Peatland Science Symposium – PERG and Can-Peat / *Symposium scientifique sur les tourbières – GRET et Can-Peat*

Wednesday, February 21, 2024 / *Mercredi, 21 février 2024*

Hôtel Plaza Québec, 3031 Bd Laurier, Québec, QC G1V 2M2

Schedule and abstracts / *Programme et résumés*

AIM OF THE SYMPOSIUM:

The joint event "Peatland Science Symposium" aims to present to various stakeholders in the peat, peatland, and wetlands sectors on various peatland research topics such as restoration, carbon cycling, policy, and new harvesting methods. The event will feature presentations and posters from the Peatland Ecology Research Group (PERG) and Can-Peat researchers, fellows, students, and partners.

BUT du SYMPOSIUM:

L'événement conjoint « Symposium scientifique sur les tourbières du GRET et de Can-Peat » vise à présenter aux différents acteurs des secteurs de la tourbe, des tourbières et des zones humides divers sujets de recherche sur les tourbières tels que la restauration, le cycle du carbone, la politique et les nouvelles méthodes d'extraction de la tourbe. L'événement comprendra des présentations et des affiches des chercheurs, stagiaires postdoctoraux, étudiants et partenaires du Groupe de recherche sur l'écologie des tourbières (GRET) et de Can-Peat.

Layout / Mise en page: Kim Kleinke, Claire Boismenu & Kathy Pouliot

Note: The content of the abstracts has not been reviewed by the organizing committee. / *Le contenu des résumés n'a pas été révisé par le comité organisateur.*

Program and Index / Programme et index

Symposium langage: mostly in English / *Langue du symposium: majoritairement en anglais*

* Indicates a student presentation (for the Student Award vote!) / * *Indique les présentations étudiantes (à considérer pour le vote des prix des étudiants!)*

14:45	**Coffee break and 2nd poster** session** (30 min.)	
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15:45	**Samantha Price*** (U. of Waterloo) – Carbon exchange after 0-2 years of acrotelm-harvesting method application	19
16:00	**Lucas Voirin*** (U. Laval) – What information can acoustic data provide for peatlands conservation?	20
16:15	**3rd Poster Session** & Happy Hour refreshments (16:15 to 17:30)** **Announcement of best student oral presentations (2) and best student poster (1)**	

**** Posters / *Affiches:***

1. Mélissa Lauder* (U. Laval) – Distribution of root biomass in restored peatlands	21
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5. Elyn Humphreys (Carleton U.) – Evaluating remote sensing and process-based models of surface-atmosphere carbon dioxide exchange in the Hudson Bay Lowlands	25
6. Marissa Davies (U. of Waterloo) – Improving estimates of annual methane emissions from the Canadian Model for Peatlands (CaMP)	26
7. Adam Kirkwood (WCS Canada) – Modelled peat depth and mercury storage in the Hudson Bay Lowlands	27
8. Victoria Goodday (WCS Canada) – Developing a National Vision and Strategy for Peatlands in Canada	28
9. Melanie Bird* (U. of Waterloo) – Determining the potential of peatland restoration in Canada for mitigating greenhouse gas emissions	29
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11. Lujyne "Elle" Amro* (U. of Waterloo) – Urbanization in Ontario: A Historical Perspective and its impact on wetlands	31
12. Rayden Laliberté* (U. of Waterloo) – Spatial and seasonal patterns of dissolved organic carbon in undisturbed and mine impacted peatlands in the Hudson Bay Lowland region	32
13. Fiona Kurylowicz* (U. of Alberta) – Losses of carbon from burned boreal peat plateaus in the first years after wildfire	33
14. Maryam Bayatvarkeshi* (U. of Waterloo) – Influence of seismic lines on boreal ecosystem evapotranspiration	34
15. April Dalton (UQAM) – Mapping Canada's peatland carbon stocks	35

KEYNOTE SPEAKER

MARC-ANDRÉ BOURGAULT is a professor in the Faculty of Forestry, Geography and Geomatics at Université Laval. His research investigates hydrological and biogeochemical interactions in wetlands and their capacity to reduce flood risk and store carbon. His long-term goal is to understand how natural environments are used to both adapt to and mitigate climate change. He is also involved in several agro- and hydro-climatological projects, where he analyzes climate simulation data and develops new indicators to quantify the risk of climate change on different socio-economic sectors. He oversees a research axis in Réseau Inondations InterSectoriel du Québec (RIISQ), an active collaborator in centrEAU, is a research member of the Institute of Development Studies (IDS Institute) and the director of the master's program in climate action. Dr. Bourgault is a new collaborator of the Peatland Ecology Research Group and will contribute to the hydrological understanding of fen rewetting.

Wetland hydrology at the heart of climate action

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Wetlands provide ecological services that are increasingly recognized by society. However, despite this recognition, wetlands continue to be lost in Canada and in many other countries. To ensure the ecological integrity of existing disturbed and undisturbed wetlands, as well as the restoration of disturbed wetlands, it is essential to rigorously apply known hydrological principles. This presentation discusses a set of hydrologic principles that are important to consider in wetland conservation and restoration. The principles are based on results from numerical modeling and analysis of meteorological and hydrological data collected in undisturbed and disturbed wetlands from wetlands located in the northern hemisphere. The presentation includes analyses from several types of wetlands, including raised bogs, blanket peat bogs and riparian wetlands. These principles emphasize the importance of recognizing that wetlands are connected to surface and groundwater. The hydrological functions of wetlands and their storage capacity vary considerably over time. Wetlands are often found in complexes where there is hydrological interdependence between different wetland types. Hydrogeological contexts play a role in controlling the mean annual water table depth of peatlands, and groundwater extraction in wetland recharge zones can affect their hydrology. Taken together, these results are important because they allow us to set hydrological targets to evaluate the success of a restoration project. They also help us to understand the importance of restoring wetland connectivity to surface and groundwater in restoration projects and to consider the hydrogeological environment as a factor affecting wetland restoration. Future work will focus on integrating these principles into restoration projects, as well as projects that seek to better understand the capacity of wetlands to store and accumulate carbon.

Recent and future carbon and greenhouse gas balances of peatlands in boreal western Canada; accounting for wildfire and permafrost thaw

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Western Canada encompasses the third largest boreal peatland region in the world, but the integrity of its carbon (C) storage is threatened by climate warming, an intensifying wildfire regime and accelerating permafrost thaw. Peatlands in the boreal discontinuous permafrost zone are a mosaic of peatland landforms with distinct environmental conditions and vegetation, including permafrost-affected peat plateaus and expanding non-permafrost bogs, fens, and ponds. Furthermore, wildfire has burned approximately a quarter of peatlands in the region over the last 40 years, accelerating thaw and causing multi-decadal post-fire recovery succession for peat plateaus. Fluxes of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and downstream transport of DOC differ for each peat landform, and significant efforts have been made over the last ten years to determine the magnitudes and controls using various approaches – including static chambers, eddy co-variance, and assessment of changes in soil C storage based on peat core analysis. Here we report recent advances in our understanding of how wildfire impacts the net ecosystem exchange in the years after fire, how permafrost thaw affects methane emissions, and how well different approaches agree in their assessment of the net carbon balance in the decades after permafrost thaw. Our analysis suggests that intensifying wildfires have had a major influence on the CO_2 balance, with large emissions both from direct combustion and decadal post-fire succession. Conversely, permafrost thaw and the expansion of thermokarst bogs, fens, and ponds along with direct effects of soil and sediment warming have been the main drivers of increased CH_4 emissions. A key remaining uncertainty is the CO_2 balance of thermokarst bogs and fens, where different methodological approaches have yielded diverging findings. Our analysis shows that the future GHG balance of peatlands in the region will depend strongly on potential shifts in the wildfire regimes and rates of permafrost thaw, and that there are important interactions between fire and thaw.

Winter Carbon Cycling in Canada's Northern Peatlands

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Canada's peatlands hold more than half of the organic carbon stocks stored in all Canadian soils. Over 90% of these peatlands are in the boreal and subarctic regions that are undergoing accelerated climate warming. Climate models project that the rate of warming will continue through the 21st century, with the greatest warming occurring during the non-growing season (NGS). Given that NGS carbon dioxide (CO_2) emissions are mainly driven by microbial respiration, warming, even at sub-zero temperatures, is expected to increase the CO_2 emissions during the NGS. In this presentation, we examine the role of environmental variables in NGS CO_2 emissions at a Canadian peatland research site to infer how these emissions may evolve under climate warming scenarios. We developed a support-vector regression machine-learning model whose results imply that soil moisture, soil temperature, snow cover, and photosynthesis are key predictor variables explaining the variability of net ecosystem CO_2 fluxes during the NGS. The model was applied to a 13-year (1998-2010) continuous record of eddy covariance flux measurements at the Mer Bleue Bog. The CO_2 fluxes were most sensitive to the net radiation above the canopy, wind speed, soil temperature, and soil moisture. Next, we used regional climate projections for the site to forecast future changes in the net ecosystem exchange of CO_2 during the NGS. Under the highest radiative forcing scenario, the NGS Mer Bleue peatland CO_2 emission rates could experience a 103% increase by 2100. Time permitting, we will also discuss results from a laboratory incubation CO_2 experiment with soils from Canadian boreal and temperate peatlands under variable moisture and temperature conditions. The incubation temperature ranged from −10 to +35°C and included freeze–thaw events. The results showed that CO_2 production rates increased more sharply with temperature for the boreal peatland soils than the temperate ones. This indicates that boreal peatlands may increase future NGS CO_2 losses to a larger degree than temperate peatlands. Our results thus further highlight the potential for a strong positive climate feedback loop from accelerated peatland CO_2 emissions. They also point to the need for more realistic representations of northern soil processes in earth system models.

Exploring the potential of remote sensing for estimating non-growing season CO_2 fluxes in Canadian peatlands

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Canada's peatlands hold over half of the organic carbon (C) stock of Canadian soils and are considered a critical C sink. However, during the non-growing season (NGS) these ecosystems typically emit carbon dioxide (CO_2) and how these NGS CO_2 emissions compare to the growing season (GS) CO_2 uptake remains uncertain. In addition, measuring CO_2 fluxes during the NGS is challenging due to harsh winter weather conditions, limiting the availability of eddy covariance data during this period. To combat these challenges, I explored the possibility of using remotely sensed and modeled data to determine these fluxes. In this study, we focused on five peatland sites in Canada. We defined the start of the NGS as the first day of three consecutive days with temperatures below 1 °C, and the end as the first day of three consecutive days above 1 °C. We acquired seven years (2015-2021) of derived C data from NASA's Soil Moisture Active Passive (SMAP) Carbon Net Ecosystem Exchange (NEE) datasets. We compared how the fluxes of the NGS and GS compare to each other and determined annual budgets. Finally, we compared the SMAP dataset to eddy covariance measured NEE for the same period. Our data analyses showed that NGS CO_2 release represented between 25 and 1,120% of the GS CO_2 uptake, but, that the derived C fluxes may be overestimated in northern peatlands. Some of the sites fluctuated between acting as a net CO_2 sink or source during the seven years of observation. We found no significant inter-annual differences in the GS or NGS duration at the five sites. However, there was a slight positive relationship between the total annual CO_2 NEE and the duration of the GS and, conversely, a slight negative relationship for the duration of the NGS. Our findings highlight the importance of considering the NGS when constructing annual budget estimates. Furthermore, while peatlands are likely sinks in the long term their annual sink status may be dynamic.

Invitation to Peatland Policy Framework Workshop

Lorna Harris[1]

[1] Wildlife Conservation Society Canada

Canada is responsible for one-quarter of the world's peatlands and the world's largest peatland carbon stock. Despite this disproportionate global responsibility for peatlands, Canada has no strategy or coordinated action on policy at the national level related to peatlands. Instead, peatlands are subject to a mostly outdated and fragmented assortment of laws and policies. To ensure peatlands across Canada continue to provide an essential carbon service for global climate, and critical habitat for threatened species, effective and cohesive policies for their protection are urgently required. To address these policy gaps, Wildlife Conservation Society (WCS) Canada is leading a three-year collaborative project to produce a national vision and strategy for the protection, restoration, and long-term management of peatlands in Canada. Our goal is to draw on collective experience to identify policy options, tools, and actions for peatlands at different governance levels across Canada.

Long term assessment of the Moss Layer Technique using reference ecosystem: A focus on peatland plant communities

Gwendal Breton[1], Mélina Guêné-Nanchen[1], Line Rochefort[1]

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Since the late '90s, Canadian peatland restoration has primarily focused on bogs previously extracted for horticultural peat. In response to the ecological issues arising from peatland surface losses, a restoration method known as the Moss Layer Transfer Technique (MLTT) has been developed with the explicit aim of facilitating the return of *Sphagnum* mosses. Despite numerous studies demonstrating the efficiency of MLTT in achieving this goal, none has studied the long-term vegetation succession post-restoration leading to a potential similarity with the regional reference ecosystems. Therefore, this study aims to underscore the MLTT's ability to restore a vegetation community similar to reference ecosystems across four Canadian climatic regions over a 20-year post-restoration sequence. Additionally, attention has been directed towards environmental and management practices parameters significantly impacting *Sphagnum* cover in restored peatlands over the same timeframe. Results indicate that the overall plant communities in restored peatlands in Quebec's Northeastern Forest and St. Lawrence Lowlands regions shared similarities with reference ecosystems after approximately 11 to 15 years post-restoration. Conversely, restored peatlands in the Atlantic climatic region did not attain similarity with the reference ecosystem even after 21 years post-restoration but still exhibited a succession tendency towards natural peatlands over time. In the western provinces (MB, SK, AB), 15 years after restoration, restored sites more closely resembled natural fen ecosystems rather than bogs, primarily due to the geologic landforms in which peatlands are developing in that part of Canada, in addition to the physicochemical nature of the residual peat substrate. Furthermore, an analysis of the evolution of *Sphagnum* carpet throughout the post-restoration sequence identified strong regional, landscape, and meteorological effects, in addition to residual peat physiochemistry, hydrology, and restoration management practices. Most of these results corroborate previous studies on factors influencing *Sphagnum* regeneration but on a longer post-restoration timescale. In conclusion, this study provides more accurate information about environmental factors, climatic context, and restoration expertise in which the MLTT can restore *Sphagnum* carpets and influence post-restoration plant succession towards a community similar to natural peatlands.

Improving restoration outcomes of *Sphagnum*-dominated peatlands after peat-extraction: The essential role of phosphorus fertilization

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Fertilization is a common and effective restoration practice for some ecosystems. However, there is still debate about the long-term effectiveness and impact of phosphorus fertilization during the restoration of degraded *Sphagnum* peatlands using the Moss Layer Transfer Technique. Data gathered from 114 peatland sectors that underwent restoration between 1 to 25 years ago, encompassing around 2,900 surveyed plots in Eastern Canada, was employed to investigate the influence of fertilization on plant re-establishment and community composition. This impact was examined in terms of direct effects on both alpha and beta diversity over the years following restoration. Our findings demonstrated that the application of phosphorus fertilization (15 g m^{-2} of phosphate rock pellets) accelerated peatland restoration by favouring a clear shift in plant community composition towards a *Sphagnum* dominance. Phosphorus fertilization increased the *Sphagnum* cover by 40% and total biomass production by 20% in the later stages of restoration (20-25 years post-restoration). Conversely, in the absence of fertilization, the success of restoration and long-term vegetation trajectories was uncertain. Non-fertilized plots evolved towards various vegetation outcomes, leading to communities dominated by *Polytrichum strictum*, *Eriophorum vaginatum* or *Sphagnum* mosses. Phosphorus fertilization led to an increase in plant richness in the first 5 to 10 years after restoration and enhanced spatial heterogeneity in species composition 20 to 25 years post-restoration. This potentially suggests that fertilization has the potential to foster dynamic and more diverse plant communities through a combination of deterministic factors, such as species-level selection driven by environmental changes or plant interaction. This study emphasizes the essential role of phosphorus fertilization in the restoration of *Sphagnum* peatland plant communities and functions, strongly advocating for its inclusion in the restoration process.

Biodiversity of minerotrophic peatland pools: An endeavor towards ecological restoration

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Peatland pools serve as habitats conducive to fostering unique biodiversity, hosting a remarkable variety of animal and plant species that are characteristic of these environments. In a context marked by the loss of peatland ecosystems, the contribution to biodiversity enhancement during the restoration process is of crucial importance. The main objective of the project is to identify the environmental factors favouring the establishment of plant diversity specific to peatland pools. In pursuit of this objective, nine minerotrophic peatlands situated in Quebec and Manitoba have been studied. Within these peatlands, diverse pool types were examined, encompassing natural pools (serving as reference ecosystems), pools intentionally created during restoration, spontaneously formed pools, and drainage ditches treated as created pools. Sampling was undertaken across a total of 42 pools. Subsequently, field measurements of both biotic data (plant species cover) and abiotic data (e.g., water pH, electrical conductivity, pool perimeter, and peat depth) were conducted at sites encompassing both restored and natural peatlands. These data, analyzed through multivariate techniques, illustrated the resemblance among each category of artificial pools compared to their reference ecosystems. Additionally, they emphasized the noteworthy role of spontaneous pools, underscoring their importance as small natural features. Hence, the results indicate that spontaneous pools and lawns at pool margins hold the potential to increase the ecological diversity of restored peatlands and enhance the quality of floral habitat. Furthermore, this project aims to propose guidelines for establishing pools in restored peatlands.

Unveiling the Resilience: Insights from a 13-Year Post Restoration Analysis of a Fen Ecosystem

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The peatland restoration method, the Moss Layer Transfer Technique (MLTT) has been successfully developed and implemented for the restoration of peat-extracted *Sphagnum*-dominated peatlands in North America, but the efficiency of such a management approach for fen restoration, especially regarding recovery of bryophyte carpets is less warranted. A growing number of peatlands representing minerotrophic peat conditions, particularly in the Canadian Prairies, require restoration after peat extraction. The Bic-St-Fabien peatland (Quebec, Canada) was restored in 2009 with three different approaches (rewetting only – REW, rewetting and peat profiling – REW + PRO, and a combination of rewetting, peat profiling plus mechanical reintroduction of plant material – REW + PRO + PLANT). The study aims primarily to compare the pre- and post-restoration (13 years) communities within a BACI design (Before and After Control Impact) with a focus on bryophyte carpets and to evaluate the return of wetland (Marsh-Swamp), peatland, or fen-specific species post-restoration. The line point intercept method was used to measure the plant communities in both pre- and post-vegetation surveys. Peat physiochemistry (pH, electroconductivity, chemistry, and decomposition status), depth of organic matter and water table were described from the whole site. The key outcomes include that restoration has led to an increase in the richness of peatland species mainly in the rewetting action (REW section) along with providing good results in terms of peatland true mosses regeneration. As compared to the REW technique, the REW + PRO restoration is a less promising approach, but it gives the second highest mean richness of peatland species and cover of true mosses and is a very good alternative to the REW + PRO + PLANT method as it gives better results with less investment in terms of cost of restoration. We assumed that the main factors that affected the success of fen restoration were extreme hydrological conditions (drought or flooding), minerotrophy, the dominance of undesired or atypical wetland species, and recolonization issues for some fen plant species. Our modern-day plant surveys helped to fill the knowledge gaps regarding the efficacy of these different fen restoration techniques on the ecosystem level.

Variability in *Sphagnum* structure and function: Implications for bog restoration

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There are measurable differences in *Sphagnum* structure and hydrological function between species, but less work has focused on the variability within species. *Sphagnum* structure and function are typically represented by species means that do not capture the full range of potential values. We collected 937 strands of *S. fuscum* and 628 strands of *S. magellanicum* complex from 15 peatlands to determine what drives variability in fascicle density, a variable that can be used to predict water retention. Using variance partitioning we determined that variability in fascicle density arises from differences between climate regions (11%), sites (15%), plots (21%), and species (25%) with 27% from differences between individuals and unexplained variance. We collected an additional 97 samples (0-5 cm deep) of *S. fuscum* (n=37), *S. rubellum* (n=30), and *S. magellanicum* complex (n=30) from 7 natural peatlands to demonstrate how variable bulk density is within species and to determine how much overlap there is among species. We found 56-87% overlap in the bulk density distributions for these species, demonstrating that we cannot rely on species identity alone to infer *Sphagnum* structure and hydrological function. Lastly, we combined the *S. fuscum*, *S. rubellum*, and *S. magellanicum* complex distributions to represent natural peatland variability in bulk density and compared it to a distribution of 60 samples (0-5 cm deep) we collected from 5 restored peatlands (15+ years old) near Rivière-du-Loup, QC. We found 70% overlap between the restored and natural peatland bulk density distributions suggesting that these peatlands have similar structure and function in the 0-5 cm layer. Contrary to previous work, we found that restored sites have higher bulk density than natural peatlands rather than lower, due to the presence of cutover peat in the 0-5 layer. This work has shown the importance of considering variability within species as well as between species. This variability in natural peatlands can be used as reference for assessing the outcomes of bog restoration from a hydrological perspective. Future work is needed to compare beyond the 0-5 cm layer to definitively assess bog restoration outcomes.

CanRePeat: First year results of a geospatial inventory of historical post-extraction peatlands

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CanRePeat is an ECCC-CSPMA program that aims, in part, to produce a geospatial inventory across Canada of historical post-extraction peatlands that have no intervention or have natural regeneration. Besides documenting these historical post-extraction peatlands, the goal of the inventory is to determine whether they could likely return on their own to peat-accumulating ecosystems, and, if not, what restoration interventions would be needed.

Surveys in 2023 concentrated on eastern Canada. In an initial desktop exercise, companies shared GIS data on peatland sites. Sectors ~1 ha in size were then delineated. A four-person field crew then surveyed a total of 2,118 ha in 28 peatlands across Québec and New Brunswick. The sites were managed by Sun Gro, Premier Tech and Berger, but two long-abandoned sites not controlled by existing peat companies were also surveyed. The field crew surveyed each sector for and peat chemistry, peat depth, drainage, and vegetation, especially *Sphagnum* cover.

These historic post-extraction peatlands with no intervention or with natural regeneration had a median pH of 4.2 with median electrical conductivity of 40 µS cm^{-1} and, as such, are mostly indicative of bog conditions. The median residual peat thickness was 76 cm, but 26% of sectors had less than 50 cm peat deposits. Only 6% of sites had drainage ditches blocked and only 11% had indications of surface water, so most are currently not sufficiently wet for peatland vegetation. Median plant cover was only 35%. *Sphagnum* was absent in 51% of sectors and attained more than 10% cover in only 12% of sectors. Other bryophytes attained more than 10% cover in only 9% of sectors. Conversely, 45% of sectors had more than 10% cover by deciduous trees. As such, conditions in most sites favour a switch to a more upland, forested ecosystem. Problematic invasive species, particularly *Phragmites*, were present in 5% of sectors.
The geospatial inventory will continue in summer 2024 in western Canada. Together these data will help assess natural recolonization and help strategically plan active restoration of historic post-extraction peatlands.

Using machine learning techniques to estimate peat depths over large domains

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Peatlands, characterized by the accumulation of organic matter in waterlogged conditions, play a crucial role in the global carbon cycle and climate regulation. Understanding the depth of peatlands is essential for assessing their carbon storage capacity and potential contributions to climate change mitigation. Traditional methods of measuring peat depth are labor-intensive and time-consuming, or are difficult to apply over large regions, limiting our ability to obtain comprehensive estimates over extensive regions or globally. In this context, the application of machine learning (ML) techniques could be promising for efficient and accurate estimation of peatland depths over large domains.

We integrated ML algorithms with remotely sensed data, geospatial information, and soil/peat core measurements to develop a model for estimating peatland depths worldwide. The key advantage of employing ML in peatland depth estimation lie in its ability to handle complex, non-linear relationships and generalize patterns from diverse datasets. The model can adapt to variations in peatland characteristics across different regions, moreover, the scalability of ML techniques allows for the analysis of vast and remote areas that are challenging to access for traditional field-based surveys. However, a ML-based approach is not without its challenges and potential limitations. Peatlands form over long time periods under conditions that are difficult to capture in a simple manner for the ML framework while peat core samples give an incomplete, and perhaps biased, view of actual peat depths based upon how they were sampled and the complexities of the peatland structure itself. We will discuss our ML framework, with particular emphasis on how we are approaching these challenges, to produce a global map of peat depths along with the relevance of our effort to the goals of Can-Peat.

Simulated net biospheric carbon emissions of managed peatlands, and implications of the inclusion of the fate of peat in emissions scenarios

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Peatland extraction and peat use results in a significant net emission of greenhouses gases over a relatively short time frame. To understand net-zero emissions, it is important to understand how emissions can be mitigated through management practices, and what offsets are required for irreducible emissions and the scopes on which they act. Scope 1 emissions for peat extraction includes mechanical emissions already accounted for by the industry, and the extraction of peat for horticulture. Scope 3 emissions denotes the downstream emissions relating to peat use. Thus, scope 1 management practices impact the change in carbon in the extracted peatland system, whilst the combination of scope 1 and 3 management practices will impact the change in carbon in the biosphere as a whole. Scope 2 emissions refer to emissions related to materials purchased and therefore are not assessed in our simulation. We developed an environmental system model to: (1) ascertain net biospheric carbon emissions according to our environmental systems model and (2) study the impact of management strategy variation in scope 1 and 3 on peat carbon emissions and biospheric carbon store.

We will present how scope 1 management practices, such as extraction duration, extraction intensity and restoration delay impact simulated biospheric carbon. Our simulations also include the fate of extracted peat (scope 3), demonstrating how peat use, storage and stabilised peat carbon impacts net emissions and the biospheric carbon stores. Our current scenario simulations suggest that it takes several thousand years to restore the biospheric carbon store of an extracted peatland, when only scope 1 management is considered. However, assuming on the assumed fate of the peat scenario, the addition of scope 3 management can reduce the biospheric restoration by 50-75% of time taken to recover carbon lost through peat extraction and use.

Water table-soil temperature interaction is important for understanding carbon fluxes from peatlands under active extraction in Canada

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Peat extraction substantially alters a peatland's pore structure and hydrology, which in turn affects the surface-atmosphere exchange of carbon. In preparation for extraction, companies drain a peatland and remove the surface vegetation. Peat is then vacuum harvested for use as a horticultural growing medium. Despite this disturbance covering only a small percentage of Canadian peatlands, the shift from being a net sink to a net source of carbon during the 15-40 plus years of active extraction makes it an important system to study.

We conducted research at two actively extracted peatlands near Drayton Valley, Alberta (Western Site), and Rivière-du-Loup, Quebec (Eastern Site). Daytime ecosystem scale measurements of carbon dioxide (CO_2) and methane (CH_4), using the eddy covariance technique, were measured from March to October in 2020, 2021 and 2022 at the Western Site, and from May to October in 2020 and 2022 at the Eastern Site. We also measured average hourly water table depth (WTD) and soil temperature during a subset of the study period.

Overall, soil temperature was not a strong predictor of CO_2 or CH_4 emissions, in contrast to previous studies. There was a significant WTD-soil temperature interaction, with a moderate positive effect of soil temperature on CO_2 emissions when the water table was within the top 50 cm of the peat profile, and then a weak negative effect under deeper water table conditions. We observed comparable March and April emissions to those in July, suggesting the increased importance of freeze thaw dynamics rather than temperature during early spring. Interestingly, CO_2 emissions were ~0.4 g C m^{-2} d^{-1} higher during the wet (WTD> 0.5 m) 2020 and 2022 May to August periods at the Western Site compared to during the dry (WTD ~ 0.7 m) 2021 period. This finding suggests that in deeply drained peatlands, an increase in WTD can cause insufficient surface moisture conditions for microbial decomposition. This research will aid in updating emission factors for active extraction in Canada and will help guide industry practices on site management.

Machinery, Methane, and Moisture: Unveiling the Dynamics of Carbon Release in Extracted Peatlands

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Natural peatlands can undergo land-use change to actively harvest peat for anthropogenic uses (i.e., horticulture, fuel), shifting the biogeochemistry and carbon function of the ecosystem from a net carbon sink to a carbon source. Our work aims to evaluate the effect of peat extraction management practices on greenhouse gas (GHG) emissions, including investigating differences in field emissions resulting from the manipulation of the uppermost layer of the field by machinery during extraction processes. Fieldwork was conducted at actively extracted peatland sites in Riviere-du-Loup Quebec, from May to November 2022. Using a closed chamber and portable greenhouse gas analyzer (LI-COR), we collected data on CO_2 and CH_4 fluxes from peat fields during the four phases of extraction: harrowed, drying, conditioned, and vacuum harvested. We used temperature and moisture probes to determine both the conditions of the surface peat and the profiles of temperature and moisture below the surface. We also collected surface peat samples for gravimetric water and bulk density analysis and measured the thickness of the surface layer in each phase. Our results indicated that while there was no difference in CO_2 emission rates between extraction phases, methane emissions in the harrowed, conditioned, and vacuum harvested phases were significantly greater than those of the drying phase. We found the surface peat of the drying phase to be thicker, cooler, and less moist than the other phases. The moisture profile of the fields in the drying phase differed from that of the other phases until a depth of 40 cm, while the temperature profile remained uniform throughout the extraction processes. We observed a disturbance effect on methane emissions when categorizing field fluxes based on the time elapsed since the last passing of machinery over the fields, whether it was a harrower, conditioner, or vacuum harvester. Methane emissions appeared to be at their peak and most variable closest to the time of disturbance, dissipating and stabilizing with increased time. Our results will help better account for land-use GHG emissions in Canada and guide the peat industry towards more sustainable practices.

Quantifying greenhouse gas (GHG) emissions from the drainage network of an actively extracted peatland in eastern Quebec Canada

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Carbon cycling within actively extracted peatlands is a significant area of research due to the volumes of carbon that transform and exit the system as CO_2 or CH_4. However, the pathways of carbon which are mobilized from the peat-matrix and transported to the drainage network are not well studied, piquing interest in recent years for its possible contribution to greenhouse gas (GHG) emissions. The aim of our research is to quantify the fluxes of CO_2 and CH_4 from the water's surface in the drainage network of a peatland experiencing active extraction in Eastern Quebec, Canada.

Fluxes of CO_2 and CH_4 were measured using static chamber measurements. Simultaneously, water and air temperature, volume of water, and dissolved organic carbon were measured to determine what variables explained the variation in these gas fluxes.

Preliminary observations indicate that fluxes of CO_2 and CH_4 from ditches appear to be significantly lower compared to gas fluxes emitted from the field surfaces. Coupled with the low total surface area (<10%) of the drainage network suggests that fluxes from the ditches may be insignificant when calculating a carbon budget. However, during this field season, the peatland operators began extracting a new sector of natural peatland and both CO_2 and CH_4 fluxes had an overall average increase, with increased variability.

Our project attempts to estimate the CO_2 and CH_4 ditch emissions by determining the drainage networks wet surface area and duration of wetness using satellite imagery and our empirically derived emission factors. Additionally, the changes in emissions throughout the opening of the new sector will be examined to identify if there is any significant relationship present.

This research will aid in quantifying the GHG contribution to the atmosphere from the drainage network of an extracted peatland. Further contributing to our overall knowledge on carbon cycling within an entire extracted peatland system.

Peatland Management Innovation

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Premier Tech (PT) is the story of one team, and of how we have constantly reinvented our business approach and challenged existing paradigms to deliver on our commitments. It all started in 1923, with PT's long-term vision already empowering us to master our destiny. In 1933, peat harvesting operations began in North America. Our commitment to securing access to raw materials remains core to who we are. In 1968, PT drew from the Cornell University research to develop and launch PRO-MIX®, transforming an entire industry. In the late '70s, way before it became a subject of discussion, PT began using peat extender with bark and compost. In 1983, PT initiated research on natural active ingredients, founding the Premier Research Center and giving rise to the innovation culture as well as the Innovation, Research & Development (IR&D) model, a cornerstone of our success. In 1990, PT began diversifying beyond horticulture, leveraging the knowledge and know-how of its IR&D teams to develop new industrial applications for its primary resource, such as industrial automation and passive biofiltration using organic media. In 1992, the implementation of sustainable peatland management and ecosystems protection initiatives in collaboration with PERG has grown into a key lasting commitment. In 2013, PT kept innovating on peat extender with coconut coir. Over time, PT has built a team of 225 researchers with over 200 patents worldwide. Today, as PT celebrates its 100th anniversary, we seek new ways to make a difference in the life of people, businesses and communities.

As a leader in responsible peatland management, PT relied on its innovation culture to develop an acrotelm-harvesting method (ACM) for vegetated undrained bogs. Since 2017, PT delves into the valorization of sphagnum fiber to contribute to a more sustainable economy, leading PT to file the first in a series of patents on the Method and Devices for Removing the Acrotelm of Peatlands in 2019. The main principles and development steps of this patent will be presented to you.

The impact of the innovative "Acrotelm-Harvesting Method" on the *Sphagnum* regrowth potential

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Peat, composed of partially decomposed *Sphagnum* mosses, is extracted from Canadian peatlands, to be used as a growing substrate in horticulture. Aligned with its commitment to continuously enhance responsible peatland management practices, the horticultural peat producer Premier Tech is currently engaged in the development of the "Acrotelm-Harvesting Method" (ACM) This approach aims to harvest only a part of the subsurface acrotelm layer ~ 8 to 12 cm layer, where the organic matter is less decomposed, and leaving the surface vegetation almost intact. However, the broad-scale implementation of this method remains a challenge that necessitates thorough research efforts to refine the initial conceptualization. This research project aims to assess the impact of this method on the acrotelm regrowth potential, by evaluating *Sphagnum* productivity and decomposition.

This study takes place on a peatland located in the Côte-Nord region (Quebec, 49°8'N, -68°13'W). The regrowth potential of the acrotelm was examined in two sectors harvested 3 and 2 years ago (referred to as Sector A and B, respectively), and compared to an undisturbed sector (control), for the three dominant plant communities: hummock, lawn, and hollow. In each sector, three experimental units were set up per plant community, and decomposition bags and brush wires were monitored over two consecutive growing seasons post-harvesting.

The decomposition rate was similar between the sector A and control of the three plant communities. *Sphagnum* productivity was lower in the lawn community of sector A one year after harvesting compared to the control, but appeared to recover two years after harvesting. Overall *Sphagnum* productivity was higher during the second growing season of monitoring for all the sectors, with positive effect on hummock and lawn communities of the sector B one year post harvesting. *Sphagnum* productivity remained negligible in the hollows of both harvested sectors. Nonetheless, ongoing harvesting processes indicate improvement, notably evident in the sector B, which displayed enhanced productivity post-harvesting, suggesting a less disruptive harvesting process due to machinery improvements. Monitoring will persist over the next two years to assess a longer-term response of the acrotelm and evaluate the sustainability and viability of this harvesting approach.

Carbon exchange after 0-2 years of acrotelm-harvesting method application

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The acrotelm-harvesting method (ACM) is a new approach to peat extraction that is being developed by Premier Tech, with the goal of minimizing disturbance to the ecosystem and carbon cycle of a peatland. This method extracts sphagnum fiber without draining the water table and replaces the original surface vegetation immediately after extraction, essentially performing restoration right away. This method differs from vacuum harvesting in that one area is harvested over one season, then left to recover for few years. Ideally, this area would have regenerated enough after 5 to 20 years to then be able to re-harvest in that area again. This would be an example of a renewable peat resource in natural peatlands.

With the preservation of the original water table and surface vegetation, it is expected that the carbon uptake capabilities of the ACM area should recover much faster than a vacuum harvested area after restoration. In addition, a vacuum harvested site would be active for about 30 years before restoration, locking that area in to 30 years of emissions from peat decomposition in the fields until restoration is applied. On the contrary, the ACM by avoiding drainage and allowing immediate restoration, should lead to no or a much shorter period of peat decomposition emissions from the extraction site.

This talk will discuss the results of chamber-scale carbon flux measurements across two growing seasons and three ACM harvested sites, as well as an unharvested site for a control. The first site, harvested in 2021 has two years of data collection from 2022 and 2023, while the two other sites, harvested in 2022 and 2023 were installed and measured over the growing season in 2023. The unharvested control was also installed in 2022 and has two seasons of data. CO_2 and CH_4 exchange between the soil to the atmosphere was measured across every site. Carbon uptake rates will be compared to the nearby unharvested site to determine the level of recovery to that undisturbed state. These preliminary results show promising rates of CO_2 uptake, especially in the *Sphagnum* lawn communities that dominate parts of this peatland.

What information can acoustic data provide for peatlands conservation?

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Passive acoustic monitoring (PAM) is an increasingly popular method in ecology and conservation. Thanks to the growing availability of hardware, computing power and data storage, acoustic approaches open up new perspectives to study wildlife. Autonomous acoustic recorders are deployed during extended periods of time and over large areas with minimal human intervention. With the use of synchronized recorders arrays it is also possible to investigate fine-scale acoustic behavior within a small area. In addition, recent computing methods involving artificial intelligence allow the treatment of large amounts of data with limited manual operations.

Wildlife monitoring is an important strategy to inform conservation efforts about population trends and habitat use. Understanding such dynamics is particularly valuable in the context of assessing the impact of human activities. Acoustic data can help us gather this information. Passive acoustic monitoring can detect small changes in populations and other dynamics across various spatial and temporal scales.

This presentation will focus on the methodology used in the context of assessing the impacts of an acrotelm-harvesting method (ACM) on wildlife. We will highlight methods such as automatic detection using pre-trained neural networks, acoustic localization using a grid of recorders, and the associated statistical analyses. Furthermore, we will outline the sampling design adopted for the wildlife study and the expected results.

Distribution of root biomass in restored peatlands

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Peatlands are characterized by specific plant communities that play an important ecological role in storing carbon in peat soils. Despite extensive research on the distribution of root biomass in natural peatlands, the subject remains largely unknown in post-extracted peatlands that have undergone restoration using the Moss Layer Transfer Technique (MLTT). It is in this context that this study focuses on evaluating root biomass development in restored ombrotrophic peatlands. The first objective of this study is to evaluate both fine and coarse root biomass by determining their depth distribution in restored peatlands. The second objective is to identify factors influencing root biomass distribution, focusing on abiotic factors (bulk density, degree of humification, nutrient content, and water table level) and biotic factors (aboveground biomass and vegetation community). To achieve these objectives, 24 restored sectors in Quebec and New Brunswick were selected covering three groups of age post-restoration (5, 10 and 20 years). It is hypothesized that physicochemical constraints present in restored peatlands (soil compaction and water table level variation) will limit root biomass development in these environments. This will result in root growth being limited to a maximum depth of 20 cm in residual peat, regardless of post-restoration age. However, for older sites, a higher concentration of root biomass is expected to be observed in the newly formed acrotelm compared to residual peat. Furthermore, root biomass is anticipated to differ depending on the dominant plant community. And so, it is expected that root biomass will be higher in communities where Ericaceae species prevail compared to those dominated by Cyperaceae species. Overall, analyzing the distribution of root biomass in restored peatlands will provide a better estimate of their contribution to the carbon storage post-restoration.

Identification of alternative fertilizers to phosphate rock that promote Polytrichum strictum spore germination

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When restoring peatlands disturbed by peat extraction, it is recommended to apply a phosphate fertilizer to allow germination of *Polytrichum strictum* moss spores contained in the source material. The presence of rhizoids enables the establishment of a P. strictum carpet to minimize frost heave and stabilize the peat surface, thus promoting the subsequent establishment of a sphagnum carpet and ensuring successful restoration. Slow-release granular phosphate rock (0-13-0; NPK), in doses of 15 g/m^2, remains the fertilizer that is mainly used during restoration. However, phosphate rock is a non-renewable, costly resource that is not often available in some Canadian provinces, making some peat companies reluctant to use it as a fertilizer during restoration. Thus, new fertilizer sources need to be investigated to ensure successful peatland restoration in a sustainable peat industry. To this end, a growth chamber experiment will be conducted in Petri dishes. Nine different phosphorus fertilizers will be applied in the form of a liquid fertilizing solution (n = 9) and, for non-soluble products, in powder form (n = 7) to establish which allow equivalent or greater germination of P. strictum spores compared with the usual dose of phosphate rock. The fertilizers with the highest total P content should be those with the highest assimilable P content. As quantities are standardized on the amount of assimilable P, germination rates should be roughly the same between products. Also, the type of preparation should influence phosphorus bioavailability. Germination rates will be higher for solution preparations than for powders. The results will provide comparative data for subsequent larger-scale field studies.

Long-term monitoring of plant phenology in wetlands at very fine spatial scale in Quebec

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For several years, numerous changes to abiotic conditions in Quebec's wetlands, particularly in peatlands and marshes, have already been underway or anticipated due to the increase in global temperature. These modifications lead to direct impacts on the structuring processes of these ecosystems, influencing the biotic components, including plant communities. However, the effect of these changes within plant communities is poorly documented at this scale. To respond to this issue, the Quebec Biodiversity Monitoring Network has implemented several ecological indicators to monitor and detect these changes. The current project is based on one of these indicators, plant phenology in wetlands. The objective of this project is to evaluate the success of long-term monitoring of plant phenology at a very fine spatial scale in humid environments across all regions of Quebec. To achieve this, the study is divided into two parts: the evaluation of the effect of longitude on the peak of greening in wetlands in Quebec and the evaluation of the factors influencing the obtaining of greening data for the period 2016-2022. The preliminary results of the analyzes carried out make it possible to highlight the factors allowing a better success of the in situ study of plant phenology. Control of the device in the middle of the season and adequate programming of the cameras respecting the constraints of the natural environments of the project are elements favoring the capture of greening in humid environments. The results also demonstrate a difference in the peak of greening between the regions north and south of the 49th parallel in Quebec, with a difference of approximately 28 days for greening in Nunavik with the southern regions.

Can-Peat: Canada's peatlands as nature-based solutions to climate change

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Canadian peatlands and their function as carbon (C) sinks are under threat of permafrost thaw, wildfire, and anthropogenic disturbances such as mining, drainage for agriculture and forestry, urban development, and peat extraction. Managing and protecting peatlands from these disturbances may greatly reduce greenhouse gas emissions (GHG) in Canada. However, there are uncertainties in peatland GHG emissions and removal estimates and research gaps in C stock mapping, and disturbance regimes. The Can-Peat project aims to address these uncertainties and gaps to determine the potential of peatland management as a nature-based solution to climate change. The Can-Peat project is a 5-year long project that started in 2022 and is funded in part by the Government of Canada's Environmental Damages Fund. Administered by Environment and Climate Change Canada, the project represents an over $7 million partnership between academics, governments, environmental non-governmental organizations, and private enterprise to advance peatland knowledge in Canada. Can-Peat includes multiple research activities led by internationally recognized Canadian experts in peatland sciences working together to support the building of a sustainable net-zero emissions economy by 2050. The specific goals of Can-Peat are to (1) create a Canadian peatland research network, (2) compile a peatland C database, (3) advance models of peatland C cycling and use these models to evaluate future peatland GHG uptake or emission, (4) investigate mechanisms to implement peatland nature-based solutions in Canada and develop a decision-support framework for peatland management, and (5) communicate findings to partners and provide the tools needed for climate-friendly peatland management and GHG emission reporting.

Evaluating remote sensing and process-based models of surface-atmosphere carbon dioxide exchange in the Hudson Bay Lowlands

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The Hudson Bay Lowlands (HBL) are one of the largest contiguous peatland regions in the world. The HBL stores an estimated 33 Gt of carbon as peat, about 25% of the peatland carbon in Canada. Although the HBL peatlands have been a long-term sink for atmospheric CO_2, climate change and other disturbances have the potential to impact the strength of this carbon sink in the future. In the HBL, eddy covariance towers have been used to monitor peatland net ecosystem CO_2 exchange (NEE). Over the last decade, four of the five tower sites have been net CO_2 sinks on an annual basis while a thawed peatland within a permafrost plateau region is a small net source of CO_2. These datasets offer the potential to develop remote-sensing models that can be used to monitor the broader HBL region and develop process-based models to predict future peatland carbon cycle trends. Machine learning algorithms (random forest regression models) were trained on these and satellite-based optical remote-sensing imagery. These models successfully represented spatial variations in gross primary productivity across peatland types and climatic gradients but were less successful representing interannual variability. With the addition of satellite-based estimates of surface temperature, the random forest regression models could also represent ecosystem respiration spatially. The random forest regression models were less successful representing NEE, which is the difference between these large component fluxes. These random forest models were then applied to three 48 km ? 48 km regions around the field sites to estimate NEE and were compared with recent results from CLASSIC, Environment and Climate Change Canada's process-based ecosystem and land surface model, along with other global products from other machine learning algorithms, atmospheric inversion, and remote sensing-based models for the period 2000-2020.

Improving estimates of annual methane emissions from the Canadian Model for Peatlands (CaMP)

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The Canadian Model for Peatlands (CaMP) Version 2.0 was developed to provide estimates of greenhouse gas emissions and removals from Canadian peatlands for national greenhouse gas reporting. In the current model version, methane emissions are estimated by calculating the deviation from an optimal water table depth that corresponds to a maximum methane emission for each major wetland type. Optimal water table depths and their corresponding maximum methane emissions are currently estimated from literature data from the entire global boreal region and are derived from instantaneous static chamber flux measurements. Although this method provides reasonable estimates for methane emissions at a Canada-wide scale, the drawback of this approach is that water table variation on a daily scale varies significantly more than on an annual scale, and as such optimal water table depths can be outside of the range in mean annual water table positions for a given wetland type. Therefore, this project aims to improve methane emission estimates by compiling seasonal to annual average methane data from sites across Canada and test the relationship of these seasonal methane values to mean water table depth to determine if seasonal values are more appropriate. Further, we also aim to test if other environmental variables, such as temperature and vegetation cover, should be included to calculate methane estimates. To date, 482 sample points have been compiled from both static chamber and eddy covariance methods, distributed across the major peatland areas in Canada. When all samples are combined, the maximum mean methane emissions are comparable to the instantaneous boreal estimates used in the current model, but fen and bog values have significantly more overlap. Continued data collection targeting wetter sites and pools, however, will help to refine optimum water table estimates.

Modelled peat depth and mercury storage in the Hudson Bay Lowlands

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The Hudson Bay Lowland (HBL) is the largest peatland in North America, and has been identified as region with a large store of mercury (Hg), a heavy metal which can be converted into an organic and neurotoxic species of methylmercury (MeHg) in anaerobic environments such as wetlands. However, estimated Hg storage in the HBL is based on a global synthesis of data without any field data from the HBL. Here, we present an estimate of Hg storage based on a modelled peat depth map from the Ontario (ON) portion of the HBL. Peat depth was modelled via random forest modelling from 326 measured peat depths in relation to climatic, hydrologic, and physiographic predictors. Hg storage was measured from 35 cores across the ON HBL, and the mean Hg storage was applied to our predicted peat depth map to estimate Hg storage for the ON HBL. Our mean estimated peat depth was 188 ± 51 cm, which was similar to the mean measured peat depths (196 ± 91 cm). Measured peat depths differed between bogs (225 ± 87 cm) and fens (164 ± 98 cm), but these differences were not as strongly reflected by modelled peat depths (192 ± 50 cm vs. 181 ± 52 cm for bogs and fens, respectively). Mean Hg storage in cores was 8.25 ± 4.43 mg Hg m-2, which was significantly lower than circumpolar estimates for the region, which indicated that the region stored >150 mg Hg m-2. Mean Hg storage was greater in bogs than fens (10.57 ± 4.26 mg Hg m-2 and 8.02 ± 4.71 mg Hg m-2, respectively). Using modelled peat depth and measured Hg storage, we estimated that the ON HBL stores ~2.52 ± 0.60 Gg of Hg. Variation in Hg storage between bogs and fens marginally decreased estimated Hg storage in the ON HBL to 2.44 ± 0.32 Gg of Hg. These results inform the assessment of differences in Hg storage across the HBL to facilitate the selection of priority areas for conservation, monitoring, and further research on Hg cycling in the HBL.

Developing a National Vision and Strategy for Peatlands in Canada

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Protecting peatlands in Canada is critical to meaningful global action on climate change and biodiversity. Global peatlands - a quarter of which are in Canada - store 20-30% of the world's soil carbon. Despite Canada's disproportionate global responsibility to protect and manage these critical landscapes, it has no strategy or coordinated action on policy at the national level related to peatlands. Instead, peatlands are subject to an outdated, fragmented patchwork of laws and policies and they continue to be converted and disturbed at unsustainable rates, resulting in large losses of mostly irrecoverable carbon and carbon sequestration potential (Harris et al. 2022). The Wildlife Conservation Society (WCS) Canada is leading a collaborative effort to produce a shared vision and strategy for the protection, long-term management, and restoration of peatlands in Canada. This three-year project will seek to identify workable solutions to current peatland protection and management challenges and result in policy recommendations for implementation at the federal, provincial, and territorial levels. The project will consist of two main activities: (1) A comprehensive review of existing law and policy in Canada applicable to peatlands; and (2) workshops and discussions with key players in the peatlands space, including representatives from government, Indigenous communities, academia, industry and NGOs. The final outputs, expected in 2025, will be a complete strategic framework for peatland policies, including a shared vision for peatlands in Canada and a strategy for how to get there. WCS Canada invites individuals and groups to participate and provide initial input on project areas of focus, research questions, and the identification of policy challenges and solutions.

Determining the potential of peatland restoration in Canada for mitigating greenhouse gas emissions

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In Canada, peatlands account for 12% of the land area and store an estimated 103-184 Gt of soil carbon (C). As both stores and ongoing accumulators of atmospheric C, they contribute significantly to global C cycling. The UN Environment Program's Global Peatlands Initiative (GPI) has identified them as a key nature-based solution to mitigate climate change and meet Canada's 2030 greenhouse gas (GHG) targets. However, an estimated 2% of Canadian peatlands have been degraded by anthropogenic activities, releasing 42.2 Mt CO_2e per year. Multiple restoration approaches have been trialed across Canada in the last 30 years to restore typical peatland functions to degraded sites. However, there is still uncertainty in the effectiveness and timing of the different approaches to return C sink function.

This project under the Can-Peat initiative is integrating greenhouse gas flux and carbon stock data from experimentally rewetted and restored peatland sites across Canada. Data from 7 sites spanning 1999 to 2016 have been acquired to date. By compiling historical data from published and non-published trials, it will be the most comprehensive meta-analysis of restored peatland GHG response in Canada to date. The compiled dataset will also be deposited into the Can-Peat open access database to improve accessibility for other researchers, modelers, and policy makers.

We invite collaborators with restoration trial data to work with us to contribute chamber, eddy covariance, or peat accumulation measurements to this compilation.

Assessing the effect of water table on CO_2 exchange in a rewetted peatland

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Northern peatland ecosystems are estimated to store about 450 to 650 Gt of carbon. The extraction of these peatlands turns them into sources of CO_2 to the atmosphere. Rewetting of the extracted peatland has been shown to restore the carbon sequestration function of these peatlands. The objectives of the study were to quantify growing season CO_2 exchange in a recently rewetted peatland with remnant fen peat in Elma, Southeastern Manitoba, Canada, and assess the effect of water table on rates of CO_2 exchange in the rewetted peatland. A total of 15 plots were installed along 4 transects with each transect having plots at "dry", "medium", and "wet" areas. Carbon dioxide measurements were made using the closed chamber method, twice per week from June to August 2023. Results revealed variations in CO_2 exchange with depth to the water table. Gross Primary Production (GPP) varied among the locations, with more uptake of C in the medium, and wet plots compared to the dry plots. Ecosystem Respiration (ER) varied across transects, but overall, ER was higher in the dry and medium plots compared to the wet locations. The Net Ecosystem Exchange (NEE) was higher in the dry plots compared to the medium and wet plots, meaning that the dry plots were larger sources of CO_2 compared to wet and medium plots. Overall, most plots were net sources of CO_2 to the atmosphere, likely because vegetation cover remains low so soon after restoration.

Urbanization in Ontario: A Historical Perspective and Its Impact on Wetlands

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This systematic review examines the evolution of urbanization in Ontario, Canada, from 1950 to 2023, detailing its significant impacts on wetland ecosystems. Analyzing 21 studies through a mixed-methods approach, we uncover the interplay between socio-economic drivers, legislative efforts, and the consequential wetland loss. We highlight how early policies facilitating land conversion for agriculture and urban development initiated a trend of wetland degradation. Despite conservation shifts, notably the Greenbelt Act of 2005, urban sprawl remains a persistent threat to wetland preservation, especially in Southern Ontario, where competitive land use pressures are exacerbated by high land values. Key findings indicate that from 2002 to 2011, seven Southern Ontario municipalities (Kitchener, Waterloo, Cambridge, London, Vaughan, Markham and Whitby) experienced a loss of 95.45 ha of wetlands alongside the creation of 111.64 ha of Stormwater Management (SWM) ponds, indicating a trend towards replacing natural ecosystems with engineered solutions. These findings emphasize a shift towards smaller (<2 ha) SWM ponds, which, despite their intended compensatory role, fall short of replicating the biodiversity and ecological functions of the natural wetlands they replace. This trend of urbanization-driven conversion underscores the critical impact of urban development on wetland ecosystems in the region. The review also identifies a research bias towards Southern Ontario, revealing a gap in literature for Northern Ontario and emphasizing the need for broader geographic coverage in future studies. This gap points to the essential need for research into less-explored areas, assessing emerging urbanization trends and their potential wider ecological effects now and in the future. Our analysis illustrates the complex dynamics of urbanization and its governance, showing that while some policy measures have mitigated negative impacts, achieving a balance between urban growth and wetland conservation is challenging. In closing, we advocate for enhanced, evidence-based policies and planning strategies that prioritize ecological preservation alongside socio-economic development.

Spatial and seasonal patterns of dissolved organic carbon in undisturbed and mine impacted peatlands in the Hudson Bay Lowland region

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Peatlands of Canada's Hudson Bay Lowlands, the 2nd largest peatland complex in the world, hold a globally significant store of terrestrial carbon and are important to water storage and regulation in the watershed. Disturbance to these ecosystems (i.e., climate change, resource extraction), which increases the release of waterborne carbon from these systems, will therefore also impact watershed water quality. The De Beers Victor Diamond Mine, located 90 km west of Attawapiskat, ON, provides a case study on dewatering-induced changes to waterborne carbon cycling. To this end, one impacted and one unimpacted bog-fen-tributary transect were monitored over the decade of mine dewatering for meteorological, hydrological, and geochemical analysis. Water table elevation and meteorological variables were logged continuously, and water samples collected intermittently along the peat profile from a well and piezometer monitoring network installed at each transect. Three intensive DOC sampling events representing late spring, mid summer and fall conditions were conducted five years into dewatering. Preliminary results suggest that, in both unimpacted and impacted transects, DOC concentrations consistently decreased along the flow path from bog to fen with a secondary peak where the fens intersected surface water features. With depth, DOC concentrations were generally highest in the zone of water table fluctuation, which generally remained above 10 cm bgs in the unimpacted transect but reached depths >150 cm bgs in the impacted bogs and >100 cm bgs in the impacted fens. Seasonally, peak DOC concentrations increased from late spring to mid summer in both unimpacted and impacted fens and were consistently ~3x larger in the latter (10-20 and 30-60 mg/L, respectively). Concentrations remained elevated in the unimpacted fen into the fall but decreased in the impacted fens, suggesting increased DOC flushing downgradient in the impacted transect with fall water table recovery. Similar patterns were noted in impacted and unimpacted bogs, where increased flushing and water table rise was seen during fall wet-up in the impacted bog. Regardless of the wet-up, peak DOC concentrations were similar between the unimpacted (~60 mg/L) and impacted (~70 mg/L) transects. These trends suggest increased flushing in disturbed peatlands, leading to DOC pulses in downgradient ecosystems.

Losses of carbon from burned boreal peat plateaus in the first years after wildfire

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The long-term carbon (C) storage potential of northern peatlands is threatened by an intensifying wildfire regime. Wildfires cause terrestrial carbon to be emitted during combustion and post-combustion and can more permanently alter regional carbon cycling by contributing to permafrost melt and changing subterranean hydrological connectivity. To characterize the recovery trajectory of carbon sequestration potential following wildfire, between 2019 and 2023, eddy covariance and soil static chambers were used to monitor two permafrost peatlands in boreal western Canada that burned in 2019 and 2007. The 2019 burn site was found to be a net carbon source (~104 g C m-2 yr-1) over the four initial years following wildfire, whereas the 2007 burn site was a sink (~-35g C m-2 yr-1) between twelve and fifteen years after wildfire. Over 20 years, burned permafrost peatlands were estimated to be a net source of +380 g C m-2, and to sequester and store ~2,560 g C m^{-2} less than unburned peatlands: an estimated ~1,700 g C m-2 was directly combusted during wildfire, and in the years following, burned peatlands sequestered ~860 g C m^{-2} less than unburned peatlands. This study demonstrates that when quantifying long-term carbon sequestration rates by boreal peatlands, climate models must account for carbon releases from both wildfire combustion and post-combustion processes.

Influence of seismic lines on boreal ecosystem evapotranspiration

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The hydrological process in peatlands is mostly driven by evapotranspiration which involves the combined water loss through both evaporation from the understory and transpiration from the canopy. Yet, anthropogenic disturbances aggravate the complexity of the hydrology condition of the ecosystem. Accordingly, understanding the interaction between human activities and hydrological process in peatlands is important to maintain this ecosystem to serve as a significant water source in the boreal landscape. This study aims to assess the effect of a seismic line created for petroleum resource exploration on actual evapotranspiration (AET) in the growing season of 2022 from 6 different lines at Kirby site, Conklin, AB. The findings indicated that the AET on the seismic lines is 80 % higher than off the seismic line, and the greatest water loss is associated with the mounded line by 176% which also has the highest soil temperature to other lines by 30 % compared to off the line. It was also observed that the AET on the line is mostly controlled by net radiation; however, off the line is largely driven by groundwater depth. Moreover, the calculated potential evapotranspiration by FAO-Penman–Monteith (FAO) and Priestley-Taylor (Prs-Tylr) methods illustrated a greater PET of Prs-Tylr than of the FAO equation. The α coefficient from the FAO method varies from 0.36 to 0.75 off the line, and from 0.38 to 0.80 on the line. Considering the Prs-Tylr method, the α coefficient variation is from 0.29 to 0.61 off the line, and from 0.32 to 0.66 on the line. Overall, FAO α values on the line are 20% more than off the line. However, the α values of the Prs-Tylr method on the line are 23% higher than off the line. Together these changes likely alter ecosystem functions including water balance and carbon cycling which necessitates upscaling these variables on a watershed scale.

Mapping Canada's peatland carbon stocks

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With this project, we aim to quantify the potential for peatlands to act as a nature-based solution to mitigate climate change in Canada. Peatlands cover more than 12% of Canada's land area and store 150-160 Gt of carbon (C) in their soils, which represents ~25% of the world's peatland carbon. Detailed mapping of carbon stocks in Canadian peatlands will be realized using state-of-the-art methods and tools (e.g. ArcGIS Pro, machine learning, satellite imagery). This work will become a reference for improving conservation strategies and for quantifying carbon losses caused by the destruction or alteration of these ecosystems. Using a range of databases and unpublished sources (e.g. academic literature, government reports, industry studies, and collaborative partnerships), the main objective of this project is to compile available peatland data (e.g. peat depth, peat density) into a national database which will then be used as the basis for a Canada-wide map showing the spatial distribution of peatland C stocks, accompanied by peat accumulation rates where possible. This project will be aligned with another carbon stock mapping initiative that is included in the Plan for a Green Economy 2030 of Quebec (PEV) from the Ministry of the Environment, the Fight against Climate Change, Wildlife and Parks (MELCCFP).