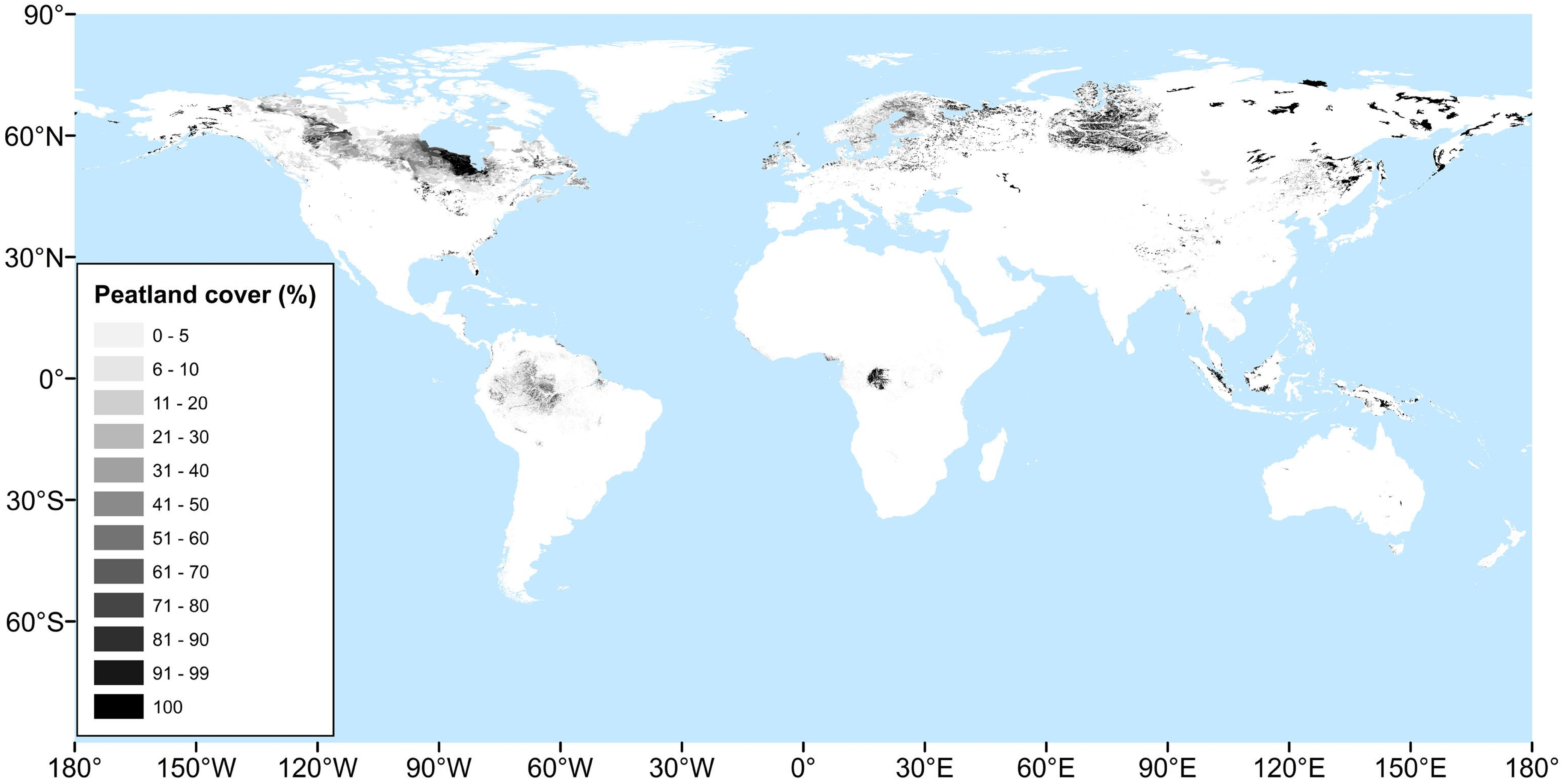
Tropical peat: a highly vulnerable global mercury sink

Credit: T. Smith, eos.org

N.R. Razavi, L.J. Lamit, E. A. Lilleskov, J. Tennant, A. Webster, N. Basiliko, A. Cobb, J. del Aguila Pasquel, J. Farmer, C. Harvey, A. Hoyt, J. Jauhiainen, M. Kononen, P.Q. Thu, J. Rutherford, G. Spiers, M. Warren, S. Watmough, G. Zahn, M. Tate, S.E. Janssen, and **C.T. Driscoll**


Credit: Flickr, CIFOR

Tropics contain ~30% of global peat reserves



Xu et al. 2018

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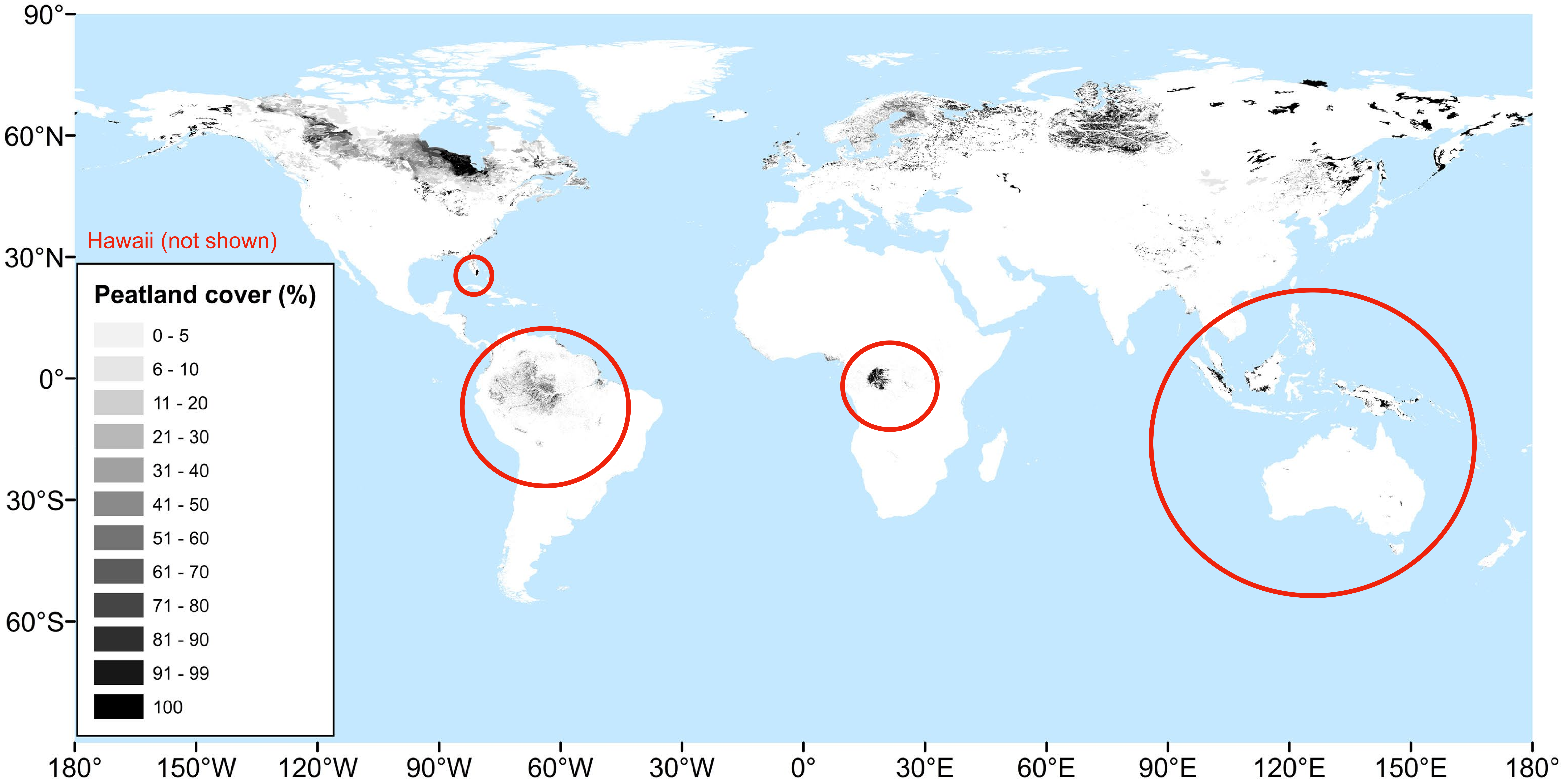


Xu et al. 2018


Critical for carbon storage globally.
What about Hg?
Credit: Flickr, CIFOR

Credit: Scott Maguffin

Credit: Arrowhead Films

Credit: Nature Conservancy

Study objectives

1. Measure tropical peat [Hg] and assess predictors, including peat characteristics, as well as geographic and land use variation

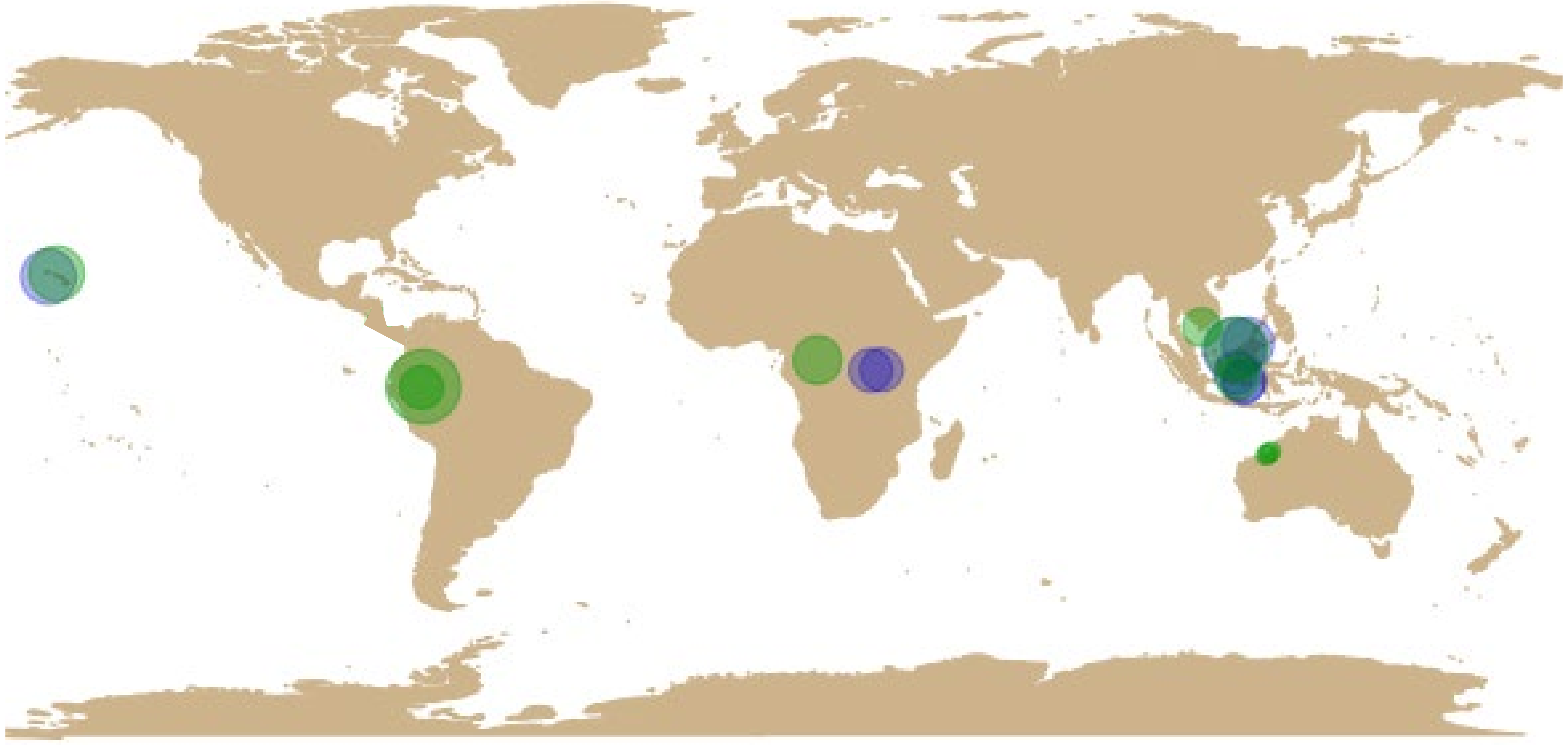
    - use Hg stable isotopes to inform Hg sources and biogeochemical controls

2. Quantify if Hg serves as a indicator of other toxic trace metal presence (i.e., Cd, As, Pb) presence in tropical peat forests.

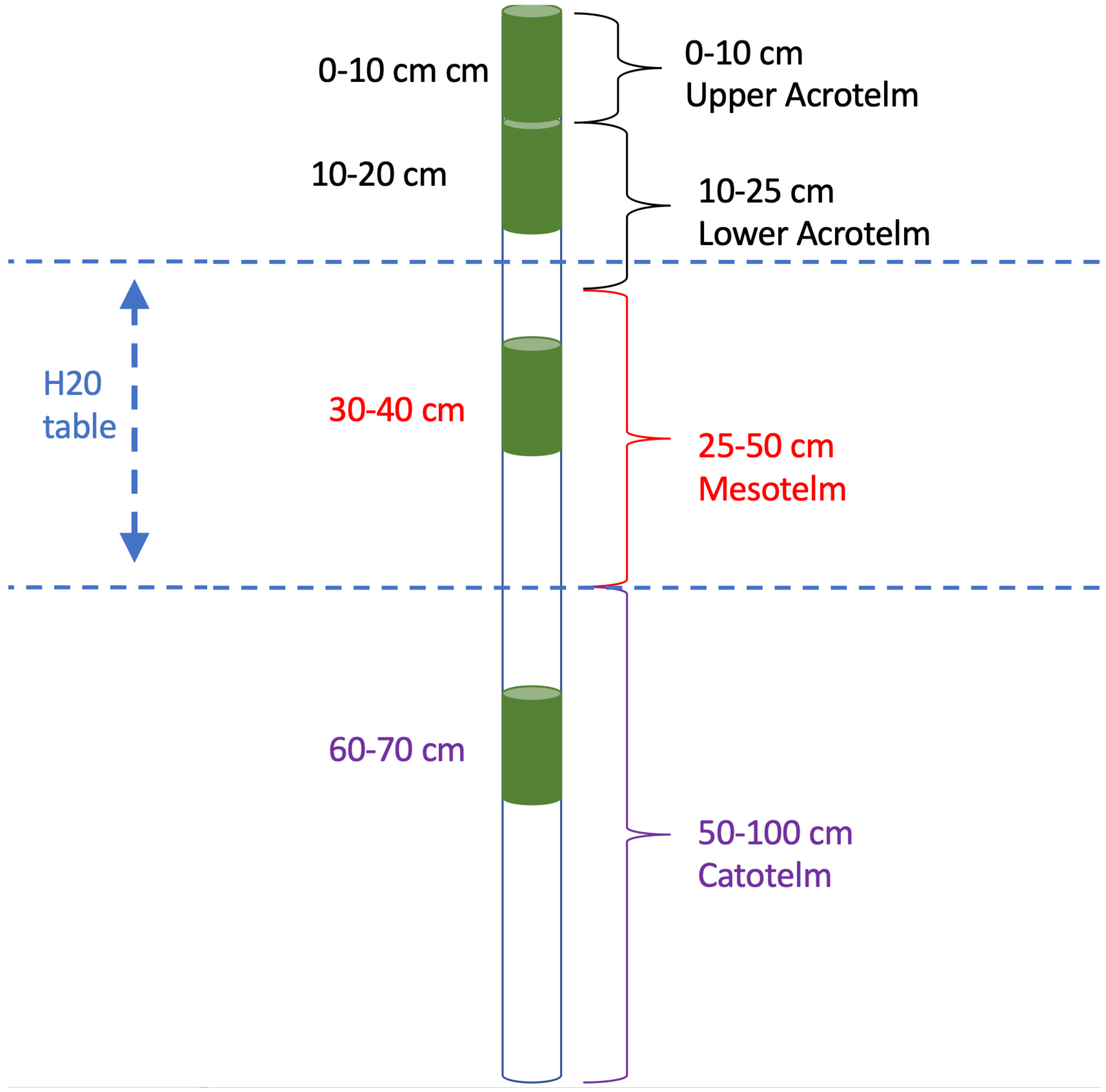
3. Generate estimates of Hg stocks in tropical peat.

Dataset description

- Peat archive from the Global Peatland Microbiome Project
- 8 countries, 5 continents
- 0 - 70 cms, 10 cm increments
- Total Hg analyses (AAS, Tri-cell DMA-80, @SUNY ESF)
  17 sites total, 281 samples
- Hg stable isotope analyses (MC-ICPMS @USGS Mercury Research Laboratory)
  subset of 52 samples
- Additional data: C, N, S, trace elements, pH, organic matter chemistry

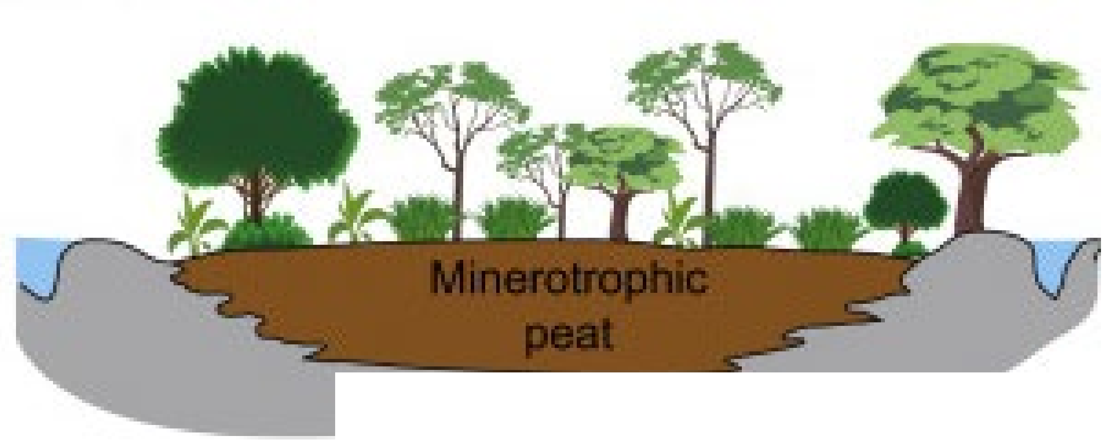


Depth of sampling



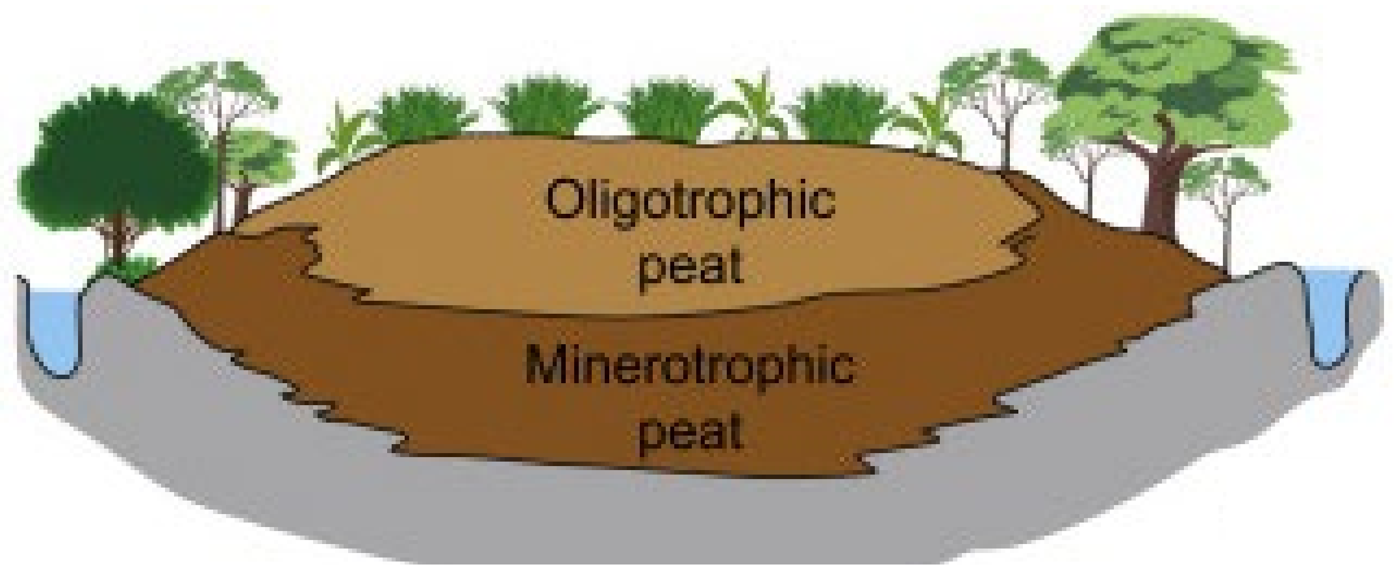
Peatland types: trophy status

Minerotrophic



- receive groundwater and/or surface water runoff
- slightly acidic to neutral pH
- This dataset range: 3.43 to 6.80
  Mean: 5.12 ± 1.2
  n = 26

Ombrotrophic



- depend entirely on atmosphere for water and nutrients
- acidic
- This dataset range: 3.25 to 4.81
  Mean: 3.79 ± 0.1
  n = 31

Peatland types: degree of disturbance

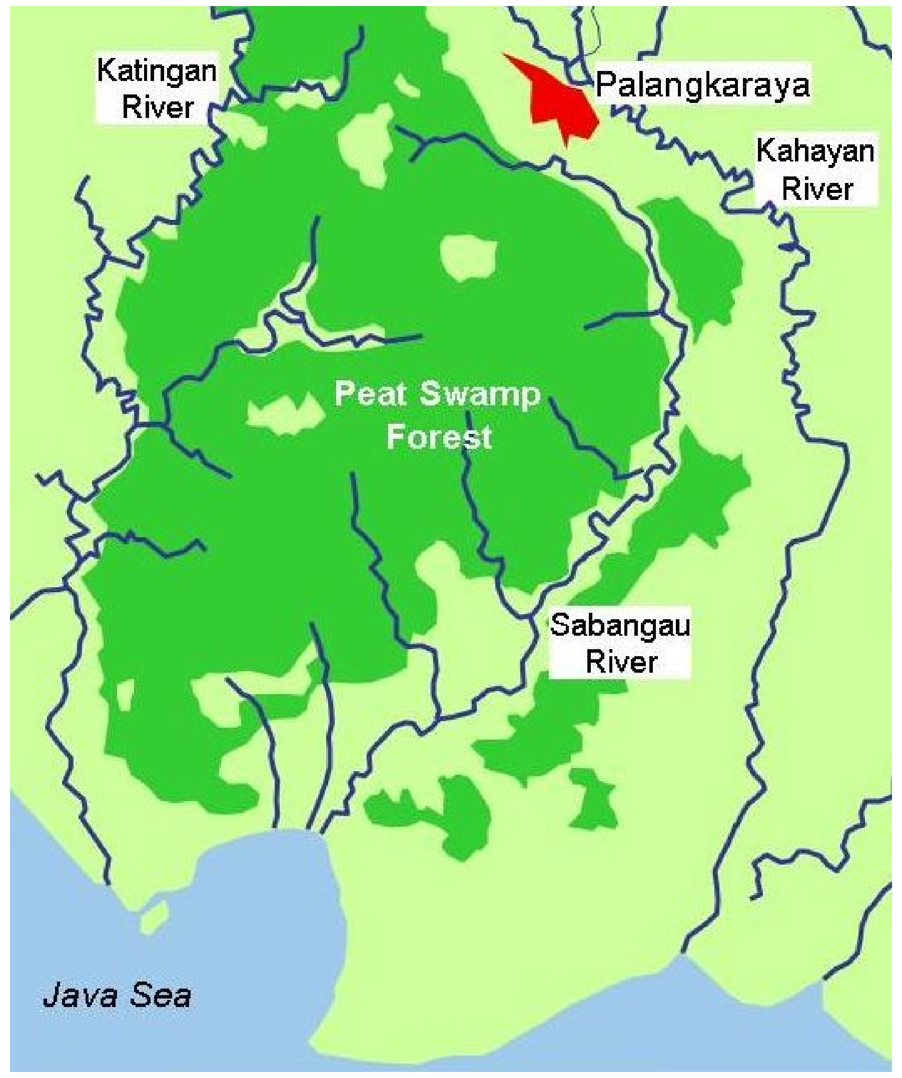
Disturbed

Agriculture

Fire

Artisanal and
small-scale
gold mining (ASGM)

Undisturbed



Australia
MIN
Borneo
OM
OM
OM
BRUNEI
INDONESIA
OM
OM
OM
OM
Vietnam
MIN
Legend
MIN = minerotrophic
OM = ombrotrophic
= disturbed
= undisturbed
Uganda
MIN
MIN
Congo, Republic of
MIN
Peru
OM
MIN
Hawaii (USA)
OM
Maps made with Datawrapper

Study objectives

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   - use Hg stable isotopes to inform Hg sources and biogeochemical controls

2. Quantify if Hg serves as a indicator of other toxic trace metal presence (i.e., Cd, As, Pb) presence in tropical peat forests.

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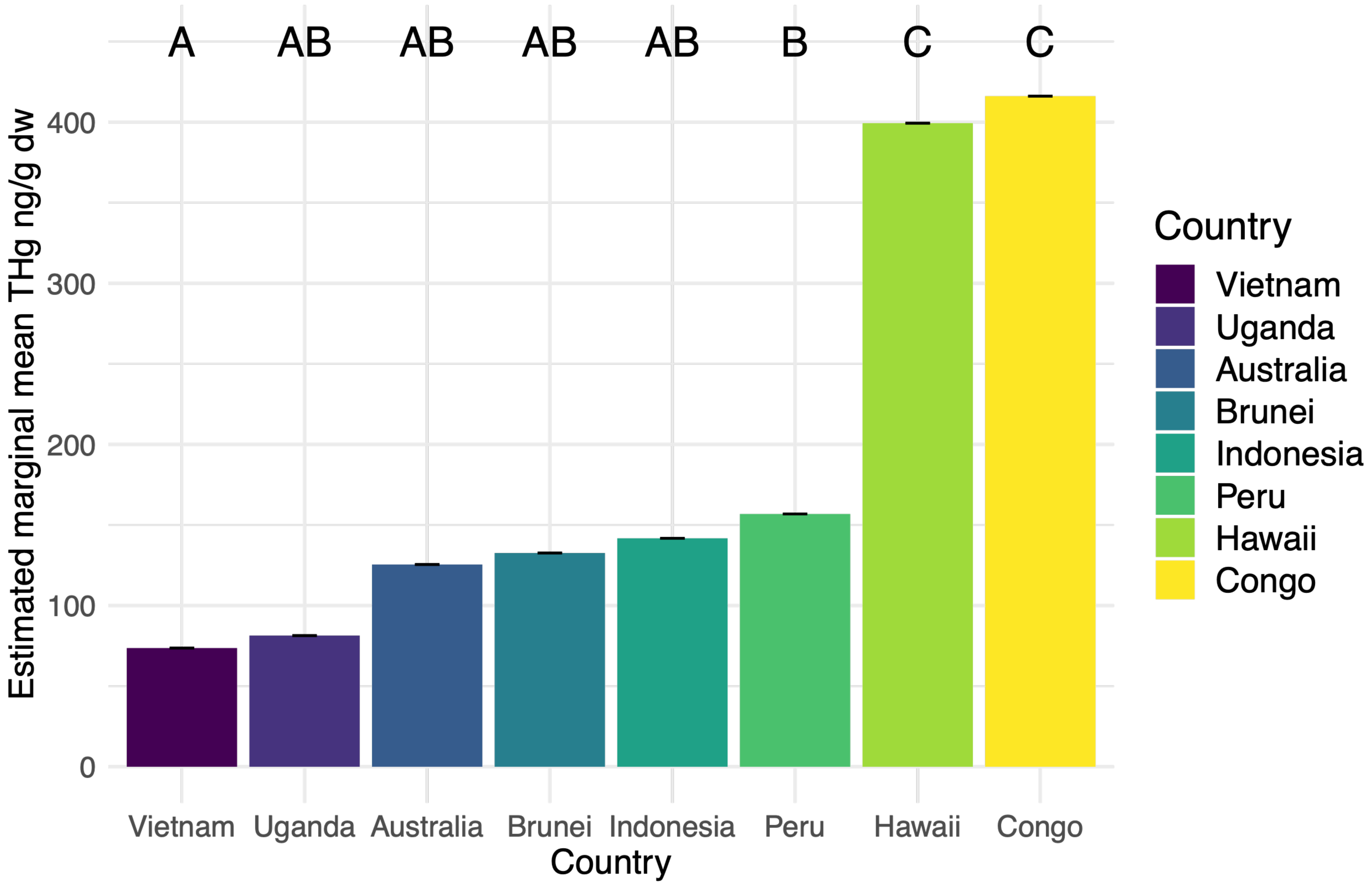
Peatland Hg varies by country

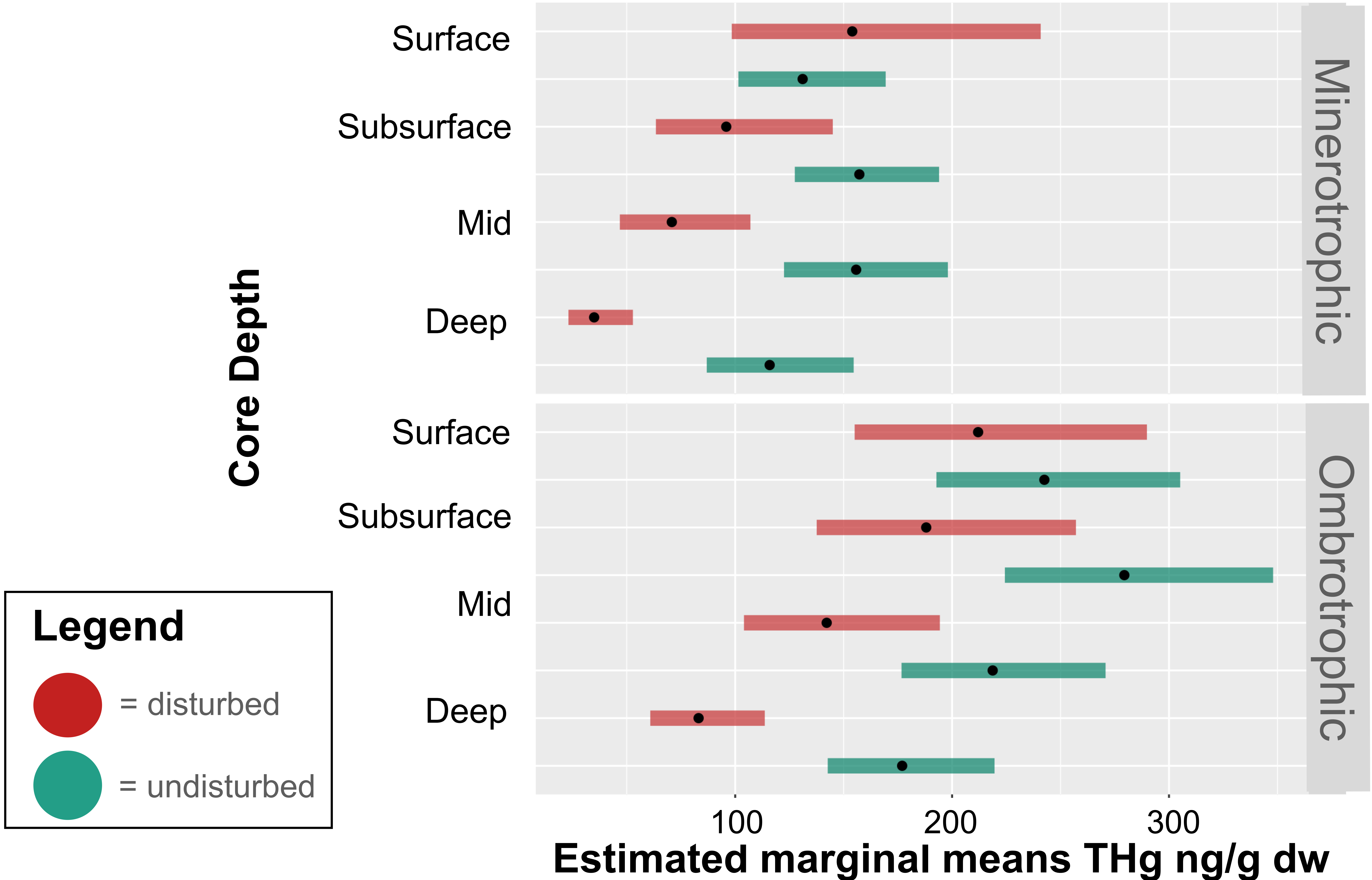
$\log_{10}(THg) \sim$ Country + Trophy * Disturbance * Depth + (1 | Core:Site:Peatland)

- Hawaii - volcanic influence
- Congo - possible ASGM influence

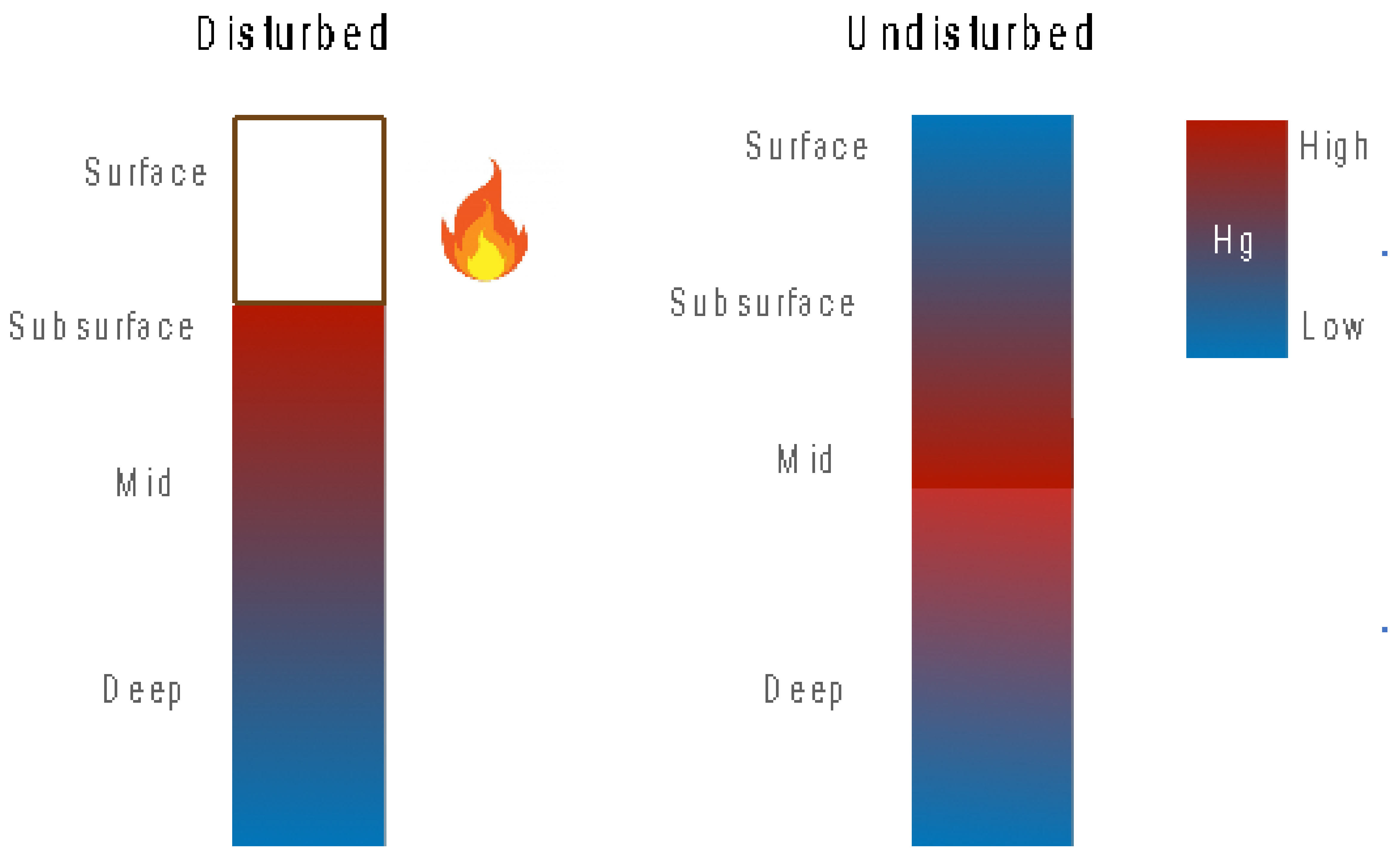


Peatland Hg varies by depth*disturbance

$\log_{10}$(THg) ~ Country + Trophy * Disturbance * Depth + (1 | Core:Site:Peatland)

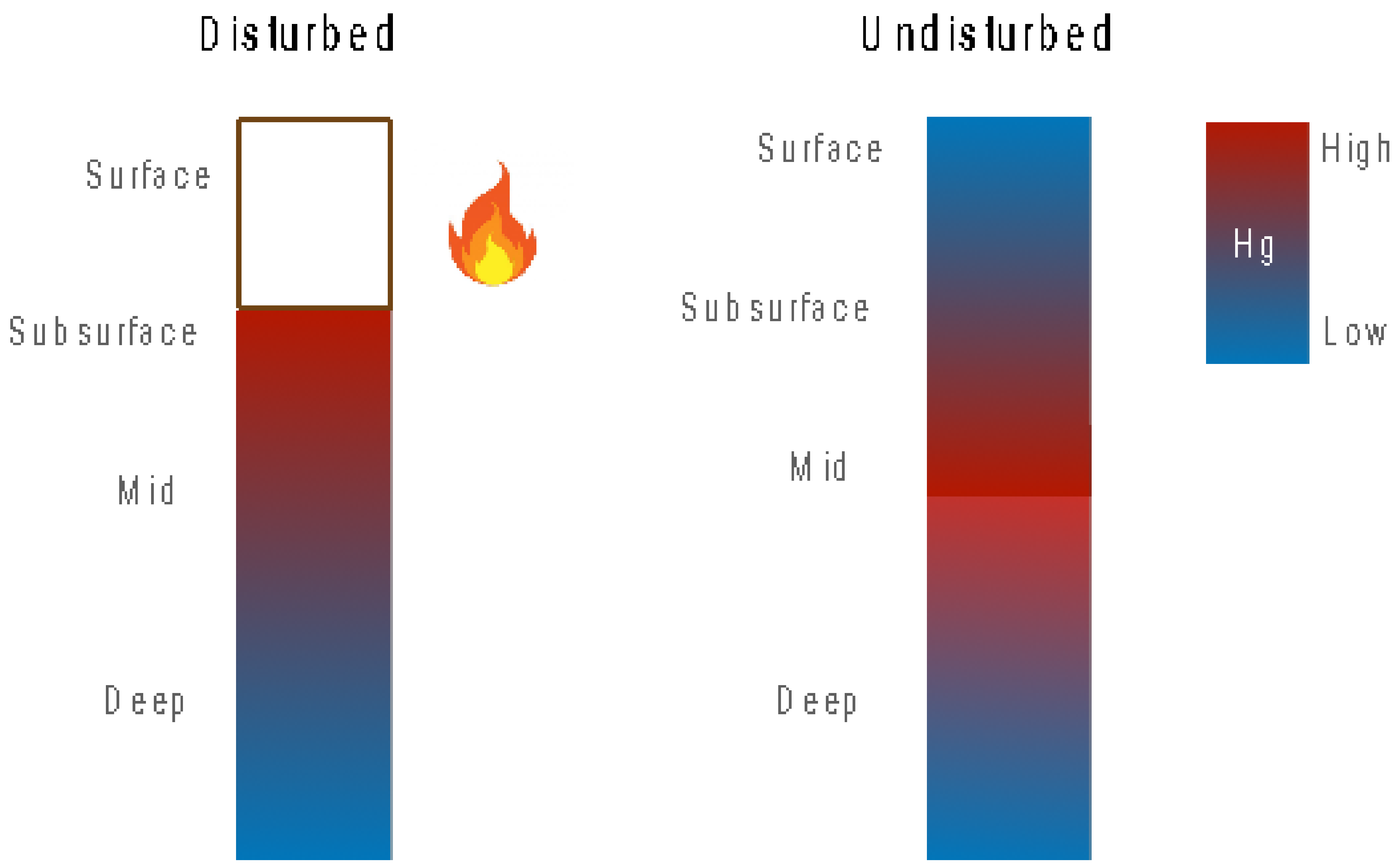


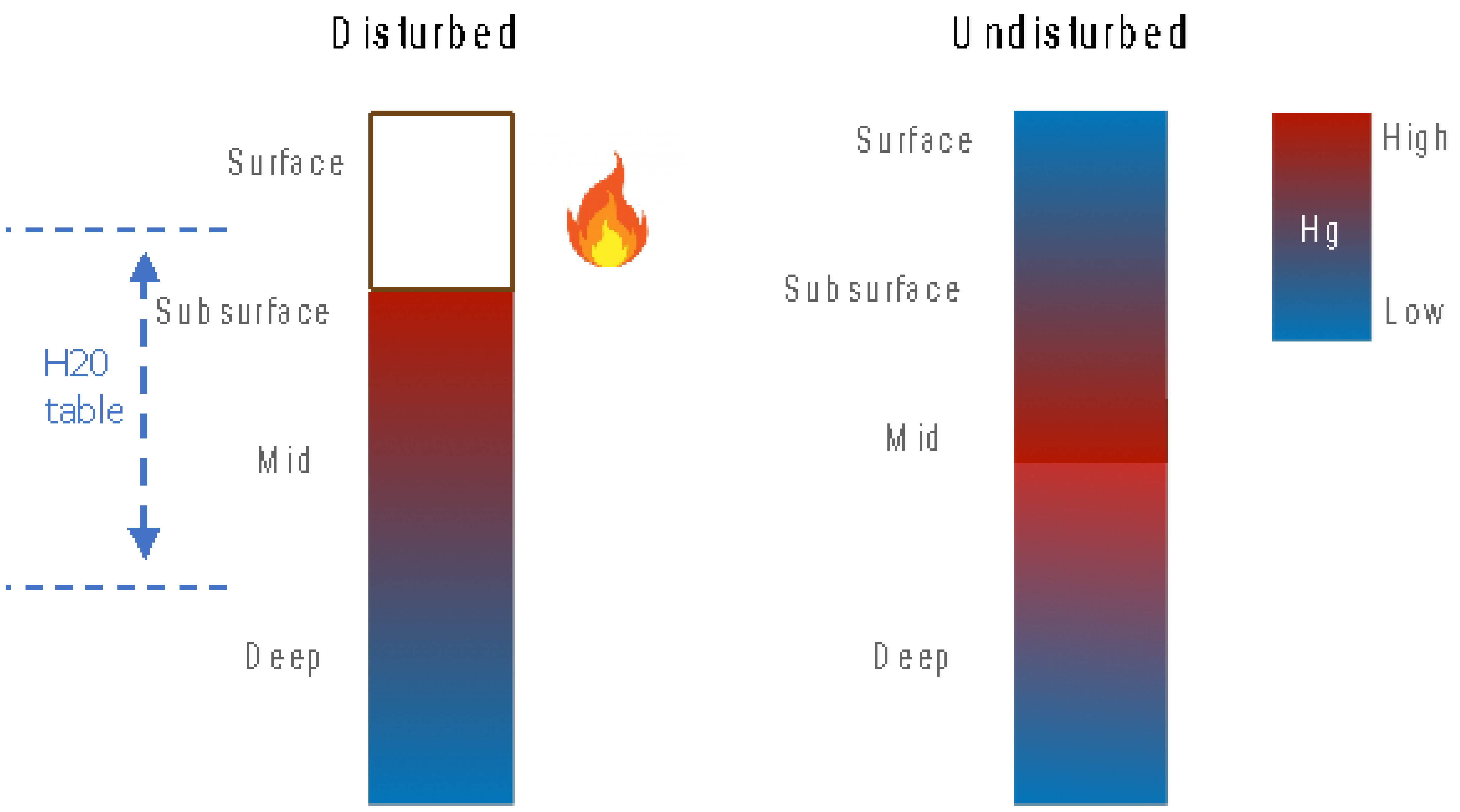
Lower Hg in disturbed peatlands with depth - mechanisms?



Hypothesis 1:
loss of organic matter causes loss of Hg via leaching or volatilization

Lower Hg in disturbed peatlands with depth - mechanisms?





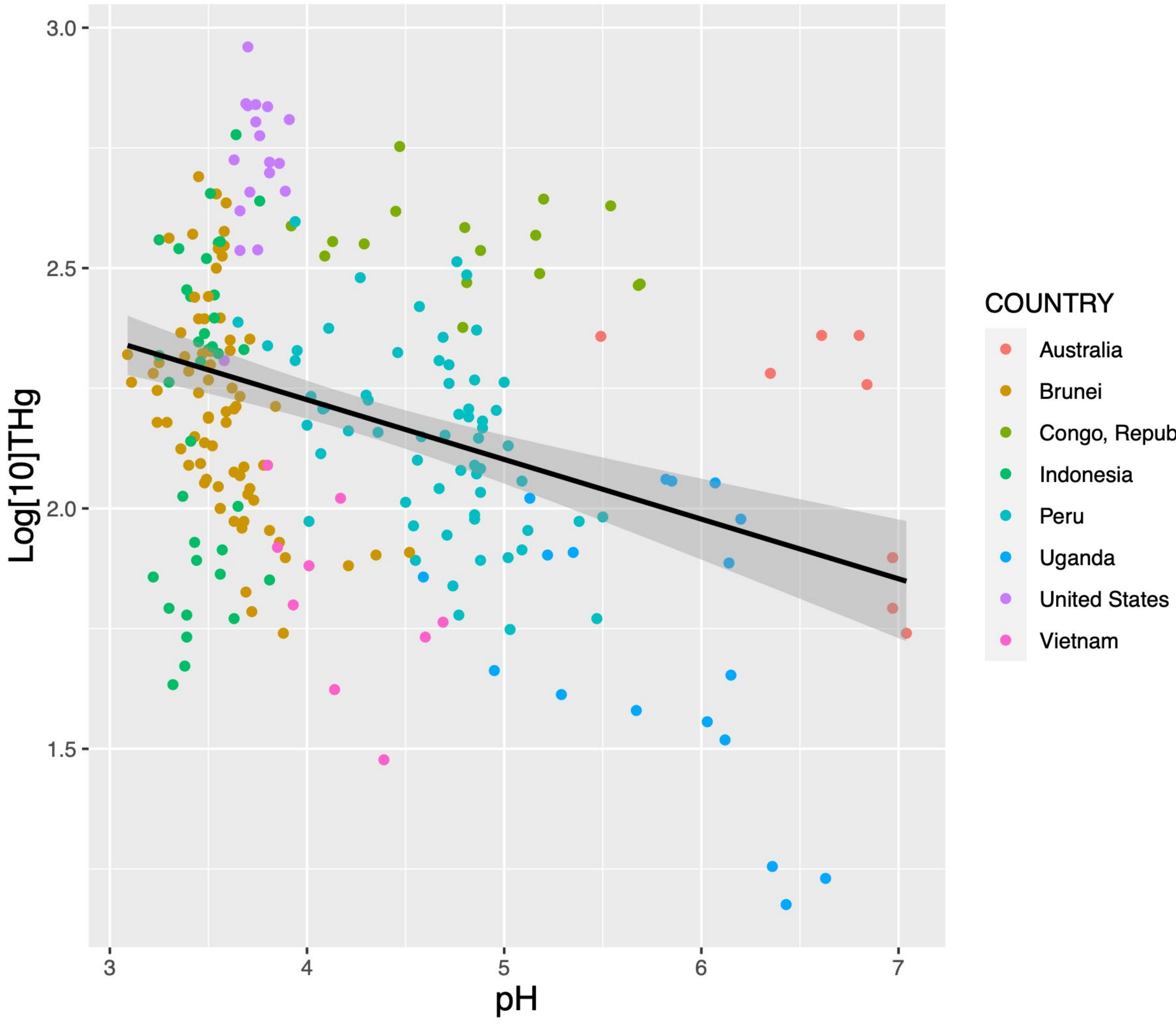
<u>Hypothesis 1:</u>
loss of organic matter causes loss of Hg via leaching or volatilization

<u>Hypothesis 2:</u>
lower water table can increase Hg methylation and mobility (Haynes et al. 2017)

Assess predictors of peat total Hg concentrations

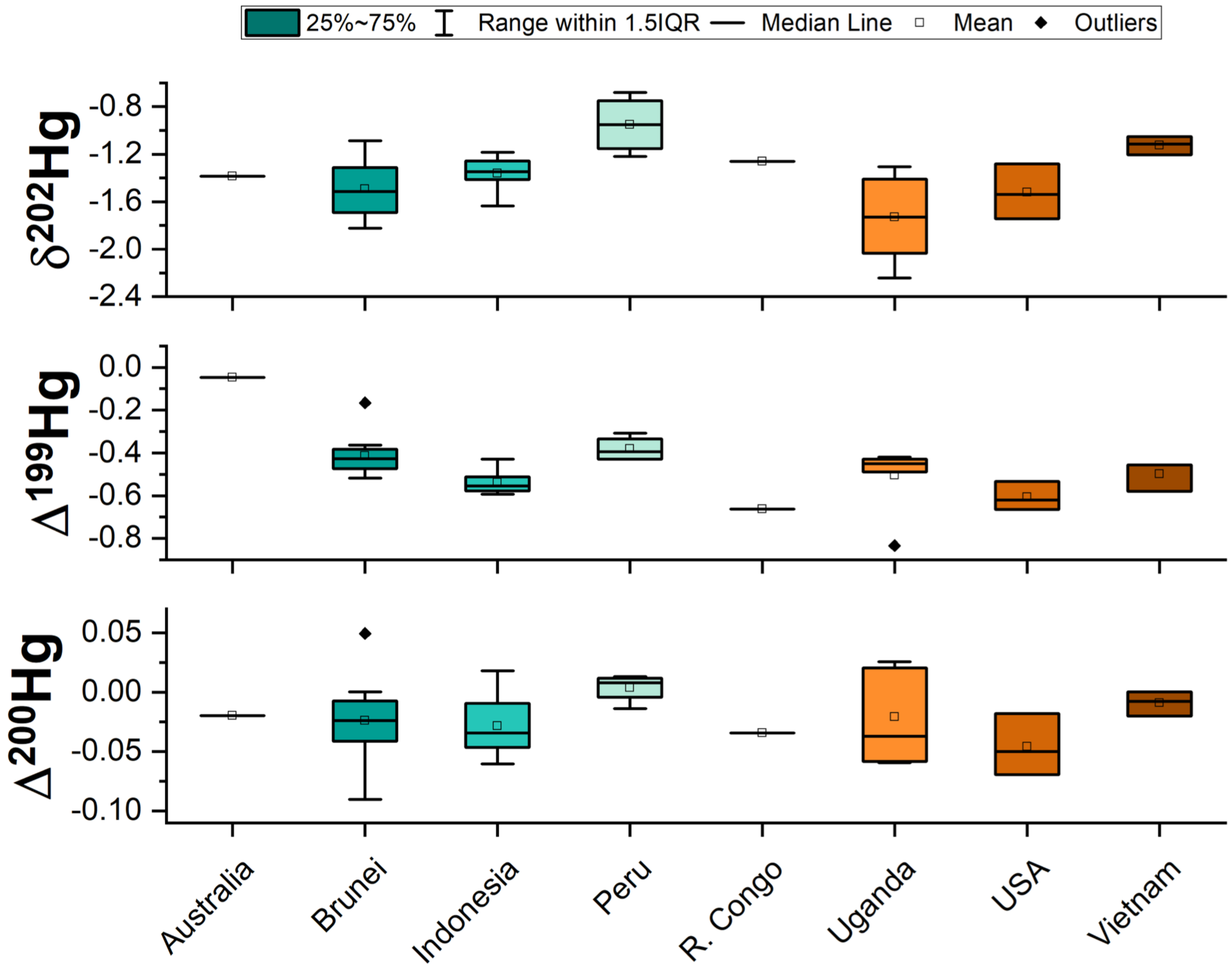
$\log_{10}(THg) \sim$ Country + Trophy*Disturbance * Depth + covariate + (1 | Core:Site:Peatland)

Covariate	p-value	estimate
%C	NS	-
%N	NS	-
%S	NS	-
C:N	NS	-
% carbohydrates	NS	-
% aromatics	NS	-
Von Post score	***	0.04
pH	***	-0.14

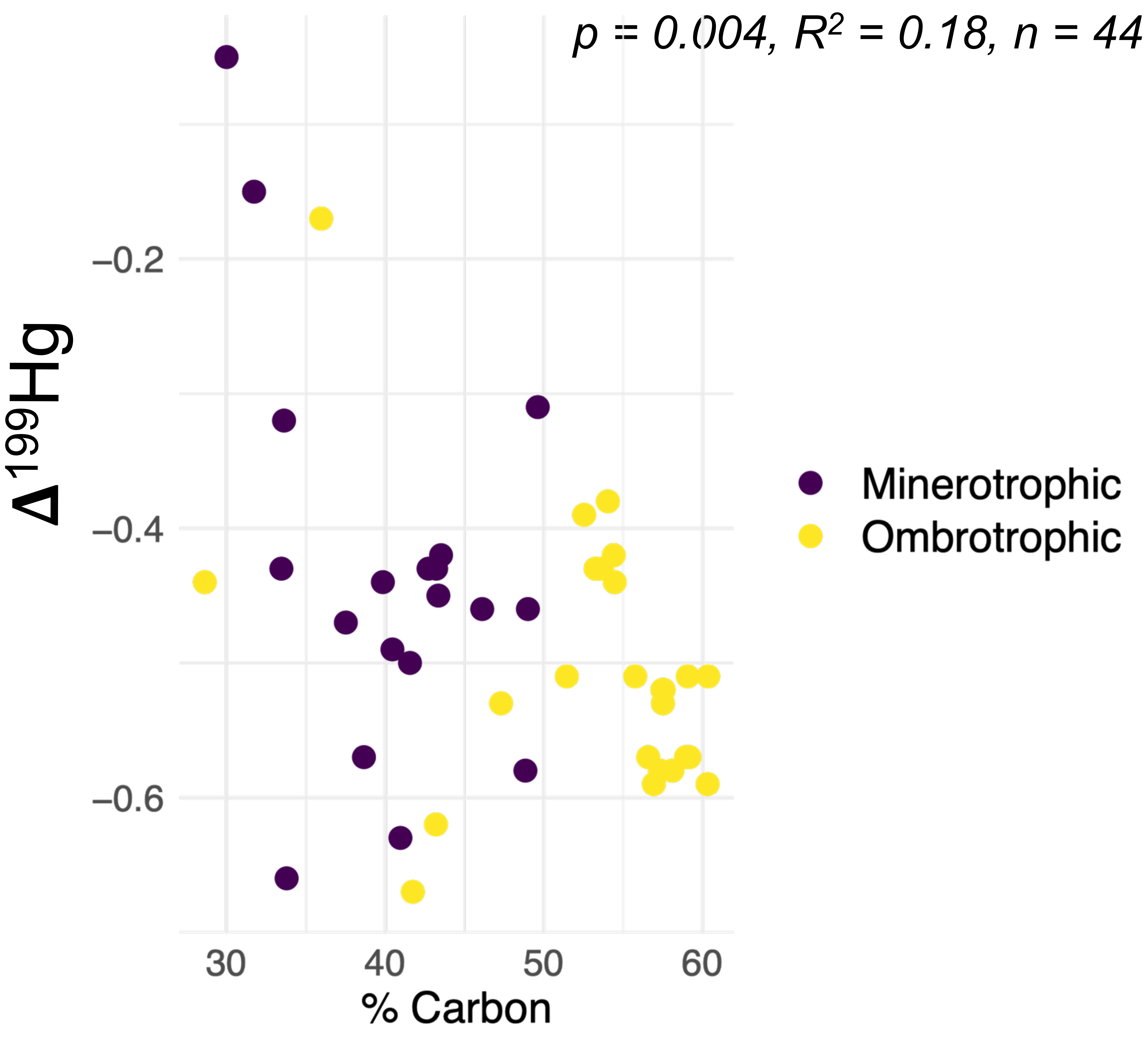


Significant country level variation in Hg stable isotopes

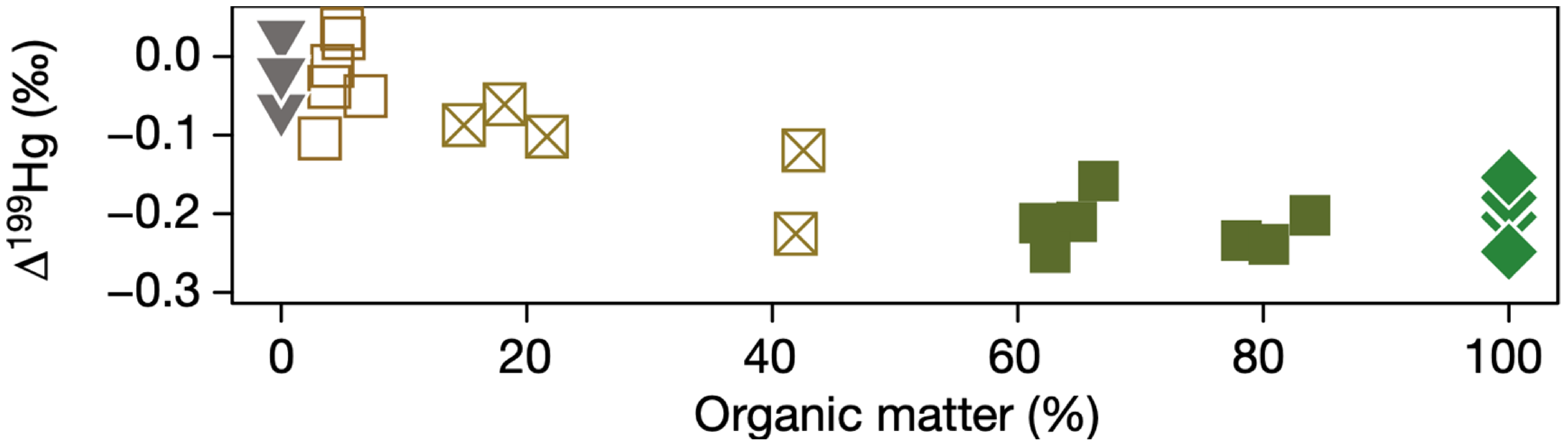
- $\delta^{202}Hg$
  min = -2.24
  max = -0.68
- $\Delta^{199}Hg$
  min = -0.83
  max = -0.05
- $\Delta^{200}Hg$
  min = -0.09
  max = 0.05



Δ^{199}Hg predicted by %carbon



Arctic peatlands (Obrist et al. 2017)



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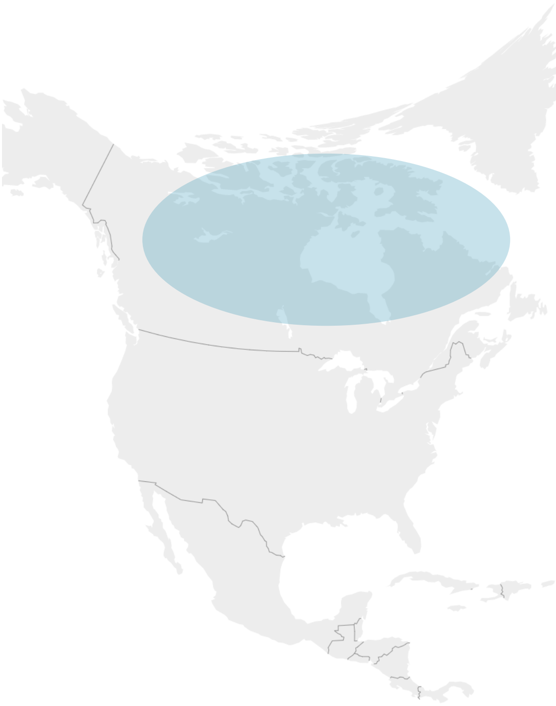
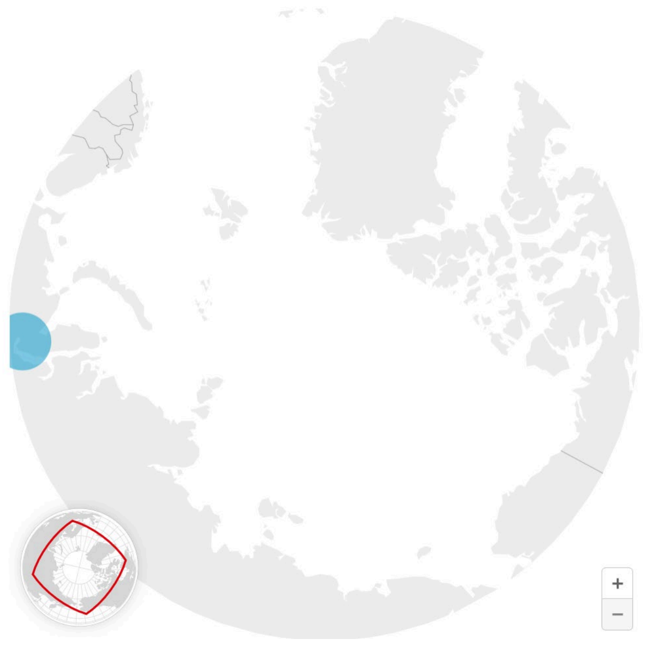
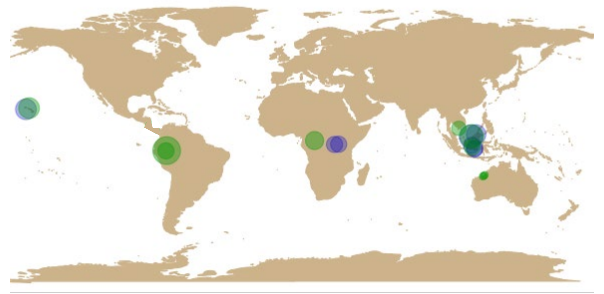
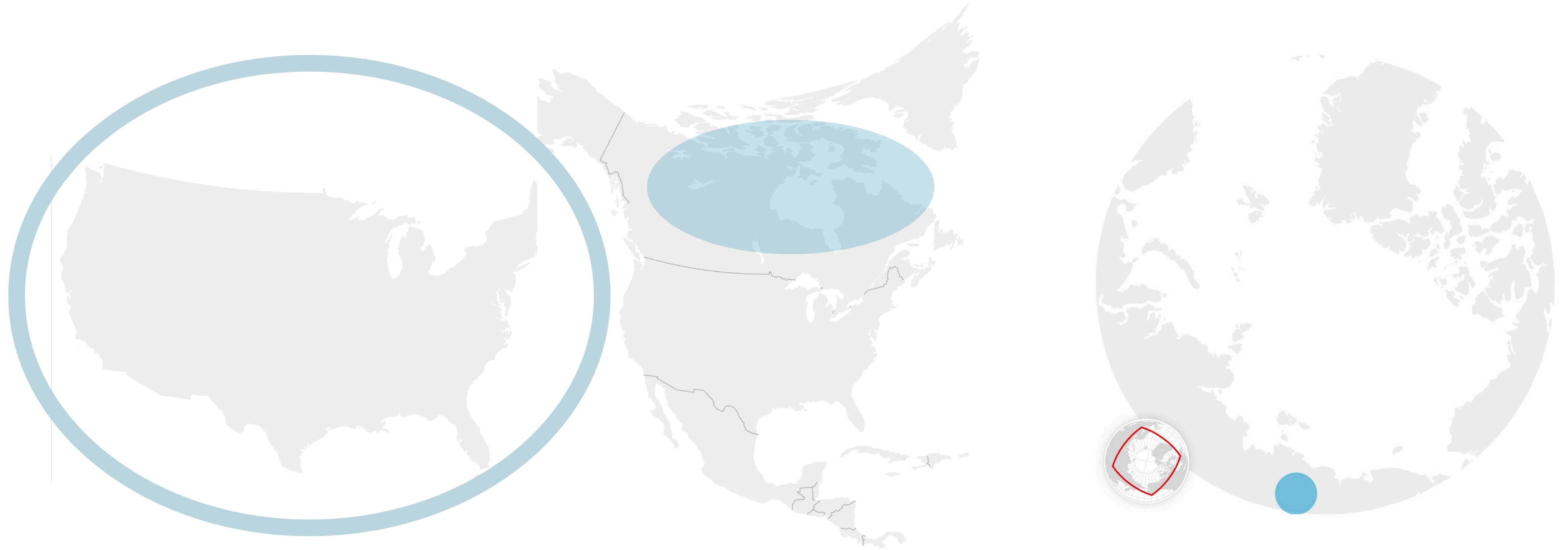
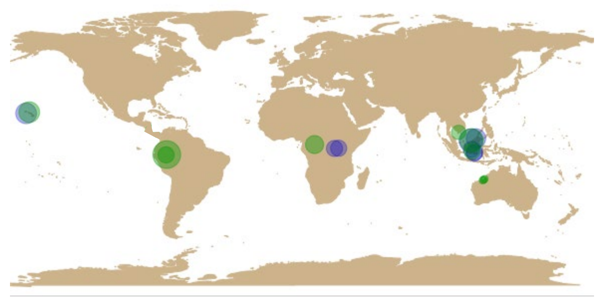
Estimates of Hg stocks in global peat

	Min	Max		Average		
	Indonesia, agricultural site	**Cuvette Centrale, Congo**	**All tropical sites, this study**	**Temperate Adirondacks, Selvendiran et al. (2008)**	**Boreal, Canada, Turetsky et al. (2006)**	**Arctic, Western Siberia Lim et al. (2020)**
upper 100 cm ($mg/m^2 \pm SD$)	6.3 ± 0.4	95.3 ± 21.6	24.8 ± 25.2	24.8	42.0 ± 5.5	6.7 ± 5.7

Estimates of Hg stocks in global terrestrial soils



	Min	Max		Average		
	Indonesia, agricultural site	**Cuvette Centrale, Congo**	**All tropical sites, this study**	**Conterminous USA Olson et al. (2022)**	**Boreal, Canada, Turetsky et al. (2006)**	**Arctic, Northern Alaska Obrist et al. (2017)**
upper 100 cm (mg/m^2 ± SD)	6.3 ± 0.4	95.3 ± 21.6	24.8 ± 25.2	20.3 ± 0.2	3.4 ± 1.2	27

Summary

- Evidence of variation across geographic regions in Hg concentrations and sources
- Disturbance lowers peat Hg concentrations relative to undisturbed peatlands
- Acidity is a strong indicator of tropical peat Hg concentrations
- Hg may serve as an predictor of other toxic trace metals, such as Pb
- Range of Hg stock estimates but can be as elevated as high latitude peatlands

U Minh Ha, Vietnam


Protecting undisturbed tropical peatlands must be a conservation priority to reduce global Hg emissions

Thank you!

Thank you to 16th ICMGP session and conference organizers!

16th ICMGP Cape Town 2024
Hg

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State University of New York

Syracuse University

Forest Service
U S
Department of Agriculture

Laurentian University
Université Laurentienne

SMART
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IIAP
Instituto de Investigaciones de la Amazonía Peruana
iiap

Newcastle University

TRENT UNIVERSITY
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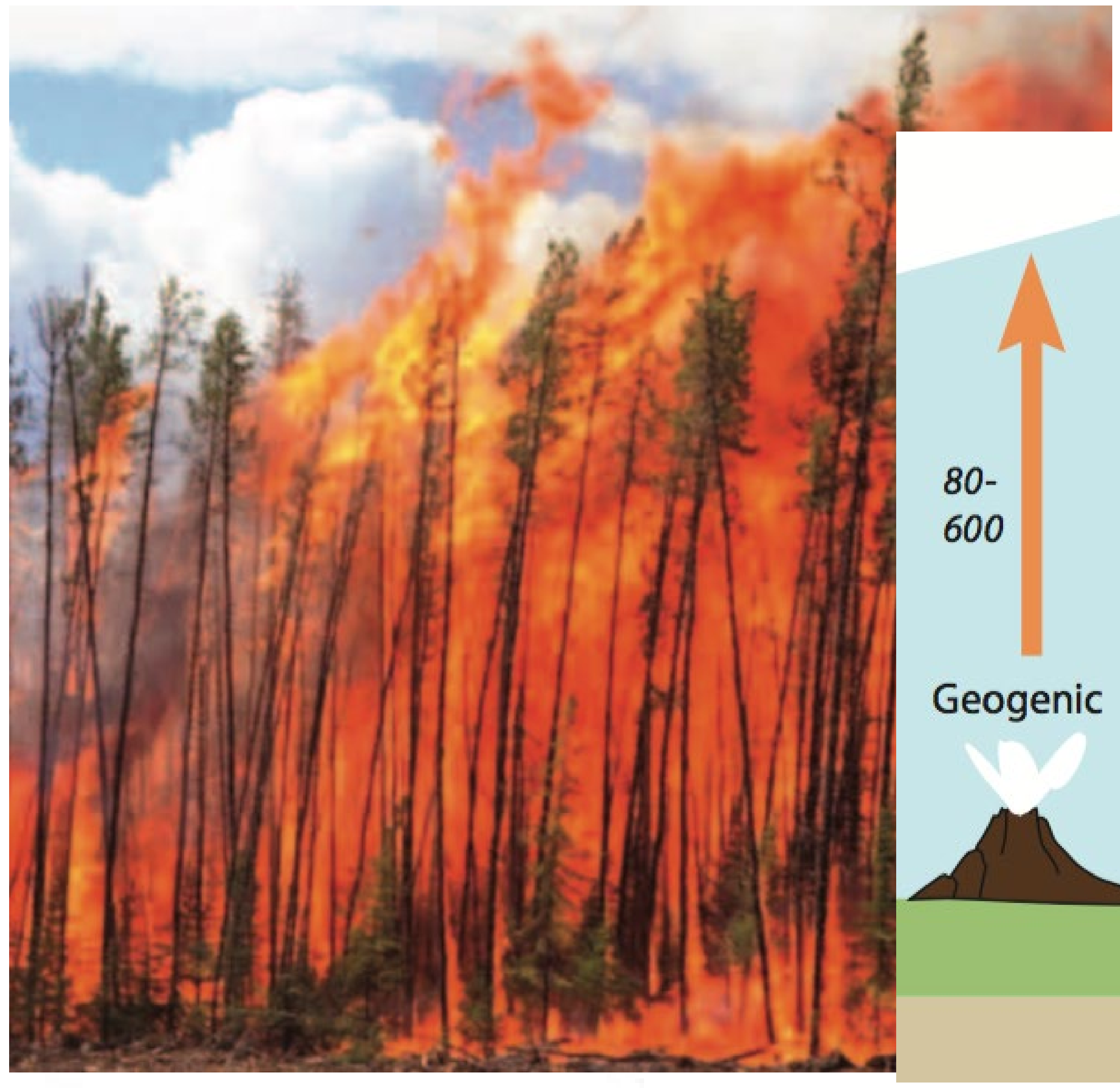
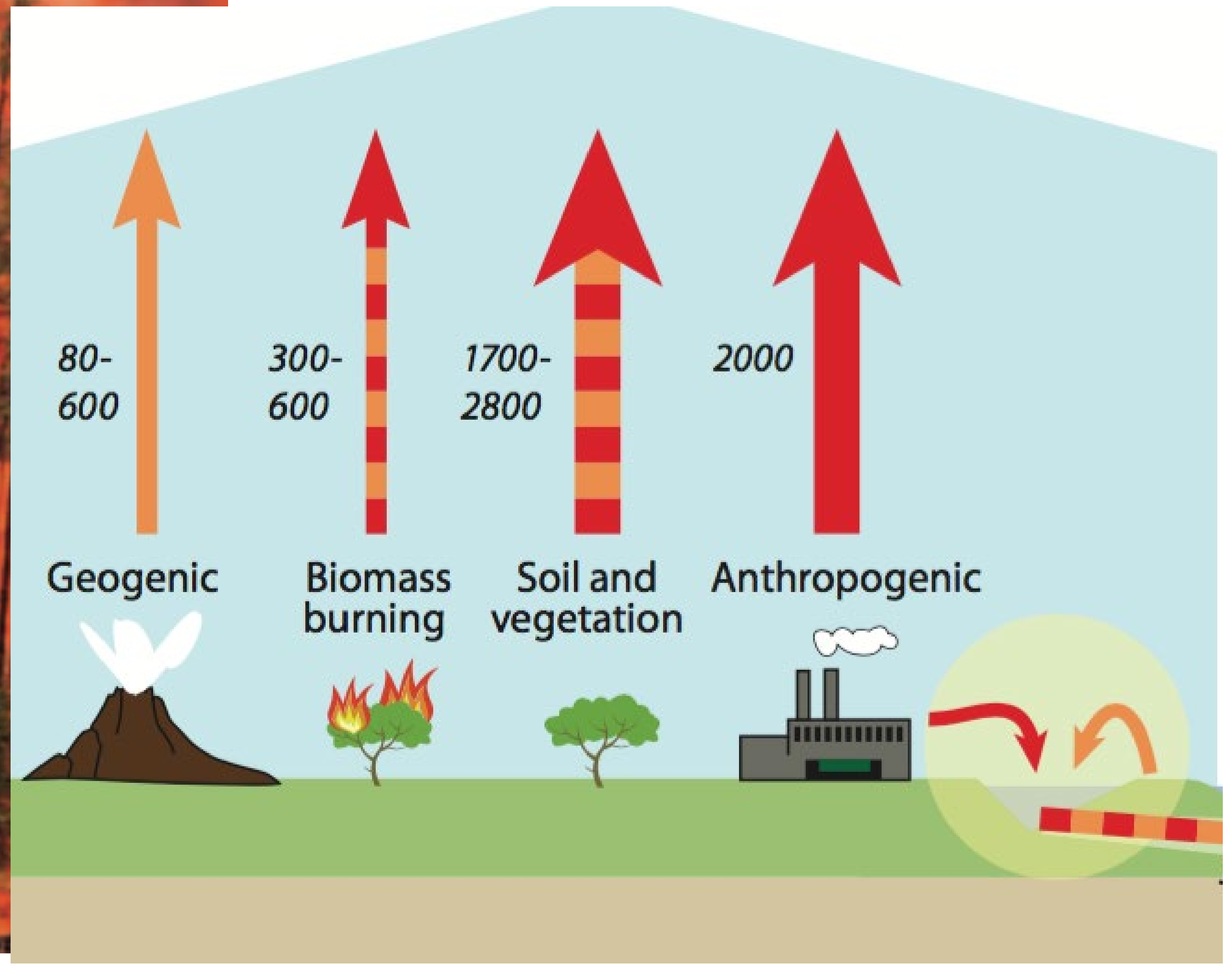
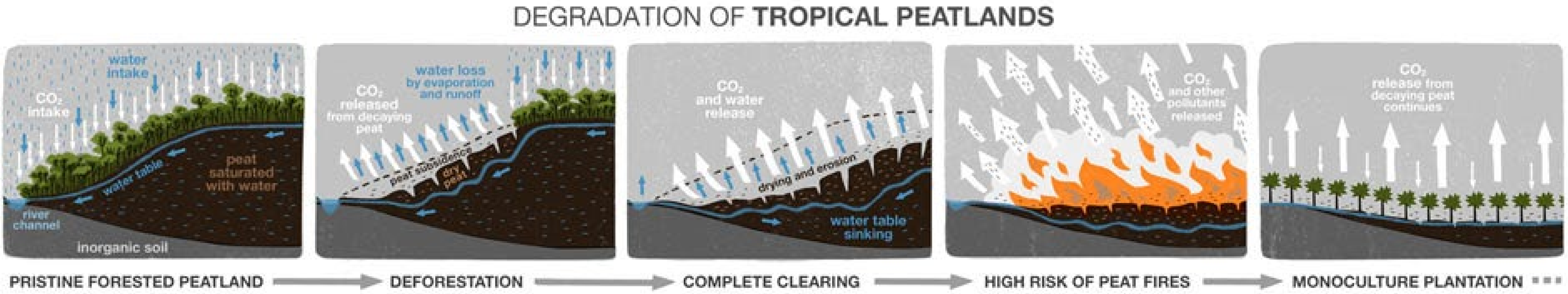
Supplementary slides

Biomass burning results in Hg emissions







Hg serves as a indicator of other co-contaminant mobilization

$\log_{10}$(Element X) ~ THg + Country + Trophy*Disturbance * Depth + (1 | Core:Site:Peatland)

- No significant relationship with cadmium
- Insufficient power to detect differences with selenium