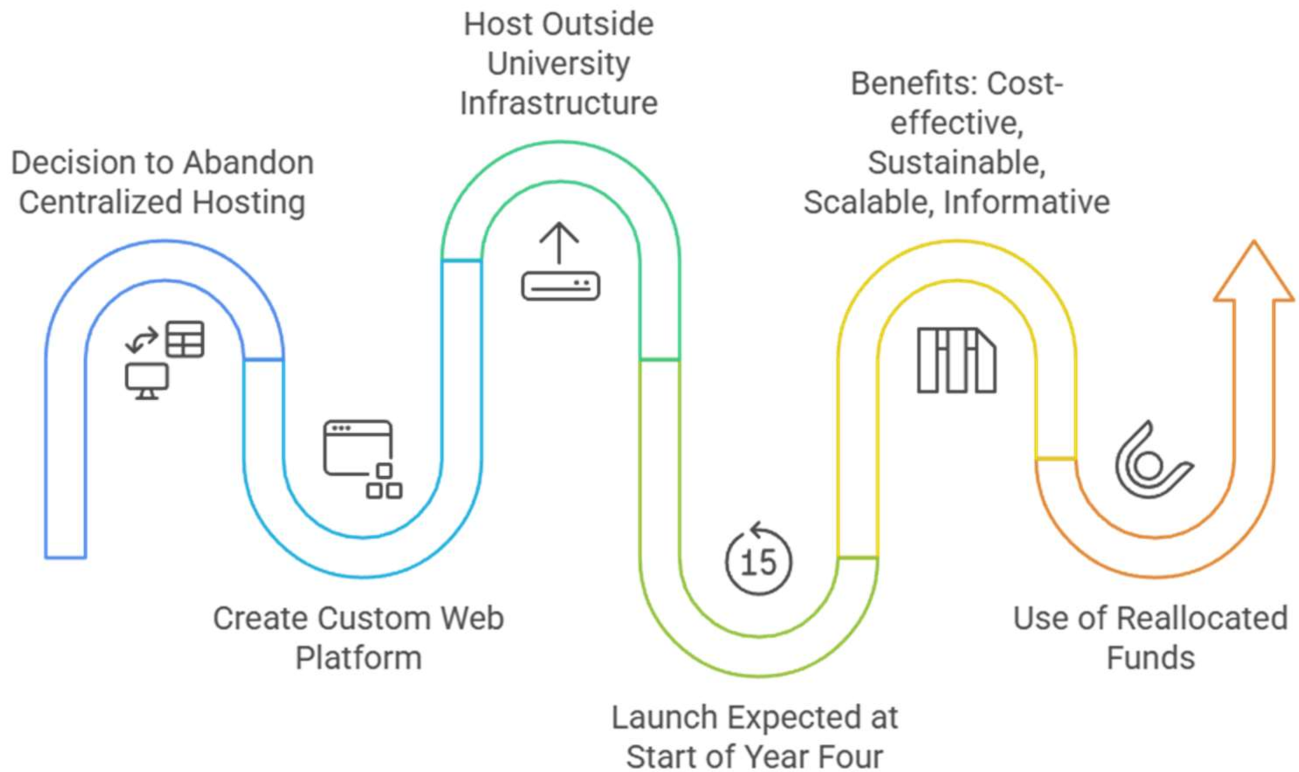
Strategic Pivot in Project Hosting



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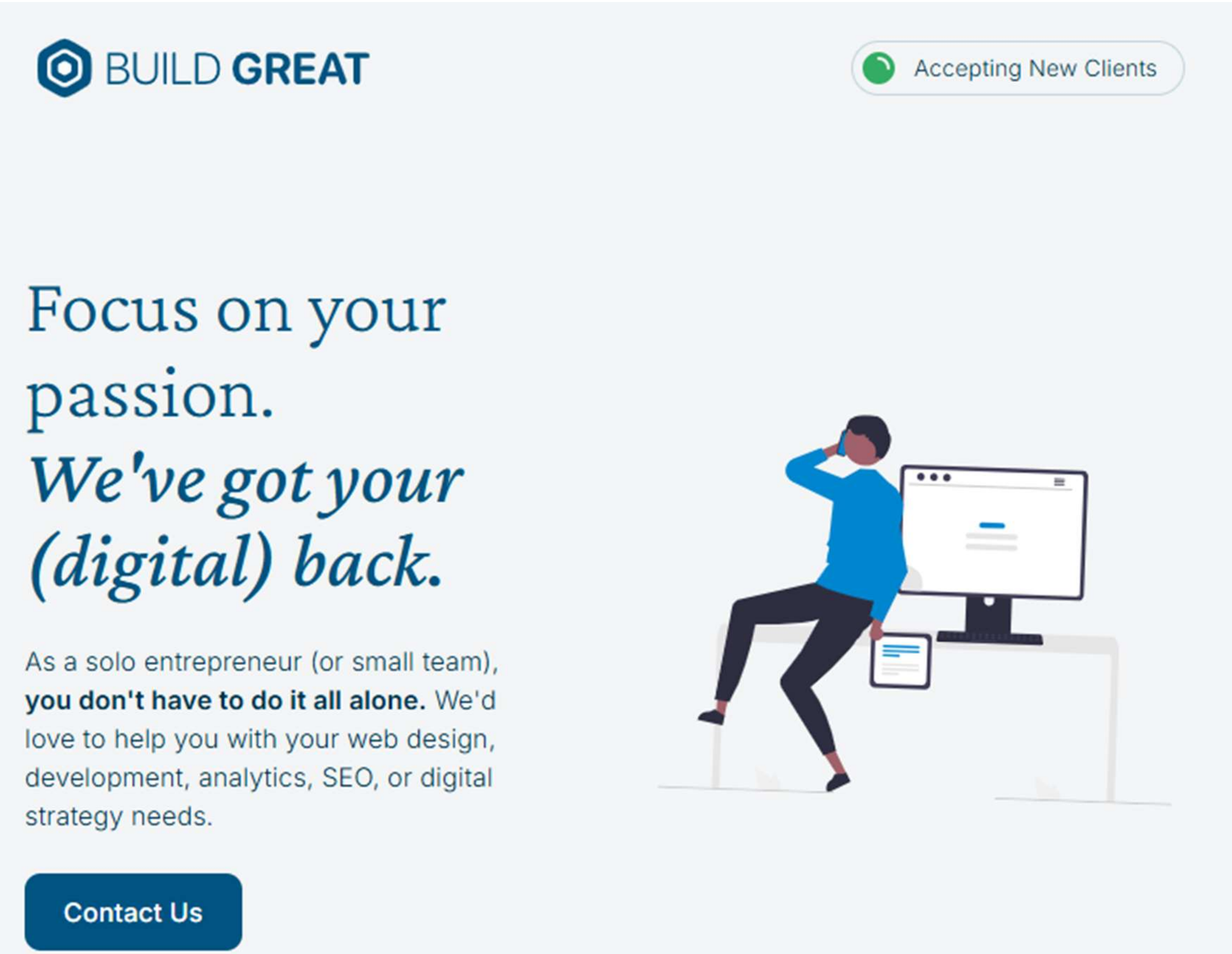
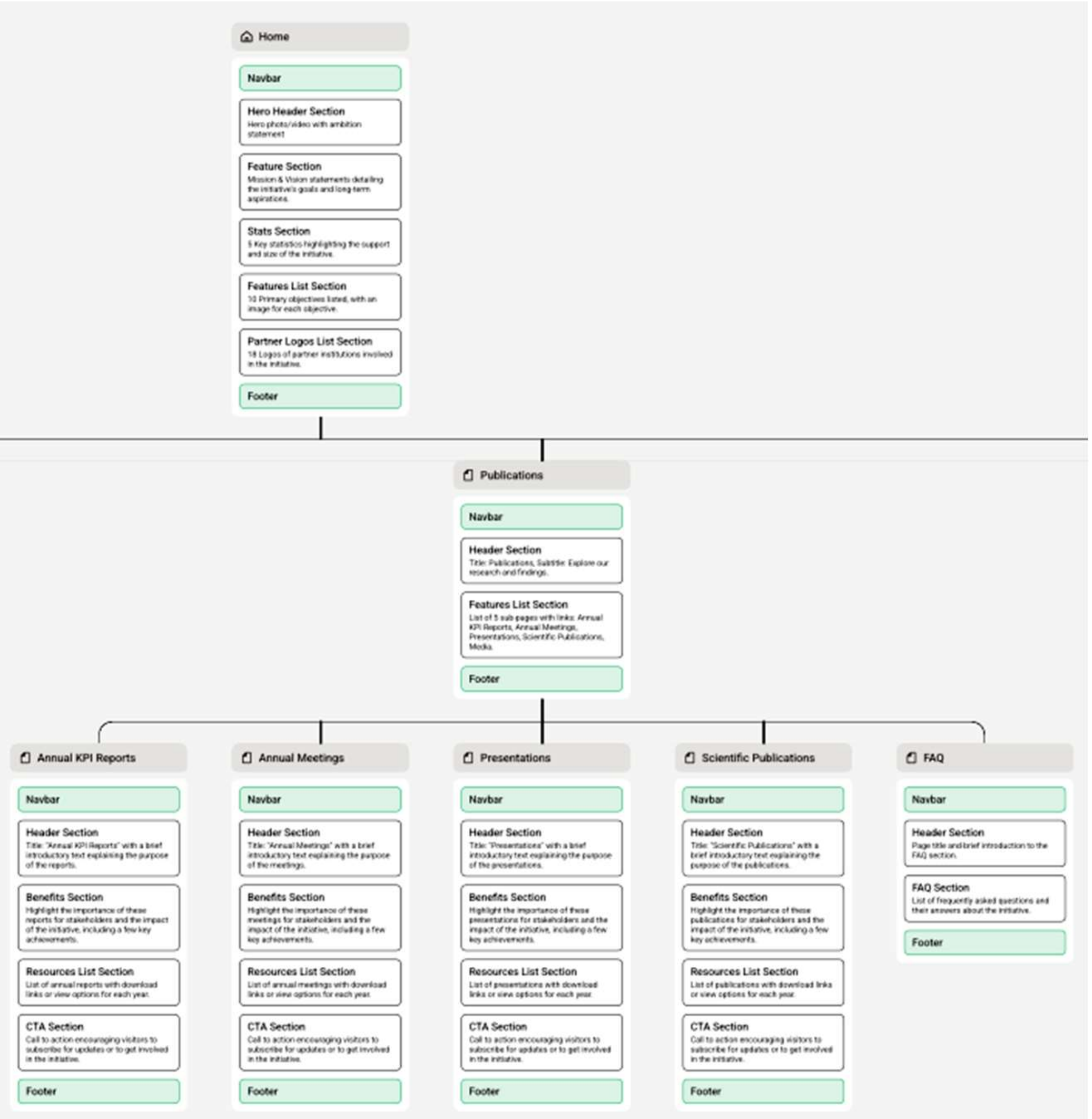
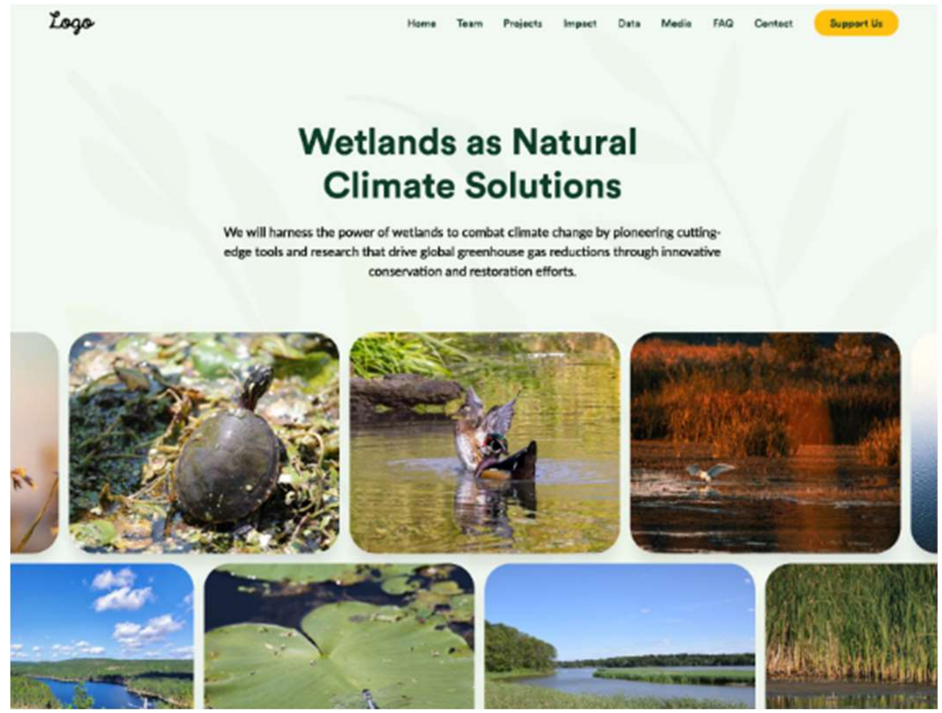


Todd Fraser is the founder of *Build Great*, a company focused on providing solutions for business websites and SEO (Search Engine Optimization).

He can be contacted through his website: https://www.buildgreat.work/



https://www.wetlandsolutions.org



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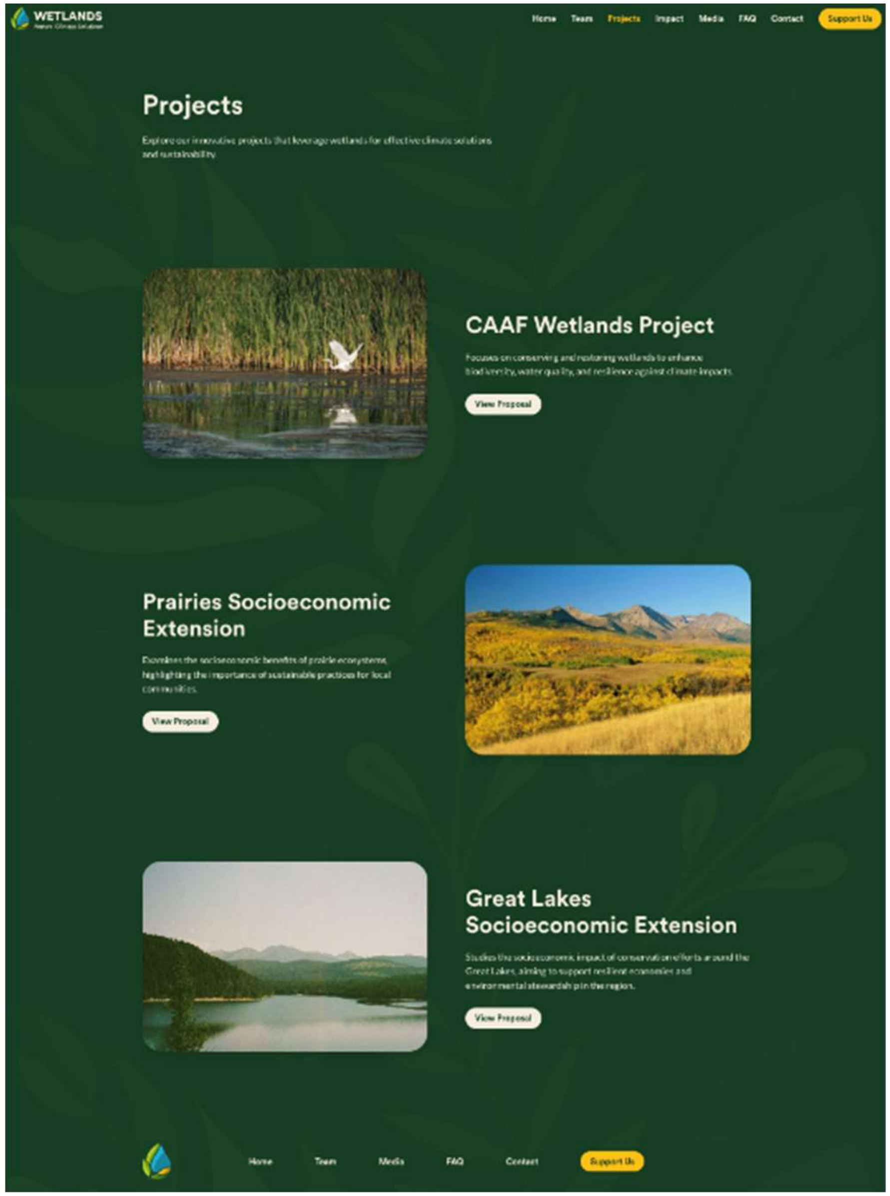
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Explore our innovative projects that leverage wetlands for effective climate solutions and sustainability.
CAAF Wetlands Project
Focuses on conserving and restoring wetlands to enhance biodiversity, water quality, and resilience against climate impacts.
View Proposal
Prairies Socioeconomic Extension
Examines the socioeconomic benefits of prairie ecosystems, highlighting the importance of sustainable practices for local communities.
View Proposal
Great Lakes Socioeconomic Extension
Studies the socioeconomic impact of conservation efforts around the Great Lakes, aiming to support resilient economies and environmental stewardship in the region.
View Proposal
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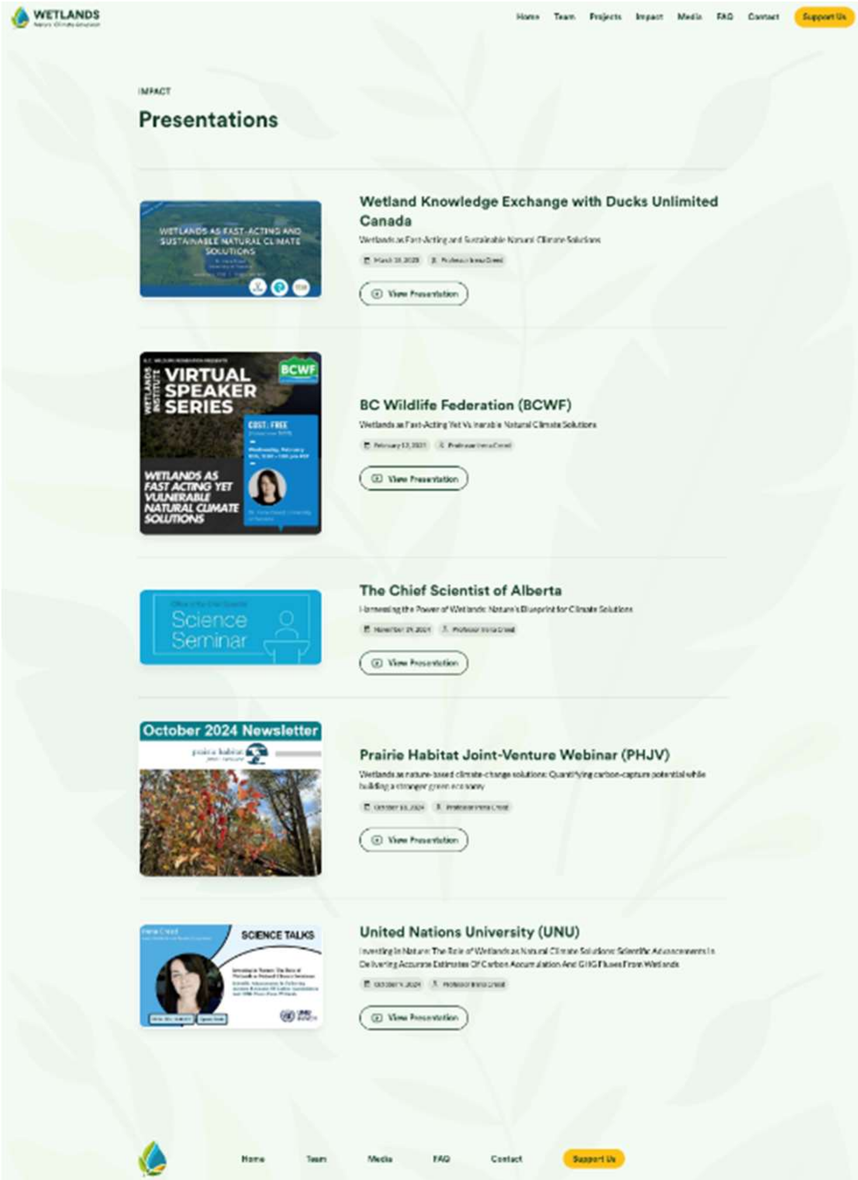
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Wetland Knowledge Exchange with Ducks Unlimited Canada
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BCWF
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BC Wildlife Federation (BCWF)
Wetlands as Fast-Acting Yet Vulnerable Natural Climate Solutions
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The Chief Scientist of Alberta
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October 2024 Newsletter
Prairie Habitat Joint-Venture Webinar (PHJV)
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Under Review
2025
2024

National GHG Inventory Report

Reporting agricultural drainage of wetlands in the national GHG inventory Report

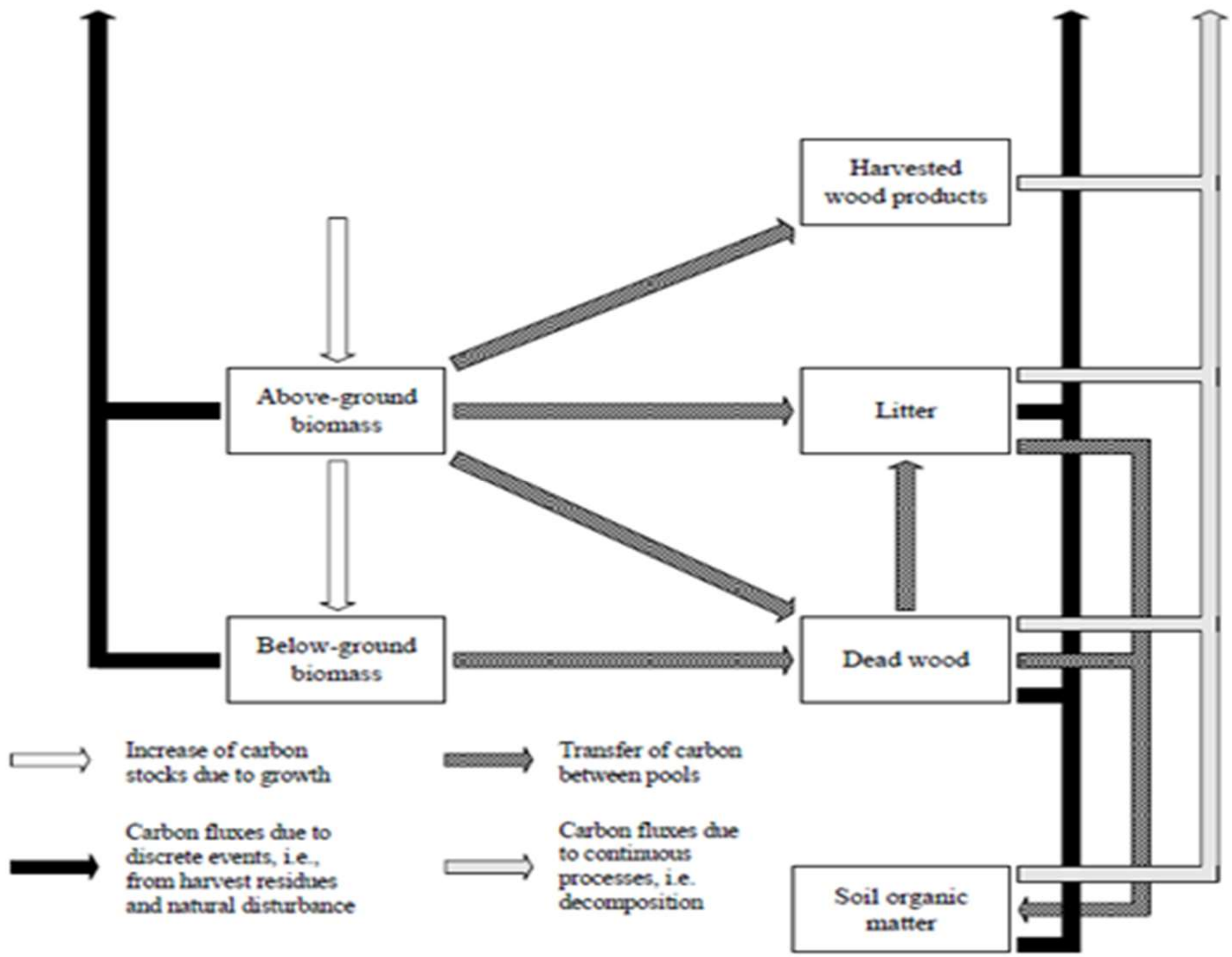
Current Status and Future Directions

Agriculture, Forestry and Other Land Use (AFOLU),
Environment and Climate Change Canada

Current Status

- Drainage of mineral wetlands for agricultural purposes is common practice in Canada
- The impacts of drainage on net GHG emissions are currently not reported, mainly due to the lack of authoritative estimates of rates of wetland loss.
- Complicated by:
  - wetland consolidation (real anthropogenic flooding)
  - “informal” dams – established throughout prairie pothole region
  - Complex, watershed scale impacts of tile drainage.

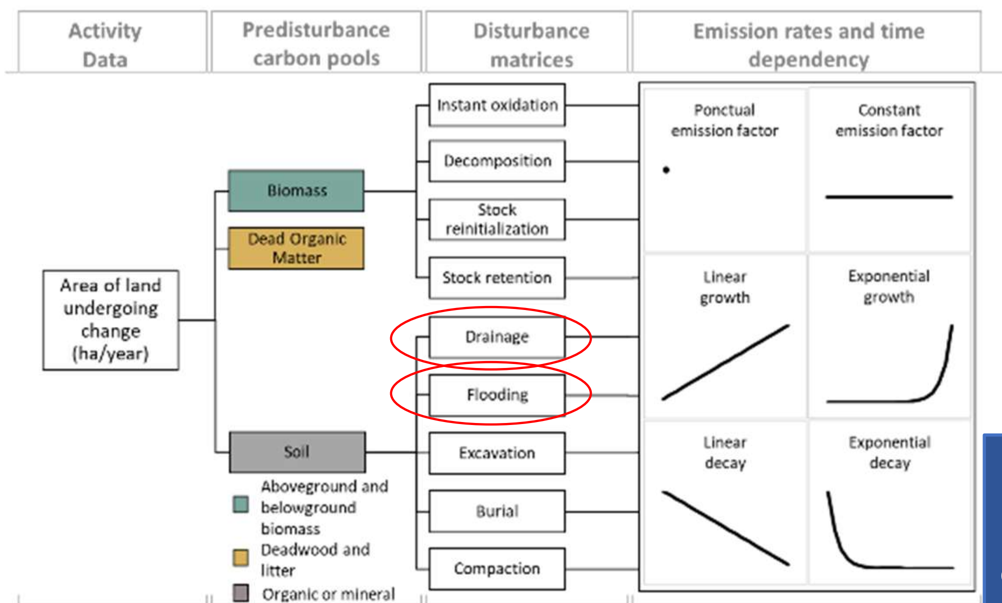
IPCC Methodologies track the movement of carbon and changes in non-CO_2 GHGs that result from direct human actions



Disturbance Estimates

Standard R-script to calculate emissions from disturbance, applicable to IPCC defaults approaches, where available, and country specific decay curves.
Applicable to prairie potholes, urban land conversion and many more methods.

GENERIC FRAMEWORK - CARBON



Activity Data
How many hectares are converted annually?

Pre-disturbance C pools
Which pools are affected? What was the carbon content of these pools before the disturbance?

Disturbance matrices
What fraction of the land is impacted by a specific disturbance? What are the transfers between the C pools and the atmosphere?

Emission rates & time dependency

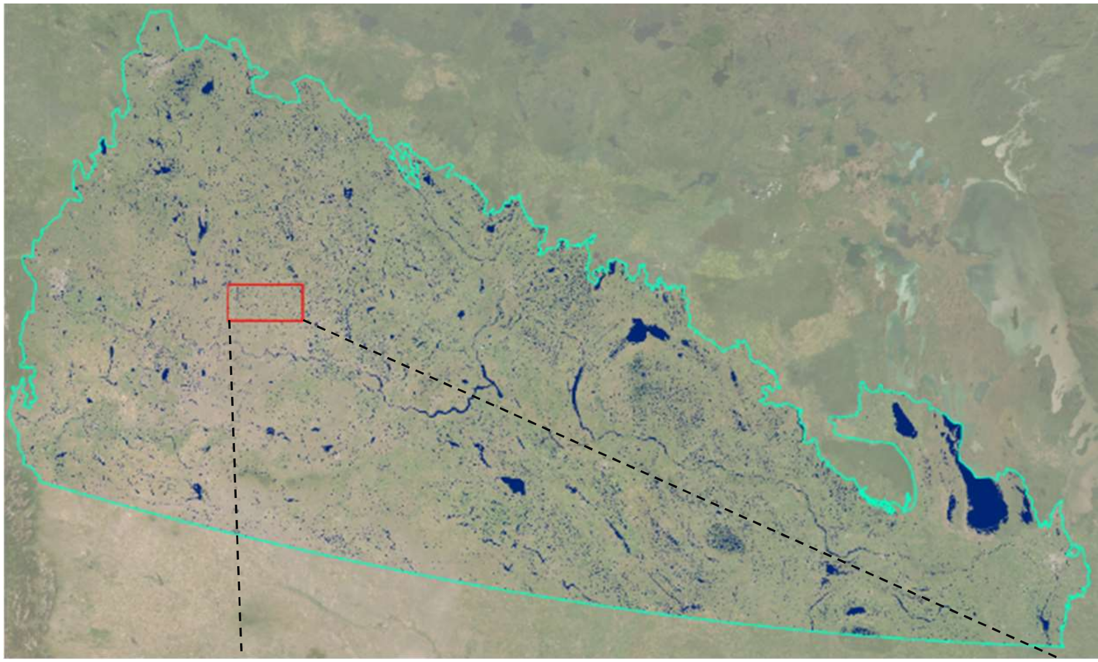
Emission rates :
Derived from model estimates, field data, paired analysis – sound method that measures change between landscape states.

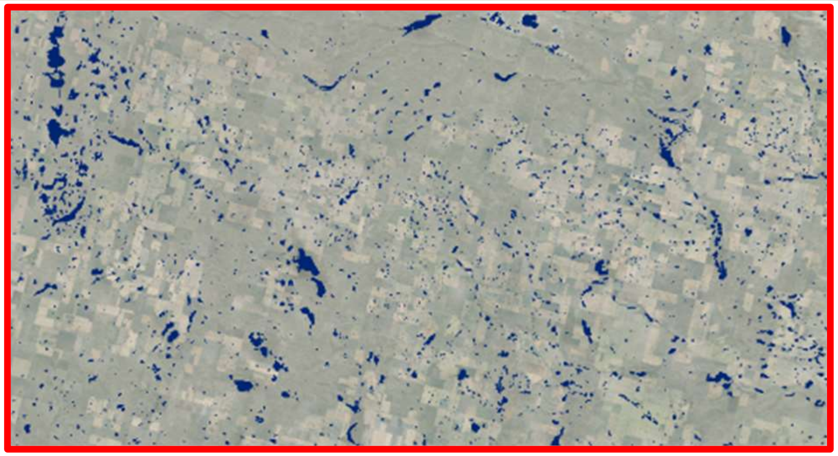
Results of research project ending in 2024

- Activity Data
  - Approach to change measurement using inundation occurrence is promising.
    - Product developed by ECCC Landscape Science and Technology Division – most useful
  - Strong interference by between human induced flooding resulting from drainage and climate change induced changes in hydrological cycles increases challenges.
    - Requires additional analysis and solutions

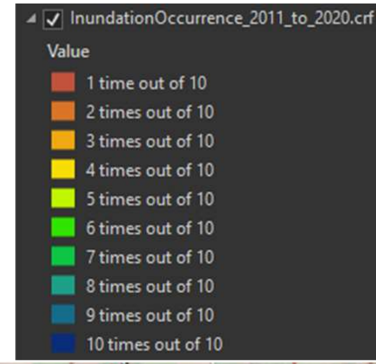
Activity Data derived from Olthof subpixel surface water fraction maps

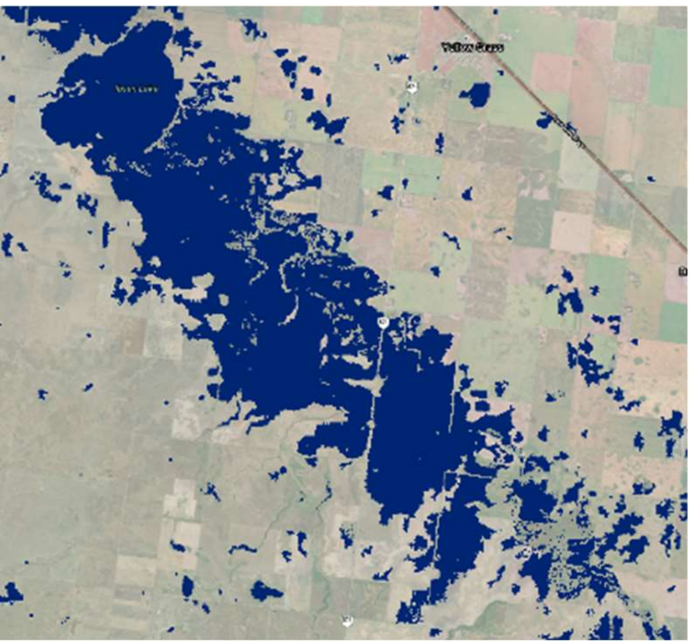
- Change detection between these 10-year window layer years:
  - 1990 (1984 – 1993)
  - 2005 (1996 – 2005)
  - 2020 (2011 – 2020)
- Remove temporary flood conditions were being captured as land use change, vs actual agriculture drainage events



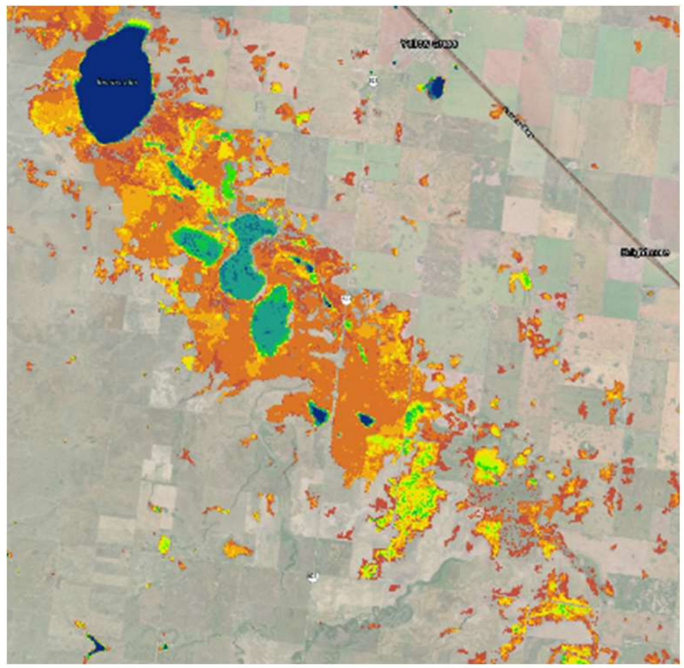


Temporary Flooding

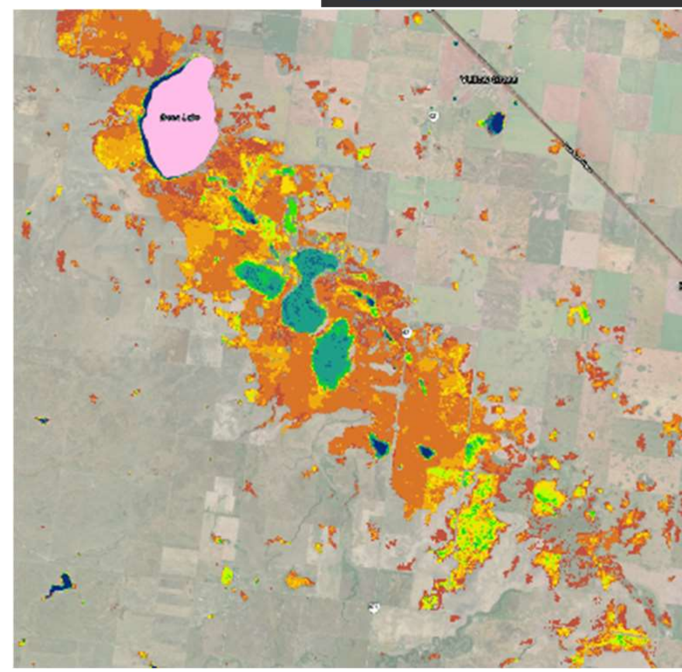




2011-2020 layer 10
year maximum



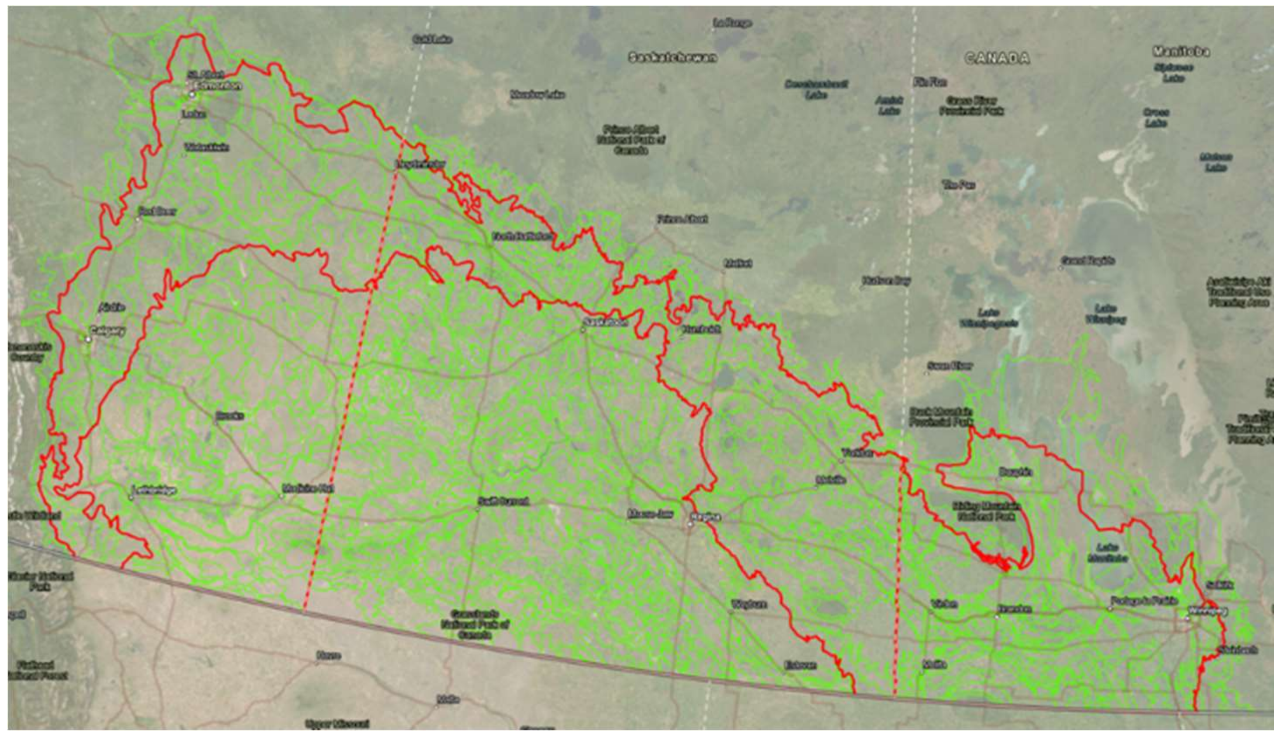
2011-2020 layer



2011-2020 layer

ECCC Spatial Processing Units used for Reporting National: (Soil Landscapes of Canada polygons)

- Estimate landuse change rates per SLC (green), aggregated per each Reporting Unit (red)
- Validated against *Surface Ditching Index, Prairie Habitat Monitoring Program*

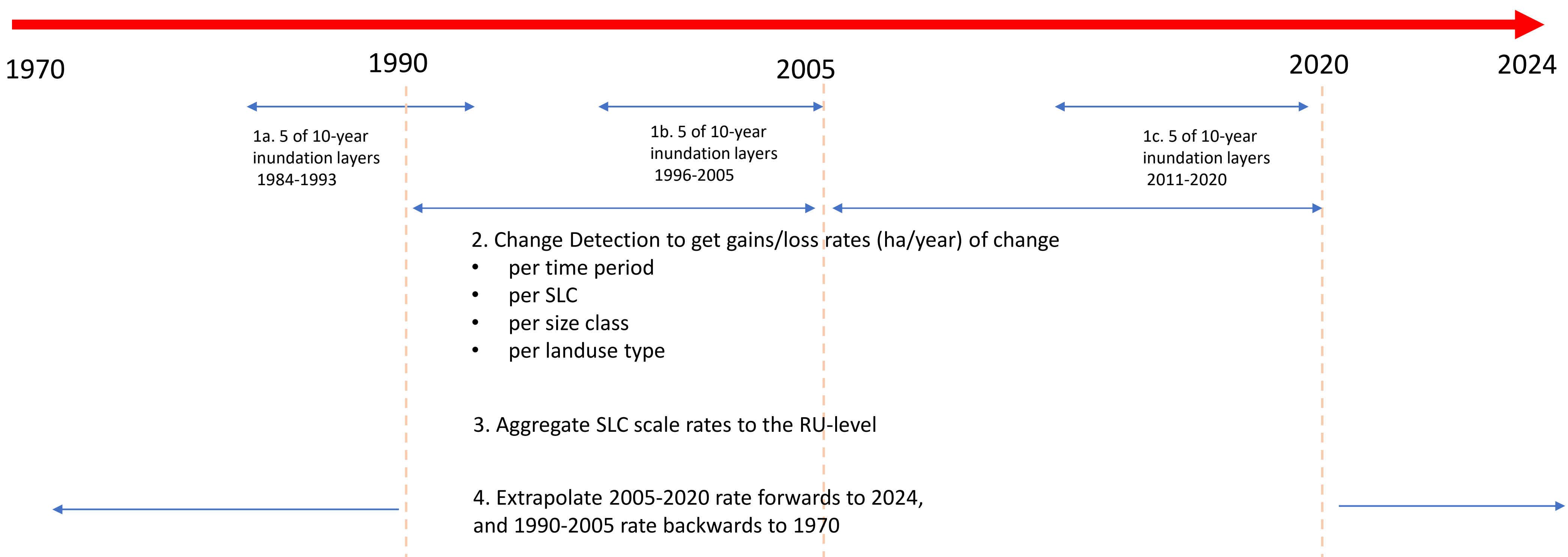


Sample count per RU
AB Semiarid Prairies: ~200
AB Subhumid Prairies: ~150
SK Semiarid Prairies: ~150
SK Subhumid Prairies: ~400
MB Subhumid Prairies: ~250

Current data processing plan

1. Delineate areas based on 5 of 10 year occurrence zones based on Ian Olthof's subpixel surface water fraction maps
2. Remove potential flood areas around all lakes/rivers
   a) Identify maximum contiguous water areas that touch boundaries of StatsCan Lakes/Rivers
   b) Remove from analysis any SLC units that primarily consist of flood areas from previous step
3. Flag wetlands within Urban Areas
4. Flag reservoirs included in NIR Flooded Land
5. Overlay AAFC maps (grasslands, croplands)
6. Power law methods to adjust estimates of smaller wetlands
7. Allocate change estimates to SLC polygons per size class per RU per time period
8. Validation based on comparisons to high resolution maps/images, field data, aerial surveys

Change detection to derive gain/loss rates



Results of research project ending in 2024

- **Soil Carbon Pool**
  - Canadian Data is sparse and inconsistent
  - Lack of data post disturbance – no final carbon stock
    - Comparative analyses often not based on Equivalent Soil Mass
  - Isotope approach is inappropriate for quantitative gain/loss rate analysis in mineral soils (time period too short)
  - American (USGS) soil data more complete
    - Questions of representativity
  - Data does confirm need to report carbon at depth (>30cm)

Application of Tier 1(2) Calculation

$$\Delta C\ SOC = C_{soc,ref} \times ((1 - F_{LU})$$

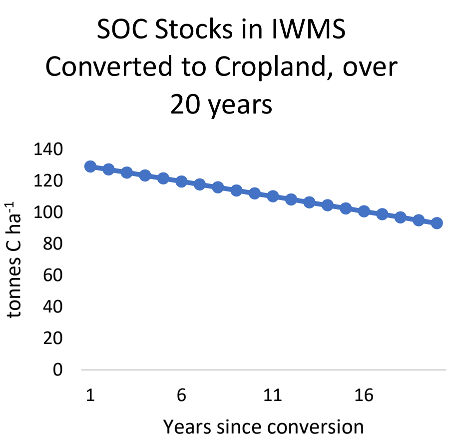
$C_{soc,ref}$ = reference SOC values

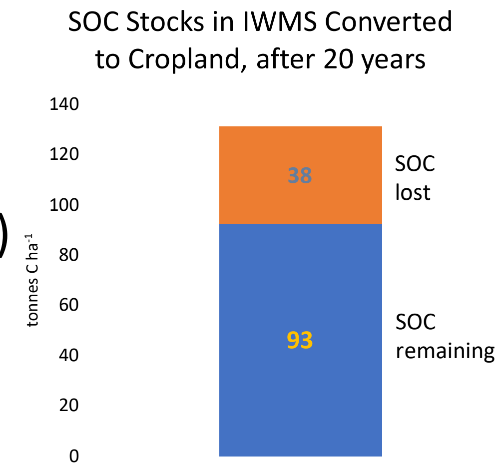
- Utilization of data collected by Dr. Creed, with collaboration from ECCC and the USGS – Dr. Sheel Bansal.
- Results demonstrated that, in general, wetlands located on different soil order and soil zones have different reference SOC stock values.
- E.g., wetlands in Chernozemic soils have greater SOC values than those found in Solonetzic soils (131 vs 107 tonnes C ha^{-1}).

F_{LU} = land-use change factor

- 0.71 – from the 2013 IPCC wetland supplement (29% of SOC lost)

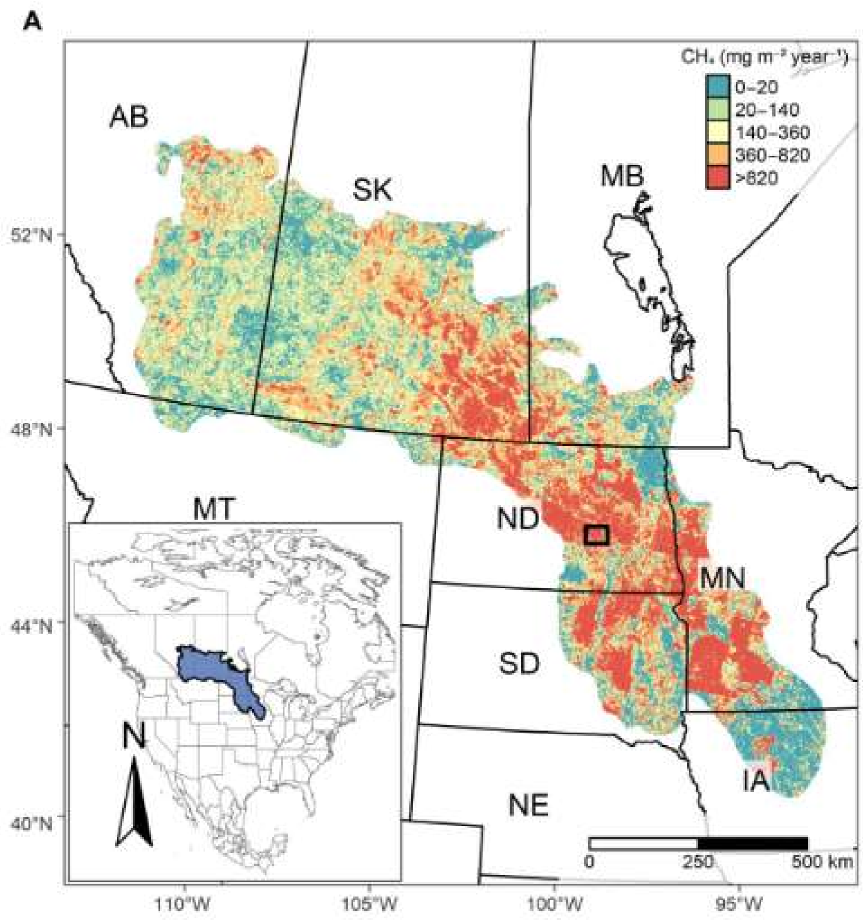
- C Stocks will be transferred 20 years post-conversion to AAFC Cropland carbon model





Results of research project ending in 2024

- **Methane emissions**
  - Canadian data is sparse, inconsistent and highly uncertain.
  - USGS modelled emission provides an option to have emission factors spatially attributed.
    - Need to validate the accuracy of estimates
    - Not likely less accurate than IPCC defaults



Results of research project ending in 2024

- **Application of Managed Land Proxy**
  - Expert opinion suggests the emission profile is modified in wetlands occurring in intensively cropped landscapes.
    - Lack of measurements to validate this hypothesis
      - Assumed based on expected processes
  - Unlikely that wetlands in extensively managed landscapes (unimproved pastures, Forest Land) have significant anthropogenic impacts to emission profile

Reporting methane

- Under Cropland remaining Cropland
  - Annual emissions on intensively managed Cropland
- Methane emissions from wetlands unreported to reported - shift from unmanaged to managed land
  - Under Forest Land to Cropland (deforestation)
  - Unimproved pasture to Cropland (Grassland to Cropland)
  - Unimproved Perennial to Annual Crop production
    - Management Change under Cropland remaining Cropland
- Under Flooded Land (Cropland to Wetland)
  - Methane from wetlands demonstrating average increase in water surface of greater than 10%

Additional REquirement

- Estimates of biomass loss post-drainage
  - Overlap with woody biomass analyses under way
  - TBD

Summary

- Aiming to integrate estimates into the 2027 National Inventory Report
- Activity data still the most significant challenge
- Approach, Tier 1, but integrating country-specific carbon pools.
  - Post conversion (after 20 years, integrated into Tier 3 Cropland modelling system)
- Methane – complex reporting structure
  - Significant impact to Cropland reporting, requiring communication strategy

WETLANDS

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Farmer Holos Model

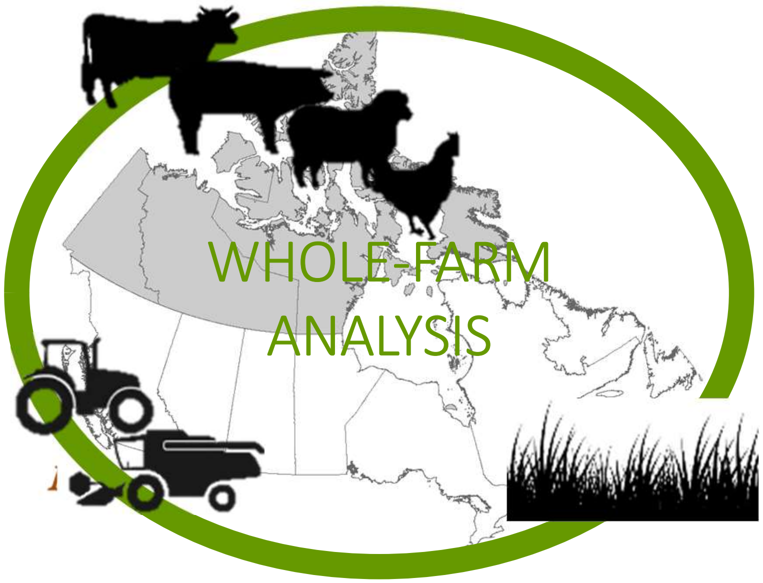
Holos - wetland

Sikoohkotoki (Lethbridge), AB
S. Pogue, A. McPherson, P. Mantle, R. Kröbel
Lethbridge Research and Development Centre
Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Canada

Holos – a whole-farm model to estimate GHG from Canadian Farms

… a Greek word meaning all, entire, total (holistic).



Guiding principles:

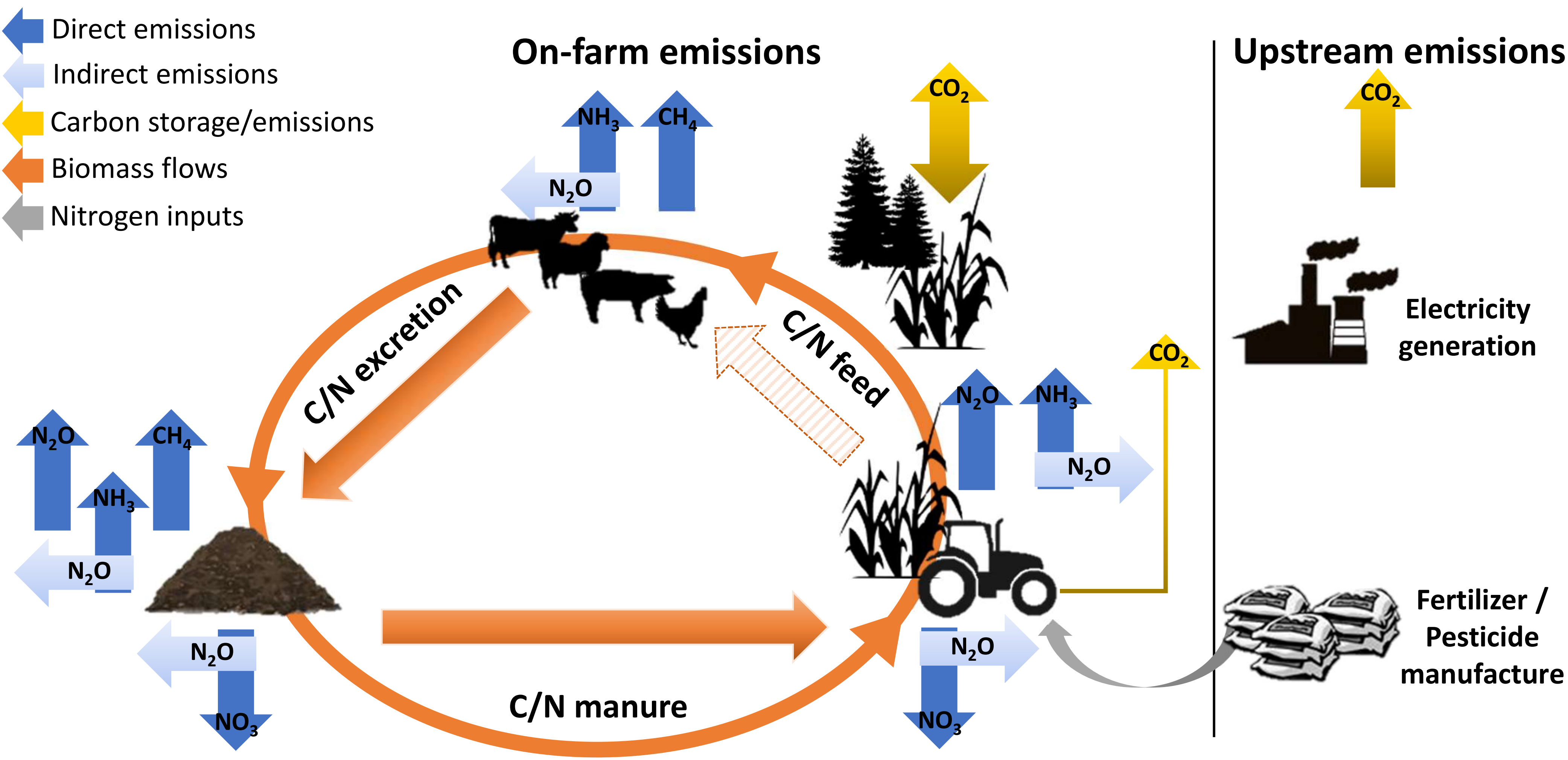
- Transparency
  - algorithm document
  - override defaults
  - open source development
- Reliability
  - peer-reviewed science
  - alignment with National Inventory Report

Software development: A. McPherson **Researchers:** Dr. S.J. Pogue, Dr. R. Kroebel

Data technician: P. Mantle **Junior techs:** Louie, Manyi

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Cycling Carbon through the farm system



Holos team – roles and responsibilities

What we do!

- **Develop the Holos model!**
  - Support 11 out of 13 Living Lab (BMP additions)
  - Support National GHG Inventory development
  - Work with multiple Canadian Universities (training)
  - Students (model experiments in whole-farm context)
  - Gov branches (training, troubleshooting)
  - Producer groups, industry and banks (adoption)
  - International partners (HolosIE)

Github – open source

AAFC Holos page and download:

https://agriculture.canada.ca/en/agricultural-science-and-innovation/agricultural-research-results/holos-software-program

Open source (GitHub):

https://github.com/holos-aafc/Holos

Discussion forum:

https://github.com/holos-aafc/Holos/discussions/2

Model components (upcoming)

Short(er) term (*we can do these*):

- Open-source interface and MacOS compatibility
- Water budget model (Martel et al. 2021)
- Multi-stage manure handling (AD already present)
- *Living labs - beneficial management practices*

Long term (*we need others to help!*):

- Shelterbelt component (completed – for now)
- Wetland component
- Dynamic economics

Future Wetland component – what could it be?

Add Wetland

Delete Wetland

Ag Field

Required:

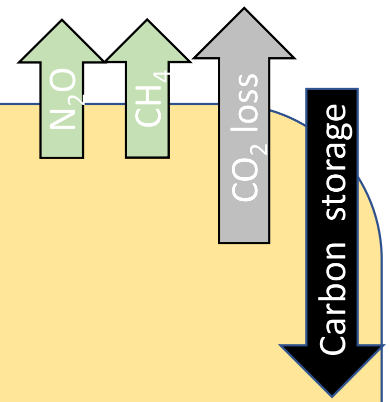
- Crop type
- Yield

Optional:

- Fertilizer type and amount
- Pesticide application
- Irrigation amount
- Manure application
- Field history (provide above info for past years)

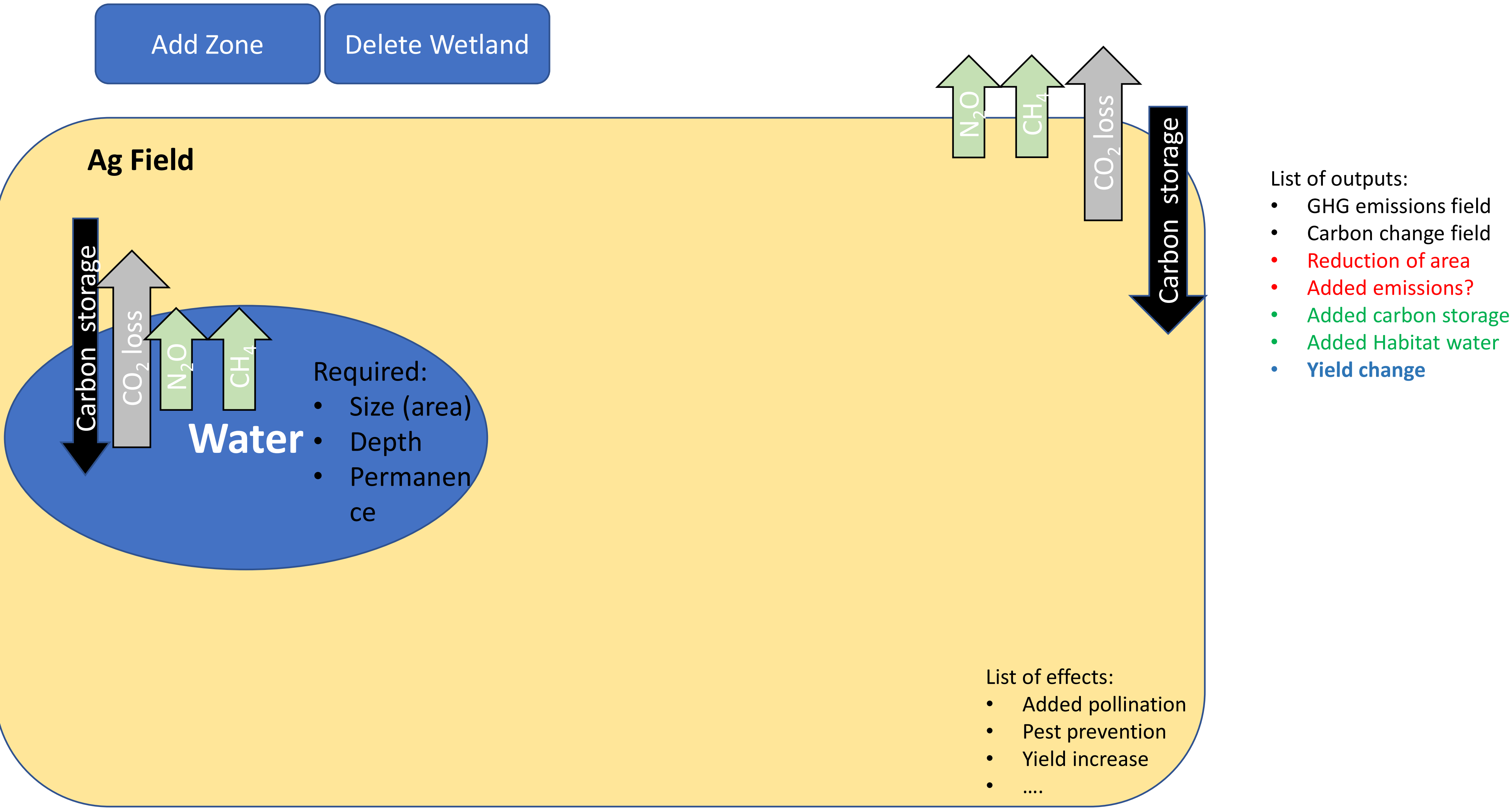
Potential (to be included):

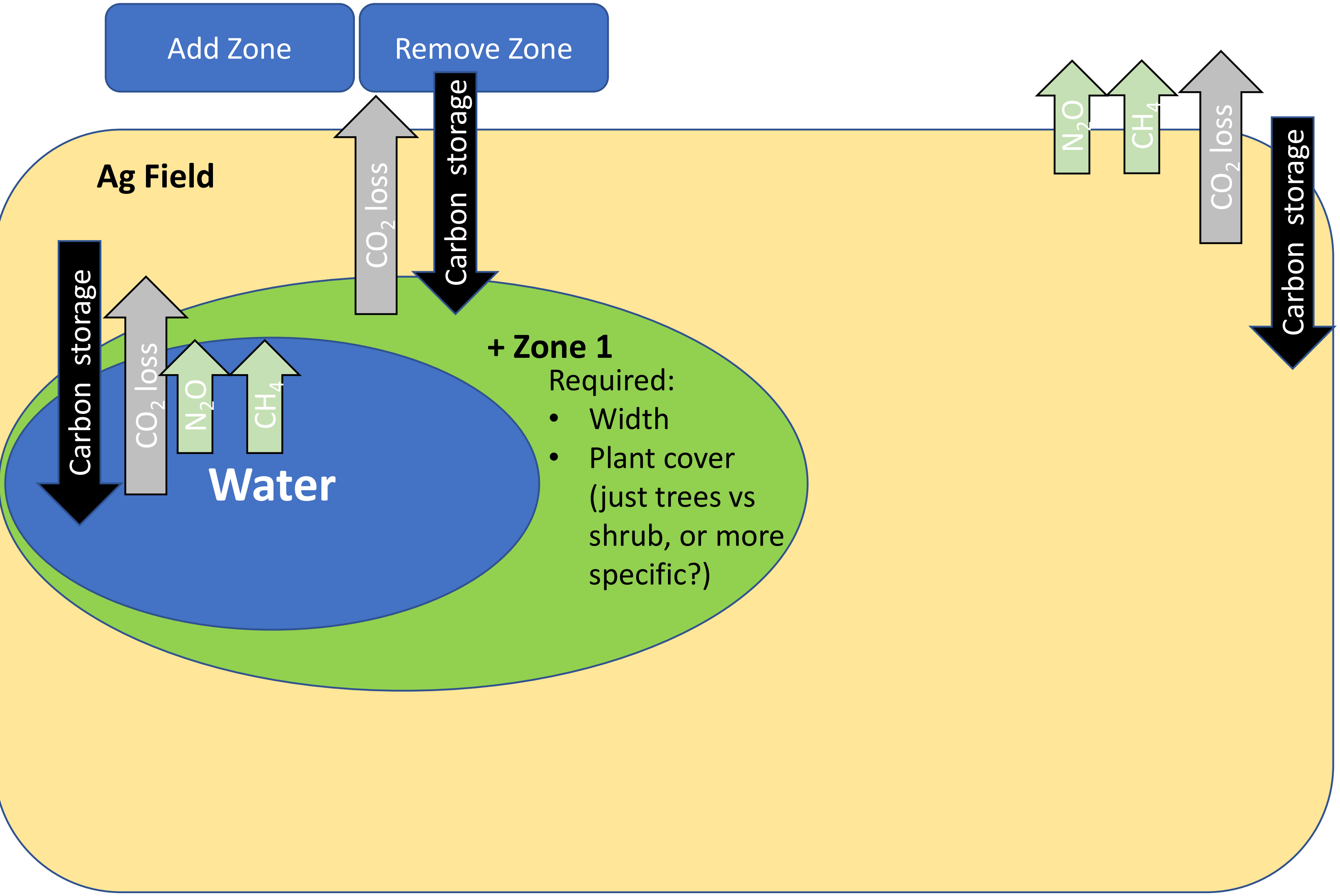
- Cover crops
- Underseeding
- Silage
- Hay
- Perennials (in rotation, or permanent)



List of outputs:

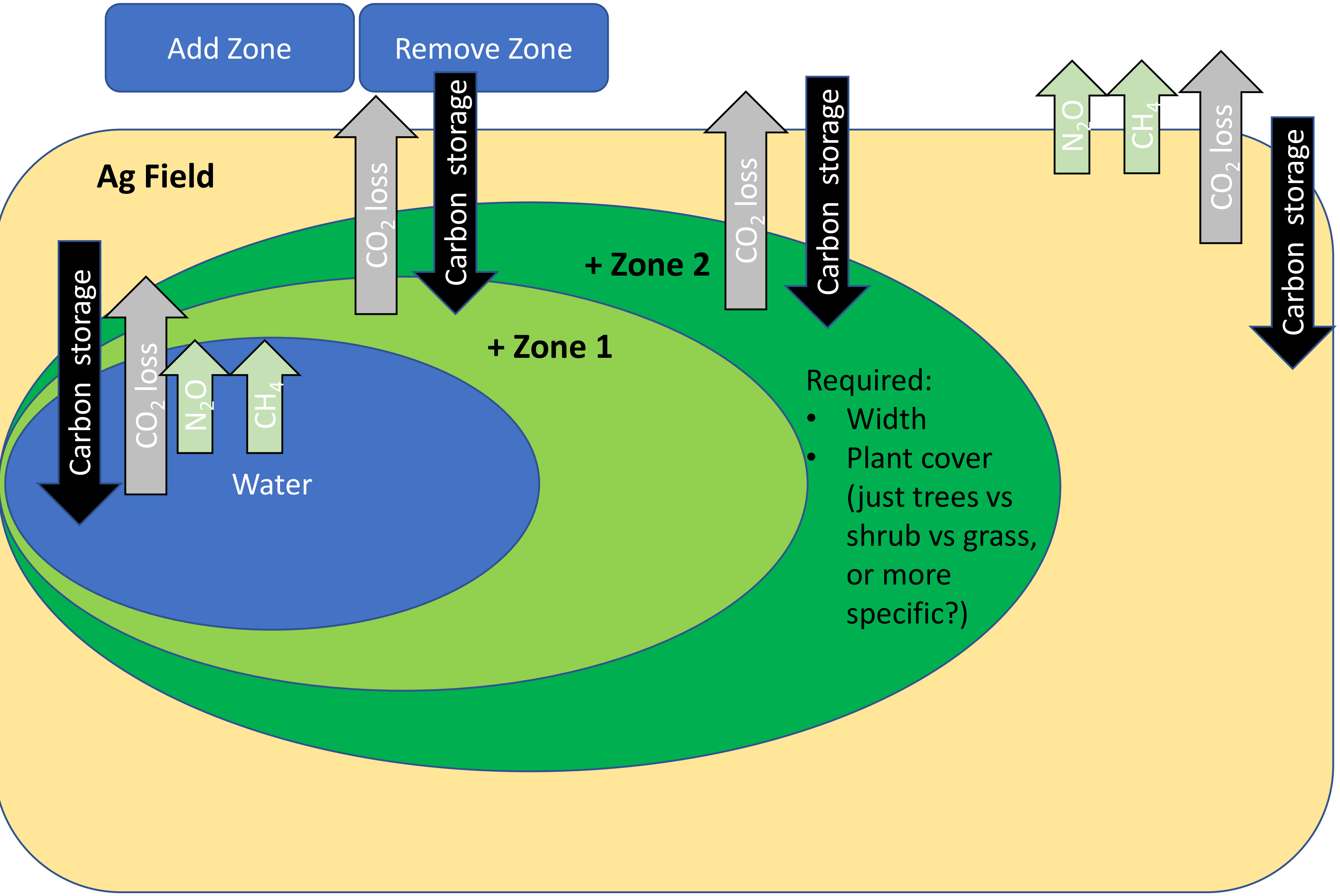
- GHG emissions field
- Carbon change field


Add Zone
Delete Wetland
Ag Field
Carbon storage
CO_2 loss
N_2O
CH_4
Water
Required:
• Size (area)
• Depth
• Permanence
N_2O
CH_4
CO_2 loss
Carbon storage
List of outputs:
• GHG emissions field
• Carbon change field
• Reduction of area
• Added emissions?
• Added carbon storage
• Added Habitat water
• **Yield change**
List of effects:
• Added pollination
• Pest prevention
• Yield increase
• ....



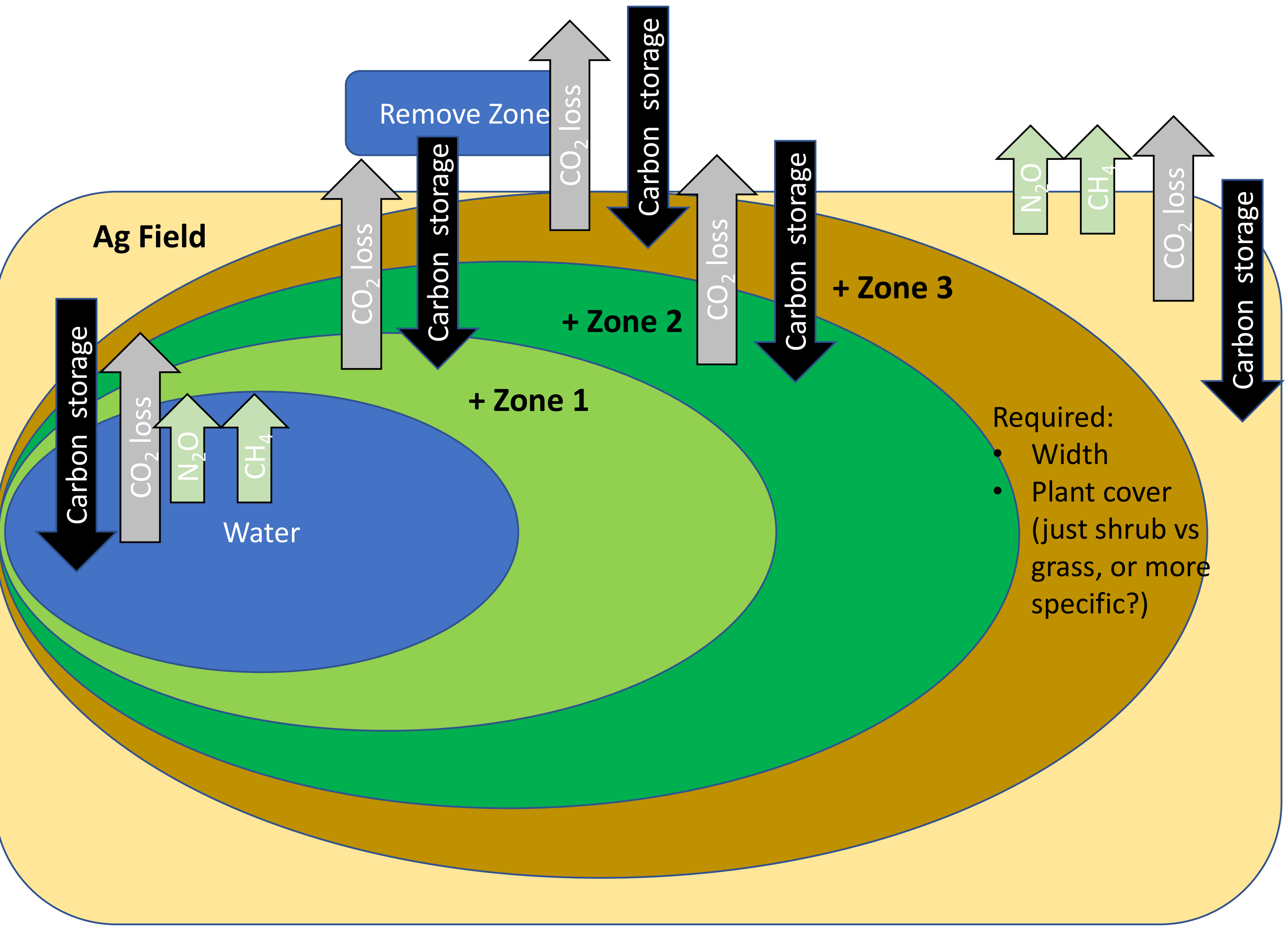
List of outputs:

- GHG emissions field
- Carbon change field
- Reduction of area
- Added emissions?
- Added carbon storage
- Added Habitat water
- Added Biodiversity water
- Habitat zone 1
- Biodiversity zone 1
- **Yield change**



List of outputs:

- GHG emissions field
- Carbon change field
- Reduction of area
- Added emissions?
- Added carbon storage
- Added Habitat water
- Added Biodiversity water
- Added Habitat zone 1
- Added Biodiversity zone 1
- Habitat zone 2
- Biodiversity zone 2
- **Yield change**



List of outputs:

- GHG emissions field
- Carbon change field
- Reduction of area
- Added emissions?
- Added carbon storage
- Added Habitat water
- Added Biodiversity water
- Added Habitat zone 1
- Added Biodiversity zone 1
- Added Habitat zone 2
- Added Biodiversity zone 2
- Habitat zone 3
- Biodiversity zone 3
- **Yield change**

Acknowledgements

Holos V4

Shakila Ekanayaka Mudiyanselage
Raheem Mir
Zishan Panchal
Wyatt Bristow
Hassan Afzaal
Matthew Ursaki
Kei De Rose
Hana Kim
Marcelle Moreira dos Santos
Jeffrey Deurloo
Ryan Rideout
Ben Hunt
Julius Moore
Adelle Herr
Steven Kega

Holos V3 & V4:

Aklilu Alemu
Myra Martel
Lilong Chai
Candace Vanin
Jose Barbieri

Holos Research & V3:

Karen Beauchemin
Shannan Little
Ken Maclean
Bobbi Helgason

Holos Classic:

Henry Janzen
Julia Lindeman

Thank you and find us:

or contact us via:

holos@agr.gc.ca

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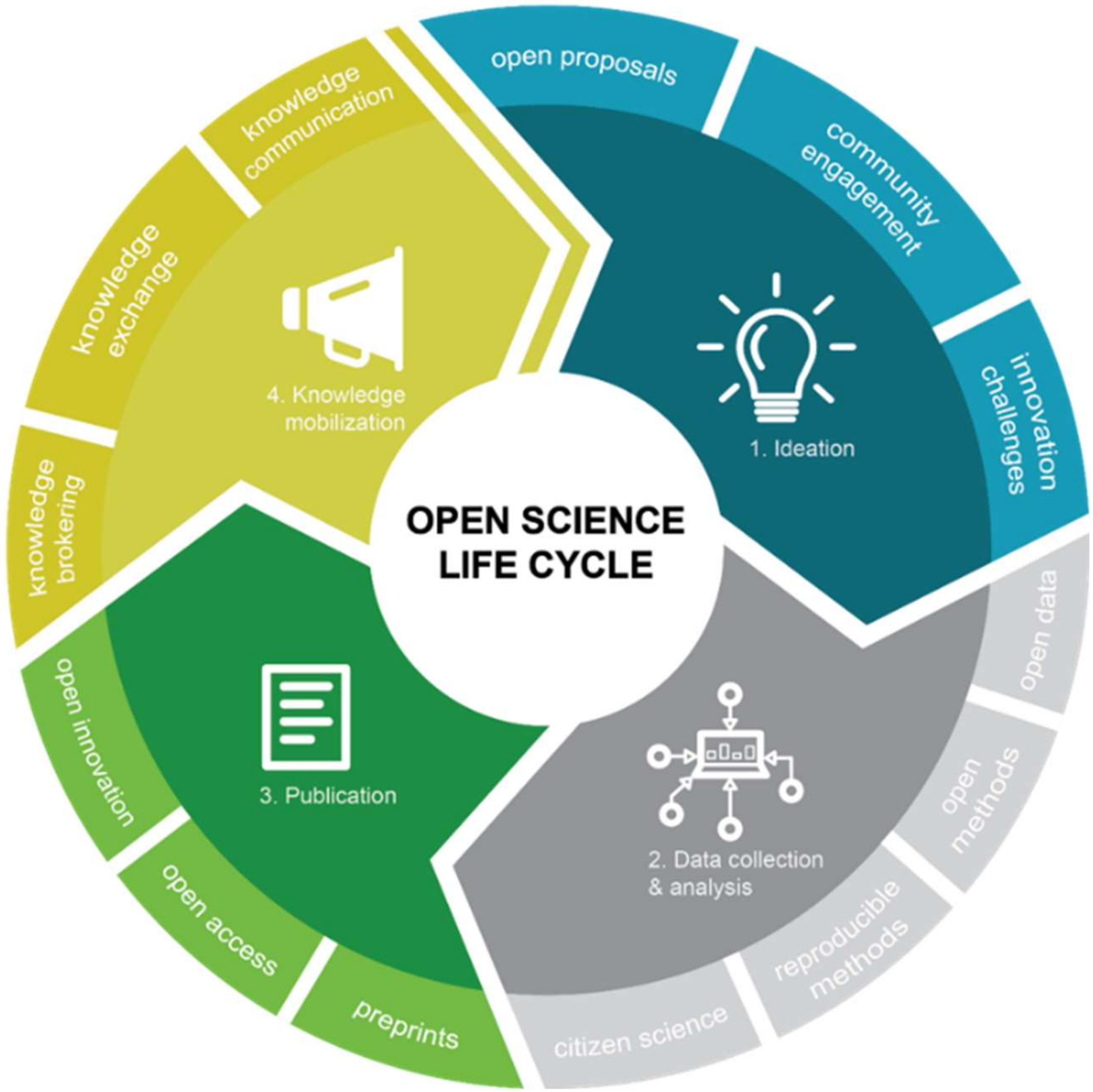
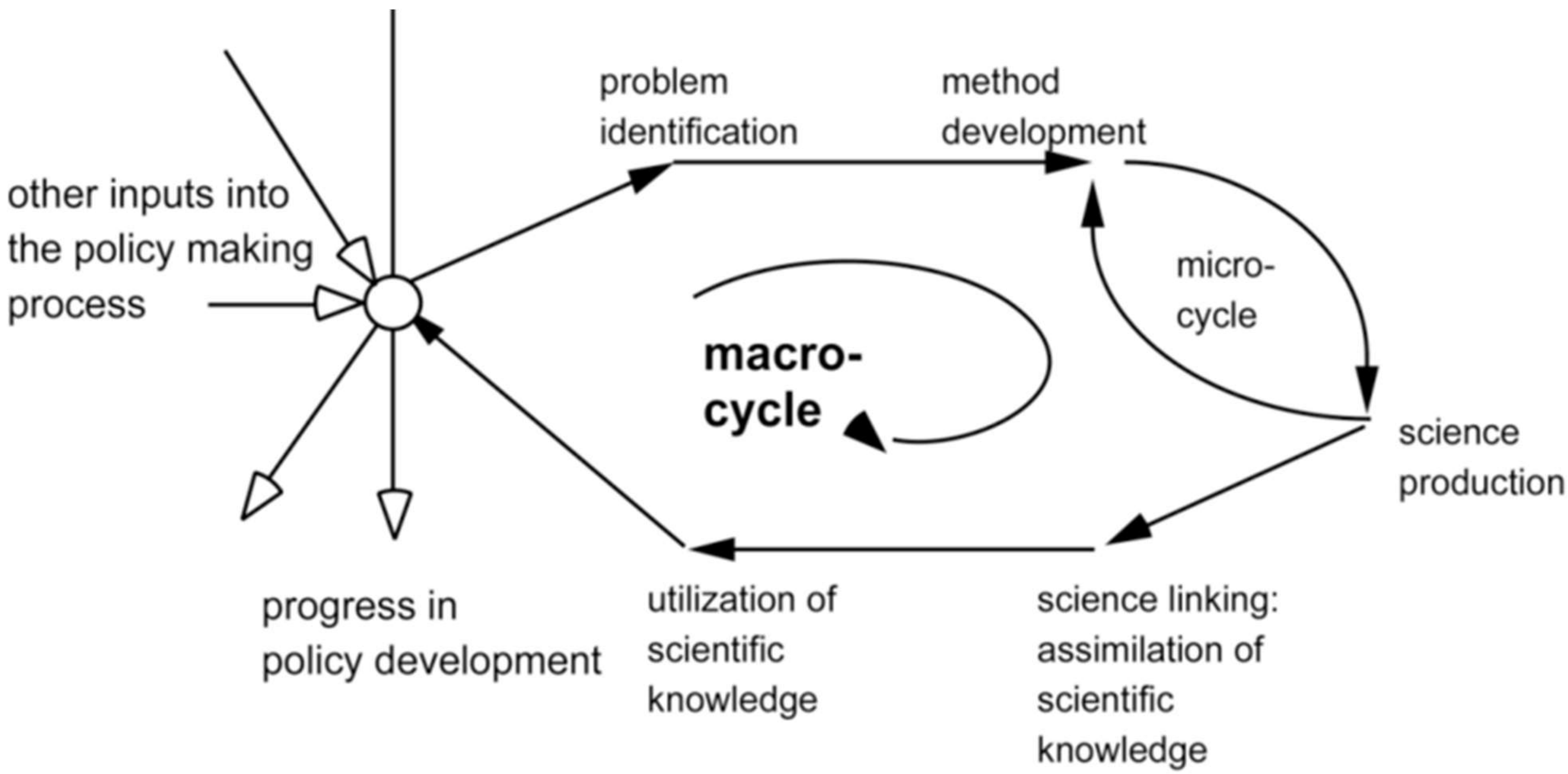
Network’s Action Science

Network’s Action Science

1:00-1:15 PM:	Network’s Action Science: Select topics and rapporteurs
1:15-1:45 PM:	Breakout Groups: Identify topics
1:45-2:15 PM:	Network’s Action Science: Finalize topics and indicate interests


open proposals
community engagement
innovation challenges
1. Ideation
OPEN SCIENCE LIFE CYCLE
open data
open methods
reproducible methods
citizen science
2. Data collection & analysis
preprints
open access
open innovation
3. Publication
knowledge brokering
knowledge exchange
knowledge communication
4. Knowledge mobilization

Macrocycle of policy-oriented research



Klabbers et al. 1996. Climate science and climate policy: Improving the science/policy interface. Mitigation and Adaptation Strategies for Global Change.

Seven Highlights

1. **Reframing "Unmanaged" Wetlands as Managed Wetlandscapes**
2. **Buried Signals: Legacy Effects of Drainage on Wetland Carbon Stocks and Restoration Trajectories**
3. **Closing the Carbon Budget: Toward a Full Accounting of Wetland Inflows, Storage, and Exports**
4. **Beyond Carbon: Reconciling Climate Cooling and Carbon Storage Trade-Offs in Wetland Ecosystems**
5. **Rethinking Incentives: Prioritizing Wetland Retention Over Restoration**
6. **Beyond Carbon: Building a Multi-Functional Wetland Assessment Framework for Policy and Planning**
7. **Getting the Numbers Right: Regionally Specific Emission Factors for freshwater mineral wetlands**

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Breakout Groups

WETLANDS
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Plans for AGM #4

Wetlands as Natural Based Solutions Yr4 AGM 2026

Harry J. Enns

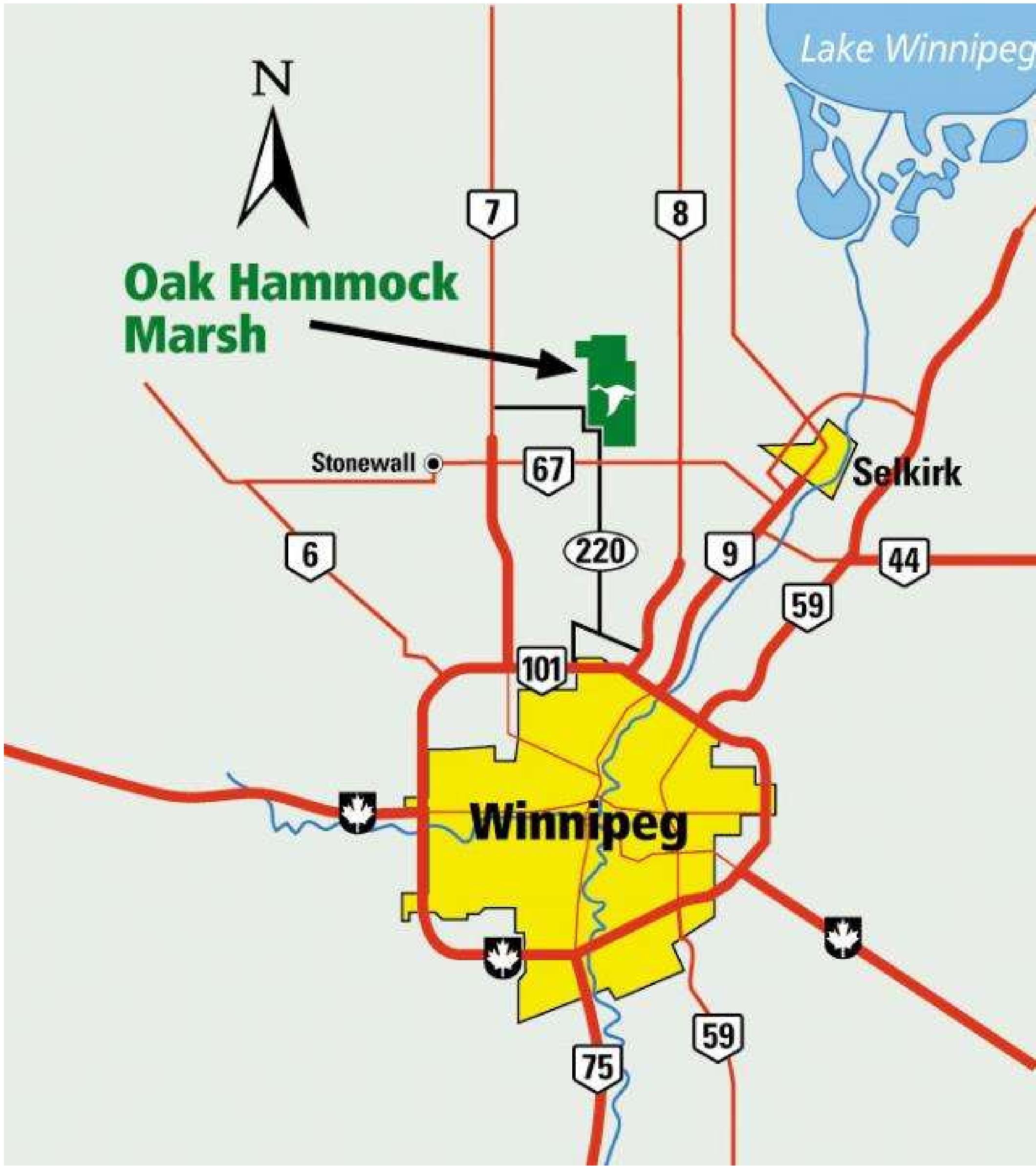
Wetland Discovery Centre

Proposed Dates:

- **April 20-21**
- **April 27-28**
- **May 4-5**
- **May 11-12**

Monday-Tuesday, which would allow people to travel Sunday.

Ducks Unlimited Canada



SSHRC Connection Grants – May 2025

POSTED BY: CHANTAL LEMIRE   MARCH 3, 2025

SSHRC's Connection Grants support events and outreach activities geared toward short-term, targeted knowledge mobilization initiatives. These events and outreach activities represent opportunities to exchange knowledge and to engage on research issues of value to those participating. Events and outreach activities funded by a Connection Grant may often serve as a first step toward more comprehensive and longer-term projects potentially eligible for funding through other SSHRC funding opportunities.

Amount:
Events: $7,000 – $25,000
Outreach Activities: $7,000 – $50,000 (potentially higher amounts)

Matching Funds: SSHRC will not fund the full cost of any connection event or outreach activity. Additional support in the form of cash and/or in-kind contributions (excluding registration fees), equivalent to a minimum of 50% of the amount requested from SSHRC, must come from sponsoring organizations. **Western Applicants can request additional funds from the Vice-President (Research) to meet their match requirements. Please read the institutional matching for SSHRC programs page for further information <*WesternID and password required*>.** Contact Chantal Lemire for assistance in securing matching funds from Western and your faculty well in advance of the deadline.

Description: Connection Grants support workshops, performances, colloquiums, conferences, festivals, forums, summer institutes, or other events or outreach activities that facilitate:

- disciplinary and/or interdisciplinary exchanges in the humanities and social sciences;
- scholarly exchanges between those working in the social sciences and humanities and those working in other research fields;
- intersectoral exchanges between academic researchers in the humanities and social sciences and researchers and practitioners from the public, private and/or not-for-profit sectors; and/or
- international research collaboration and scholarly exchanges between researchers, students and non-academic partners from other countries.

Eligibility: Applicants must hold an eligible academic research appointment at Western or be a post-doctoral fellow/associate with supervisory support

The maximum value for a SSHRC Connection Grant is dependent on whether it is an "event" only OR
if it is an event with "outreach activities".

"Event" Connection grants are a maximum of $25,000 over one year. ($7,000 – $25,000). *Applying for $25,000 would require $12,500 in-kind and/or cash contribution.*

"Event plus outreach activities" grants are a maximum of $50,000. ($7,000- $50,000). *Applying for $50,000 would require $25,000 in-kind and/or cash contribution.*

An applicant may apply for one Connection Grant per calendar year.

An applicant may not apply for or hold more than one Connection Grant for the same event or outreach activity.

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Flex Breakout Groups

WETLANDS

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