Carbon storage at the coastal wetlands of Long Point Region

Erin Naguit[1], Cecilia Cordero Oviedo[2], Sarah A Finkelstein[2,3]

[1]School of Earth, Environment and Society, McMaster University
[2]Department of Earth Sciences, University of Toronto
[3]Department of Geography, University of Toronto

Introduction

Wetlands hold a significant role in the global carbon cycle, acting both as a carbon sink and a carbon source. However, there are gaps in our knowledge of how wetland soils accumulate carbon in short and long timescales (Loder & Finkelstein, 2020). Wetlands can act as a carbon sink by providing a habitat for highly productive plants such as *Typha* (cattail) and *Phragmites australis* (common reed) which sequester carbon on its upper aerobic layers, while also inhibiting decomposition processes in its anaerobic waterlogged soils, thereby accumulating large amounts of carbon over long timescales (Loder et al., 2023, Mitsch & Gosselink, 2015)

In Southern Ontario, wetlands have been subject to intense anthropogenic pressures. This has resulted in the decline in distribution of wetlands in favour of agricultural land, recreational, and urban spaces (Byun et al., 2018; Snell, 1987). While most of the remaining wetlands present today have been heavily disturbed from tile drainage or peat extraction practices (Byun et al 2018), disturbances such as this can alter a wetlands' ability to be a carbon sink, into becoming a carbon source. This is particularly the case for the coastal marshes found in Long Point region, Southern Ontario.

Fig 1. Photo of Flight Marsh near FMW01 and FMW02.

Objectives

In this study, we focus on understanding the short-term and long-term carbon accumulation within the coastal marshes of Long Point region. We also aim to provide estimates of areal soil carbon stocks within this region.

Study Site

The Long Point region is located northeast of Lake Erie and hosts coastal marshes that are impounded by barrier beaches, act as buffers from river overflow, lake storm surges and eutrophication. Among these wetlands, we visited two coastal marshes: Flight Marsh and Hahn's Woods. Flight Marsh is a 1.27 km^2 cattail-dominated marsh outlined with dredged channels and open ponds, providing habitats for wildlife. To the west of Flight Marsh, Hahn's Woods is a smaller coastal marsh with an area of 0.06 km^2. Unlike Flight Marsh, Hahn's Woods is surrounded by woodier vegetation alongside the cattail stands. Together, both wetlands have and area of 1.33 km^2.

Fig 2. General map of the coastal marshes of Long Point region.

Methods

Field Sampling

Using depth probes, we found consistent 2-meter organic-rich deposits in mineral soil across both marshes. At Flight Marsh, we retrieved two short peat cores, FMW01 and FMW02 (56 cm and 50 cm respectively), and a long peat core, FM01, that spans the entire soil profile to the peat's refusal depth.

Lab work

We sampled FMW01 and FMW02 into 1 cm increments and sampled FM01 into 4 cm increments, while using the Munsell Soil Colour Chart to determine changes in the soil record. Then, we processed 161 soil samples in total for bulk density and loss-on-ignition (organic matter content) measurements.

Data Analysis

We used Excel to derive estimates for the areal carbon stock within each core using bulk-density and loss-on-ignition measurements obtained. Organic carbon was estimated using 50% of soil organic matter within each sample (Mitsch & Gosselink, 2015). ArcMap and Google Earth were used to extend our soil carbon stock estimates throughout the entire wetland. C2 was used to plot the data.

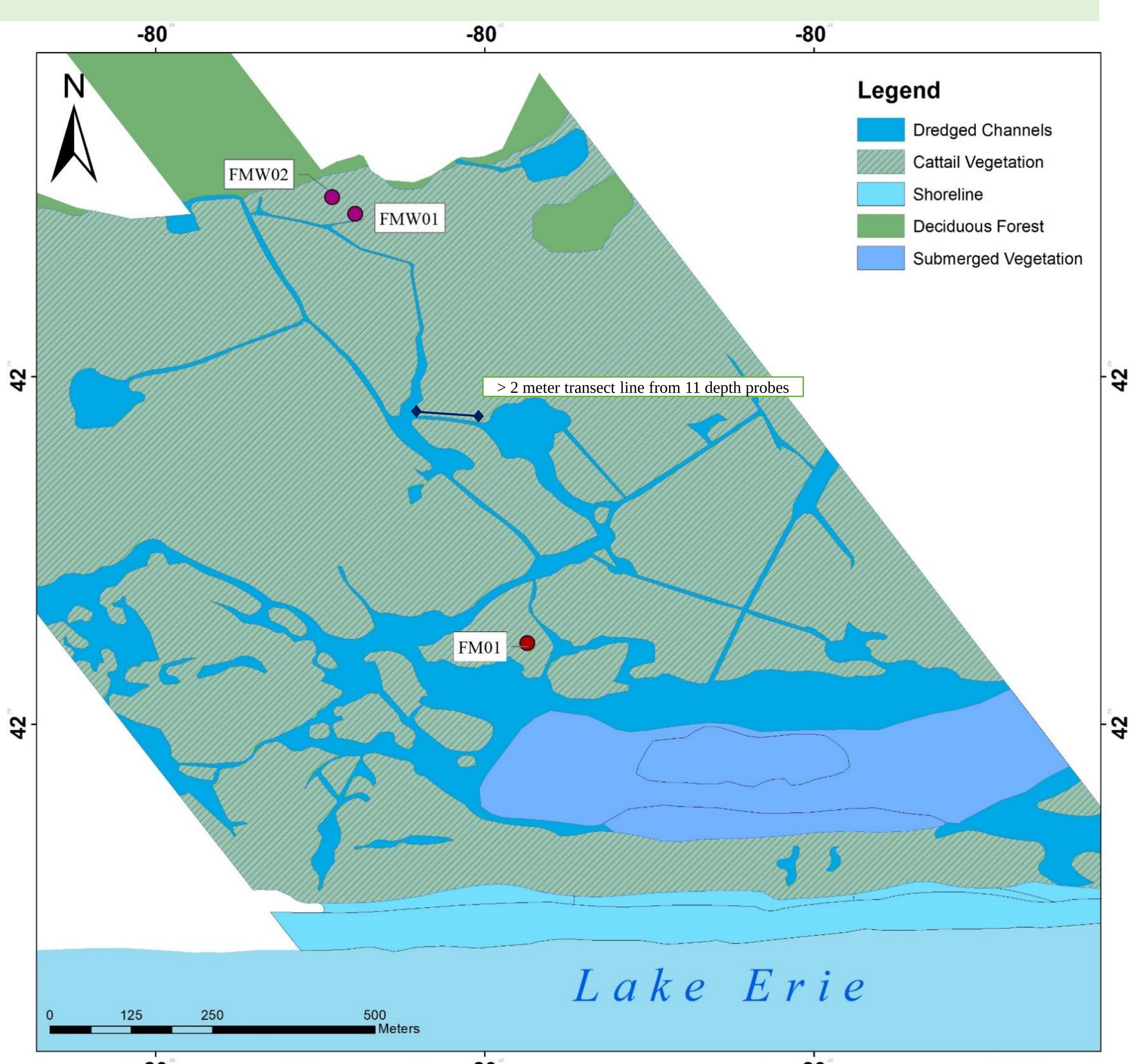

Fig 3. Map of Flight Marsh with sample coordinates. Map source NCC

Results

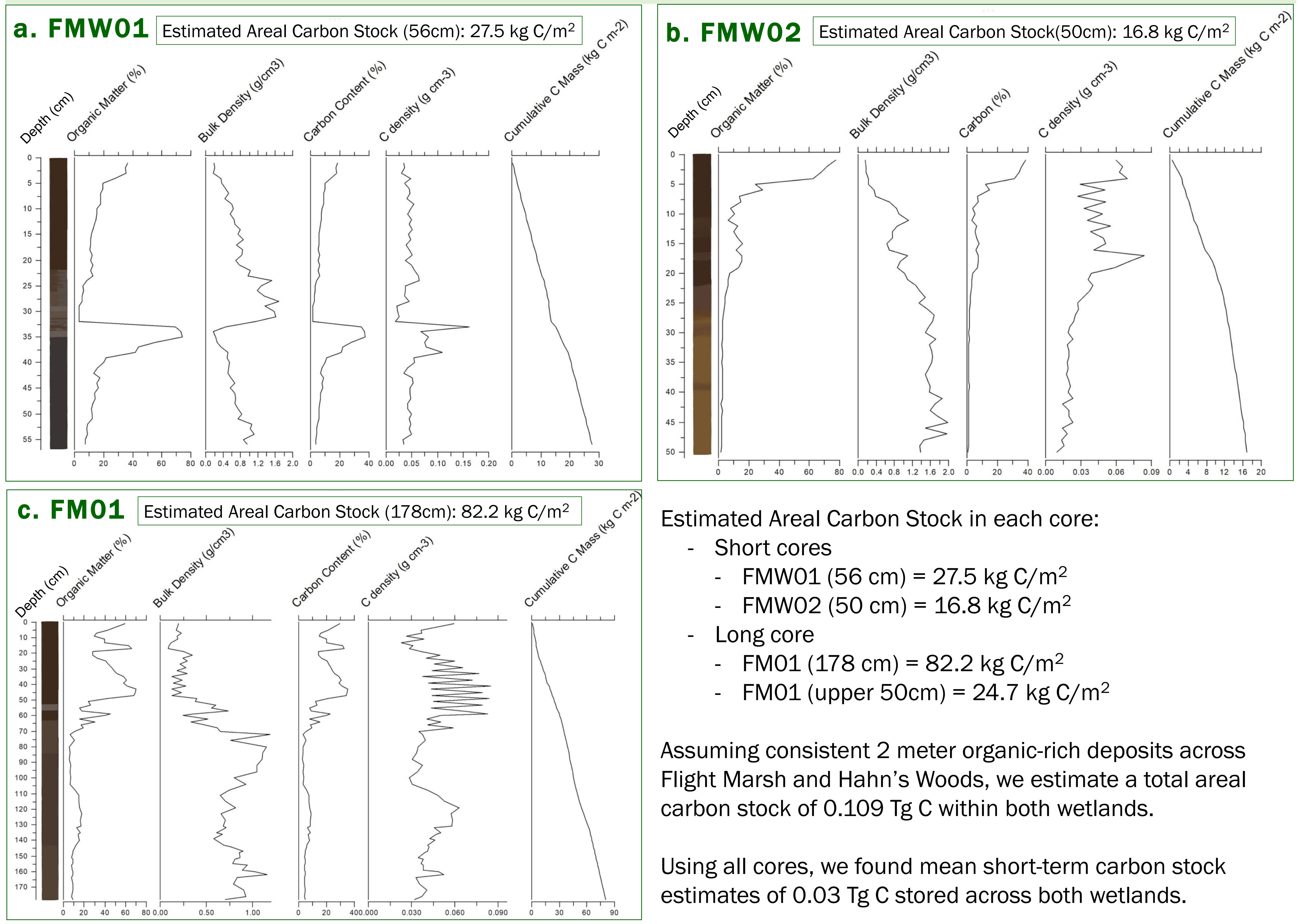

Fig 4. Plots of organic matter content (%), bulk density (g/cm^3), carbon content (%), carbon density (g/cm^3), and cumulative C mass (kg C/m^2) of **a.** FMW01, **b.** FMW02, **c.** FM01.

Estimated Areal Carbon Stock in each core:

- Short cores
  - FMW01 (56 cm) = 27.5 kg C/m^2
  - FMW02 (50 cm) = 16.8 kg C/m^2
- Long core
  - FM01 (178 cm) = 82.2 kg C/m^2
  - FM01 (upper 50cm) = 24.7 kg C/m^2

Assuming consistent 2 meter organic-rich deposits across Flight Marsh and Hahn's Woods, we estimate a total areal carbon stock of 0.109 Tg C within both wetlands.

Using all cores, we found mean short-term carbon stock estimates of 0.03 Tg C stored across both wetlands.

Discussion and Future Research

Our findings show significant short-term and long-term carbon stock values as it correlates with existing literature accounting the wetlands' contribution as a carbon sink. We find our mean short-term estimations of 23 kg C/m^2 at 0-60 cm depth to be consistent with the estimations in inland freshwater wetlands across United States (Nahlik & Fennessy, 2016). Additionally, the mean C content (%) in both short and long term cores was approximately 13%, which is consistent with estimates for freshwater marshes in temperate North America (Loder & Finkelstein, 2020).

The consistency in our results allowed us to extend our C stock estimates across Flight Marsh and Hahn's Woods. Collectively, we found a long-term areal C stock (1.78 m) of 0.11 Tg C and short-term (~50cm) areal C stock of 0.03 Tg C across both sites. Due to the heterogeneity of wetland sediments (Bridgham et al., 2006), we recognize that our long-term estimates are limited to the assumption that the extent of both sites has accumulated >2 meters of peat based on the transects measured in Fig. 3. Regardless, we are certain that the upper 50cm would be persistent throughout the wetland; thus our short-term estimates hold true.

There is also great variability between our short-term C stock estimates, we recognize that this may be due to anthropogenic or natural disturbances which have affected peat accumulation processes. Despite these disturbances, trends in cumulative C mass across all cores in Fig. 4 show the resiliency of wetlands in accumulating carbon over long periods of time. This finding shows that even remnant wetlands in highly disturbed landscapes retain a very significant ecosystem function around carbon storage. Thus, this provides a strong rationale for the continued conservation of wetlands.

Next steps will involve investigating carbon accumulation and sediment accretion rates through radioisotope dating.

Acknowledgements

We thank Liv Monck-Whipp of Nature Conservancy Canada for providing us access to the sites and for her support for this research, Cynthia Brink and Brian Craig of Long Point World Biosphere Region Foundation for their help and support during our fieldwork. I would also like to give my special thanks to Cecilia Cordero Oviedo and Sarah Finkelstein for their supervision and guidance throughout my internship, and the Paleo lab group for their support. This research was funded by Centre for Global Change Summer Undergraduate Intern Program to Erin Naguit.

References

Bridgham, S. D., Megonigal, P. J., Keller, J. K., Bliss, N. B., & Trettin, C. (2006). The carbon balance of North American Wetlands. *The Society of Wetland Scientists*. https://doi.org/10.1672/0277
Byun, E., Finkelstein, S. A., Cowling, S. A., & Badiou, P. (2018). Potential carbon loss associated with post-settlement wetland conversion in southern Ontario, Canada. *Carbon Balance and Management*, *13*(1). https://doi.org/10.1186/s13021-018-0094-4
Loder, A. L., & Finkelstein, S. A. (2020). Carbon Accumulation in Freshwater Marsh Soils: a Synthesis for Temperate North America. *Wetlands*, *40*(5), 1173–1187. https://doi.org/10.1007/s13157-019-01264-6
Loder, A. L., Zamaria, S. A., Arhonditsis, G. B., & Finkelstein, S. A. (2023). Controls on organic carbon stocks among restored wetland soils in the Long Point region of southern Ontario, Canada. *Restoration Ecology*. https://doi.org/10.1111/rec.13925
Mitsch, W. J., & Gosselink J.G. (2015). *Wetlands* (5th ed.). John Wiley and Sons.
Nahlik, A. M., & Fennessy, M. S. (2016). Carbon storage in US wetlands. *Nature Communications*, *7*. https://doi.org/10.1038/ncomms13835
Snell, E. A. (1987). *Wetland distribution and conversion in southern Ontario*. Inland Waters and Lands Directorate. Environment Canada.