How does accounting for spatial variability impact estimates of mercury storage in the Hudson Bay Lowlands (HBL)?

Adam Kirkwood[1,3], Pascale Roy-Léveillée[2], Murray Richardson[3], Maara Packalen[4], Jim McLaughlin[4], Nathan Basiliko[5]

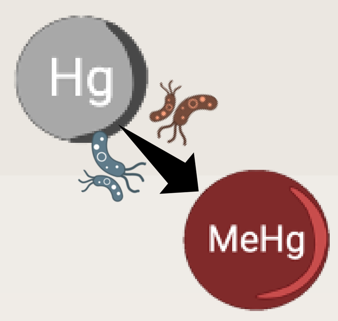
Université LAVAL · Weston Family Foundation

[1]Wildlife Conservation Society (WCS) Canada; [2]CRYO-UL, Université Laval; [3]Carleton University, [4]Ontario Ministry of Natural Resources and Forestry, [5]Lakehead University

Carleton University · WCS Canada

1 Previous estimates show that ~42 million kg of mercury is stored in HBL peatlands

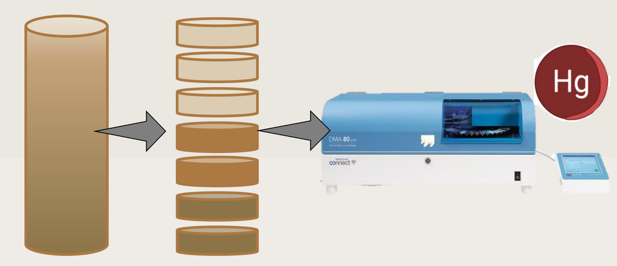
The HBL (372,000 km^2) is covered by nearly continuous wetlands (~90%), much of which occur as bogs and fens. Peatlands in the HBL have been identified as a major store of mercury (Hg), a heavy metal that can be converted to an organic and neurotoxic species of methylmercury (MeHg) by microbes in wetlands.



Estimated Hg storage in the HBL is based on a synthesis of North American and circumpolar Hg data, with no field data from the HBL, and by assuming standard peat depths (e.g. 0-30 cm, 0-100 cm, etc.). These estimates indicate that 81-150 mg Hg m^{-2} is stored in the top 0-300 cm of peat in the HBL.

How does Hg storage vary between peatland classes, and does accounting for vertical variability in peat depths across the HBL impact estimates of Hg storage?

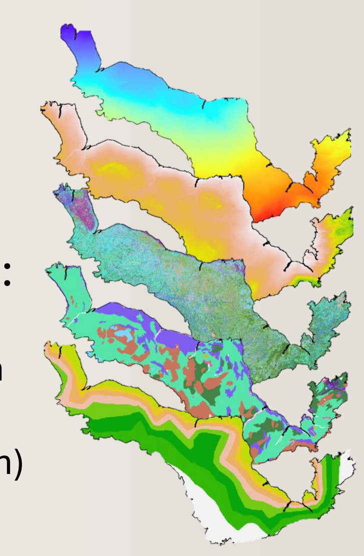
2 We examined spatial variation in Hg storage and used 5 approaches to make regional estimates



We collected/compiled 35 peat cores from the ON HBL and measured >800 subsamples for Hg concentration. We calculated areal Hg storage for each core:

$$\text{THg } storage\ (mg\ m^{-2}) = \left(THg\left(\frac{mg}{kg}\right) \times Bulk\ density\ \frac{kg}{m^3}\right) \times Sample\ depth\ (m)$$

Using a dataset of 326 measured peat depths across the ON HBL (Figure 1A), we predicted peat depth using hydrologic, climatic, and physiographic variables using random forest modelling.



We estimated Hg storage in the ON HBL with 5 approaches:

1. **Blanket value** – Mean areal Hg storage applied to area of ON HBL
2. **Peat depth** – Hg volume (mg Hg m^{-3}) multiplied by peat volume from predicted map
3. **Profile specific** – Approach 2 for specific depth profiles (e.g 0-25 cm)
4. **Landscape units** – Approach 1 applied to area of bogs and fens
5. **Landscape units + profiles** – combination of approach 3 and 4.

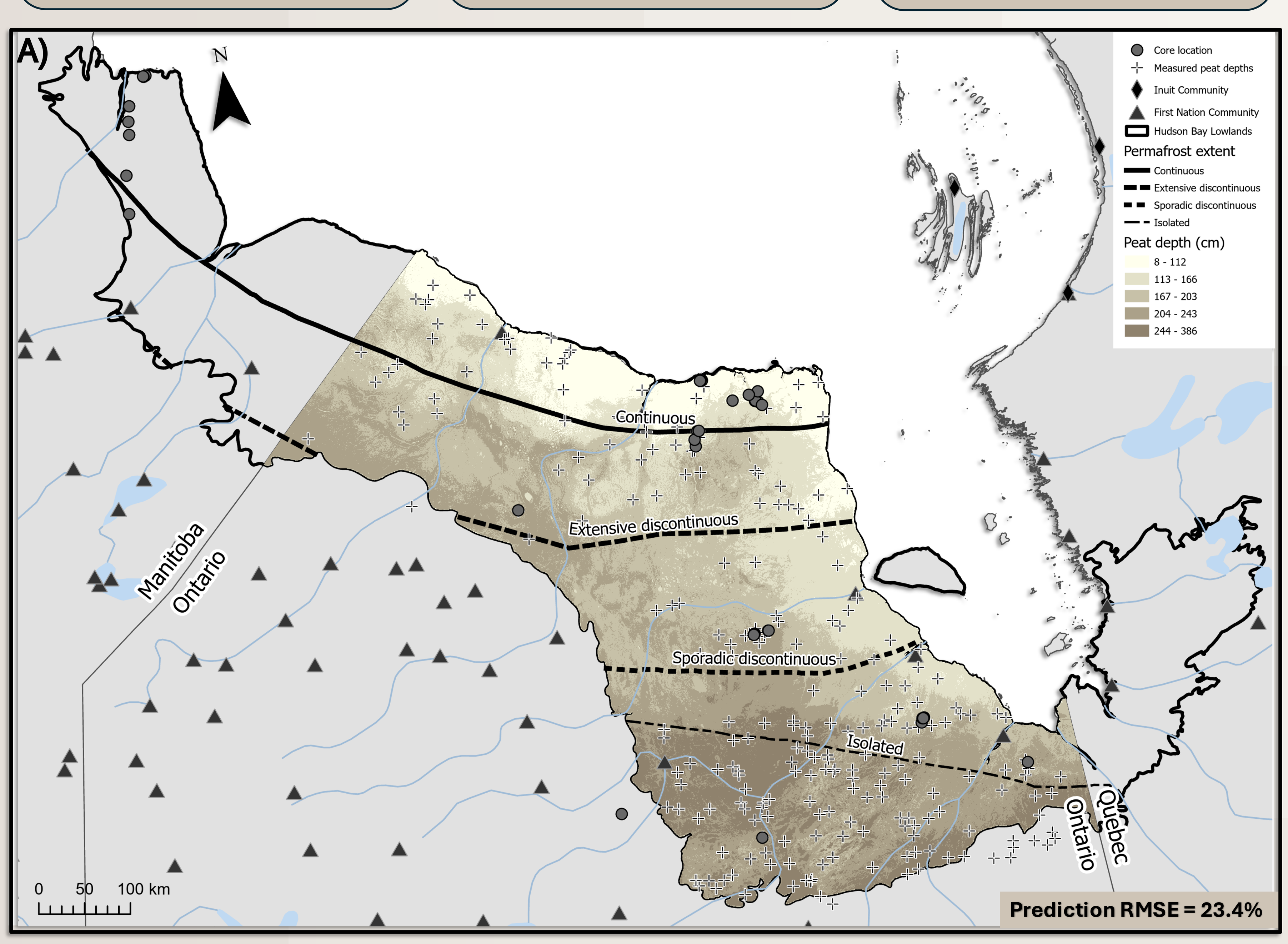
3 The HBL stores between 2.16 to 2.56 Gg of Hg

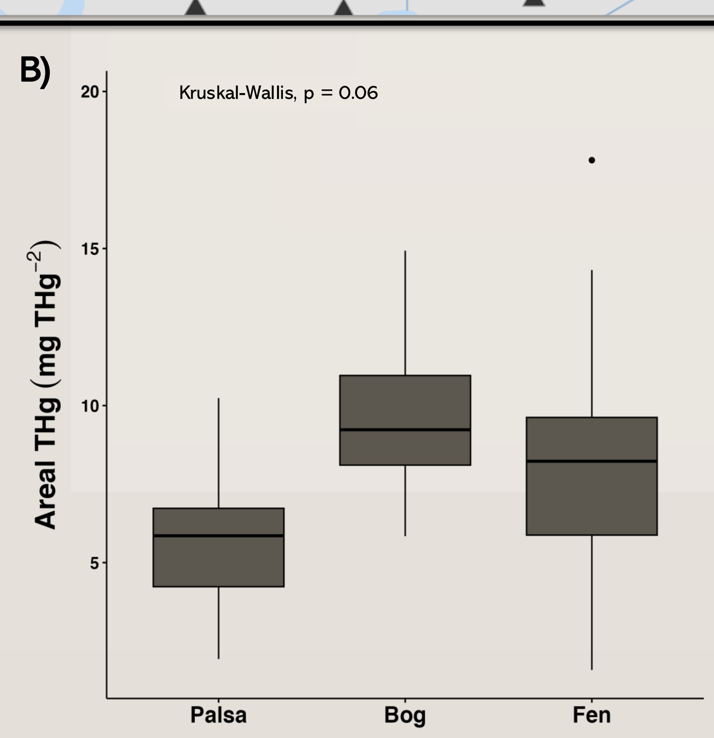
Measured vs. predicted peat depths in the ON HBL:

Mean peat depth – all:
Measured: 196 ± 91 cm
Predicted: 188 ± 51 cm

Mean peat depth – bogs:
Measured: 225 ± 87 cm
Predicted: 192 ± 50 cm

Mean peat depth – fens:
Measured: 164 ± 98 cm
Predicted: 181 ± 52 cm





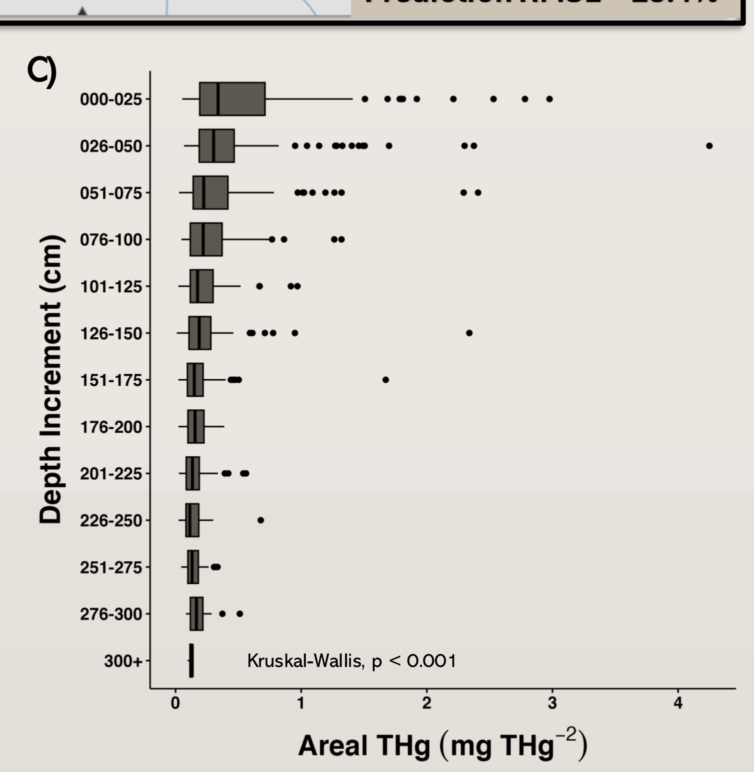


Figure 1: Map of predicted peat depth in the Ontario portion of the HBL (A) which was used to estimate THg storage in the ON HBL. B) shows differences in areal THg storage between palsa cores (n=7), bog cores (n=9), and fen cores (n=13). C) shows the decreasing trend in areal THg storage by depth in all cores from the dataset (n=35).

Accounting for differences in Hg storage between peatland classes and vertical variability in Hg storage increases the estimated size of Hg storage in the ON HBL:

Table 1: Estimated Hg storage from each of the five approaches used in this study.

Method:	Estimate ± uncertainty (Gg)
1) Blanket value	2.16 ± 0.21
2) Peat depth	2.52 ± 0.60
3) Profile specific	2.56 ± 0.63
4) Landscape units	2.44 ± 0.30
5) Landscape units + profiles	2.53 ± 0.67

Both approach 4) and 5) indicate that bogs in the ON HBL have greater storage of Hg.

Approach 4: Landscape units

Bogs: 1.08 ± 0.15 Gg Hg
Fens: 0.74 ± 0.11 Gg Hg
Remaining area: 0.62 ± 0.06 Gg Hg

Mean areal Hg storage of all samples was 8.25 ± 4.43 mg Hg m^{-2}. Mean Hg storage was higher in bogs (10.57 ± 4.26 mg Hg m^{-2}) than in fens (8.02 ± 4.71 mg Hg m^{-2}; Figure 1B). This is more than 10x lower than circumpolar estimates predicted.

More than half of Hg stored in the ON HBL is in the top 0-75 cm of peat deposits.

Approach 5: Landscape units and depth profiles

Bogs: 0.93 ± 0.25 Gg Hg
Fens: 0.87 ± 0.24 Gg Hg
Remaining area: 0.73 ± 0.18 Gg Hg

While bogs generally have larger Hg storage (Figure 1B), it is primarily in upper layers of the peat profile (Figure 1C), while fens have more consistent Hg storage throughout the profile. This is captured in approach 5 that includes vertical variability, where estimated Hg decreases in bogs, and increases in fens.

Profile	Estimate ± Uncertainty (Gg)	Cumulative estimate ± uncertainty
0-25 cm	0.64 ± 0.16	0.64 ± 0.16
26-50 cm	0.46 ± 0.11	1.10 ± 0.27
51-75 cm	0.35 ± 0.09	1.45 ± 0.36
76-100 cm	0.31 ± 0.08	1.76 ± 0.44
101-150 cm	0.43 ± 0.10	2.19 ± 0.54
151-200 cm	0.26 ± 0.06	2.46 ± 0.60
201-300 cm	0.11 ± 0.03	2.56 ± 0.63
300 + cm	<0.01	2.56 ± 0.63

Table 2: Estimated Hg storage in peat profiles of the HBL. Values in table were generated by approach 2.

4 Connecting Hg cycling across land and water

The next steps of this research are to understand how terrestrial storage of Hg relates to mobilization of Hg to aquatic ecosystems. Future work will:

- Work with community partners in Weenusk First Nation to quantify landscape change in their territory
- Determine if increased export of Hg from terrestrial systems relates to increased Hg in aquatic organisms
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Contact:
Adam Kirkwood, PhD, akirkwood@wcs.org
Research Associate in Peatland Biogeochemistry; WCS Canada

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