Quantifying Peatland Carbon Storage With High–Resolution 3D Volumetric Modeling

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1. Introduction

- Peatlands are wetlands that cover 3% of Earth's land surface.
- Peatlands store 30% of the world's soil carbon (C) (Yu et al., 2010).
- Peatlands sequester C. Waterlogged conditions trap C within the subsurface.
- Peatlands are hydrologically sensitive & are at risk of becoming C sources as global climate changes.

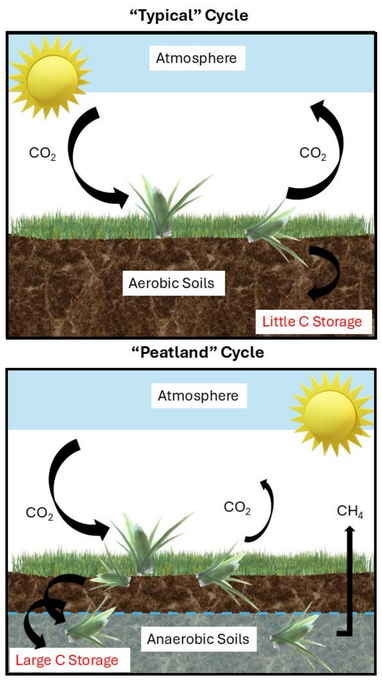


Figure 1. Peat and carbon accumulation model (compared to a more typical cycle). Waterlogged soil limits organic matter decay, leading to large C storage.

CH_4 = Methane CO_2 = Carbon Dioxide

This project aims to quantify C storage in the Välisuo Peatland located in Finland, one of the most peat-dense countries. Few individual site C storage estimates exist (globally and regionally).

Figure 2. Välisuo Peatland location in Finnish Lapland near Muonio and Pallas-Yllästunturi National Park.

Figure 3. Välisuo Photos.

We collected 180,000+ peat depth measurements.

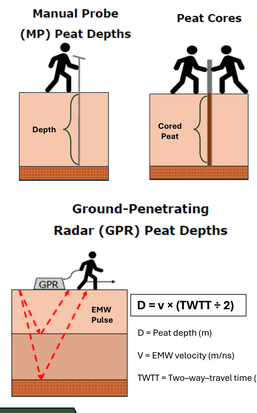
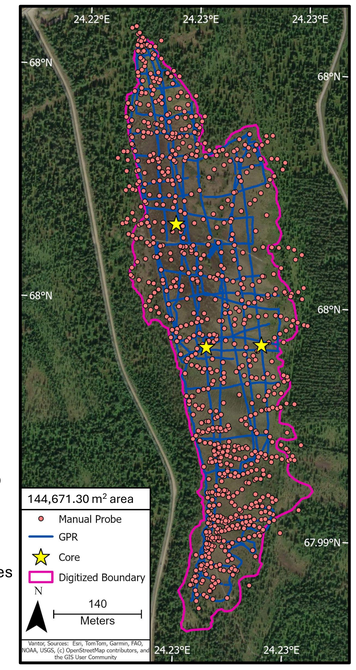


Figure 4. Data collection at Välisuo. Includes manual probe, GPR, and sediment core methods.



2. Välisuo Geophysical Mapping

We applied Ordinary Kriging interpolation to model subsurface bathymetry.

We incorporated surface elevations (a drone-derived DEM) into peat thickness.

We used peat thickness and site area to calculate peatland volume:

212,920.83 m³

Method Comparison:
223,583.9 m³ for manual probe only
202,848.43 m³ for GPR only

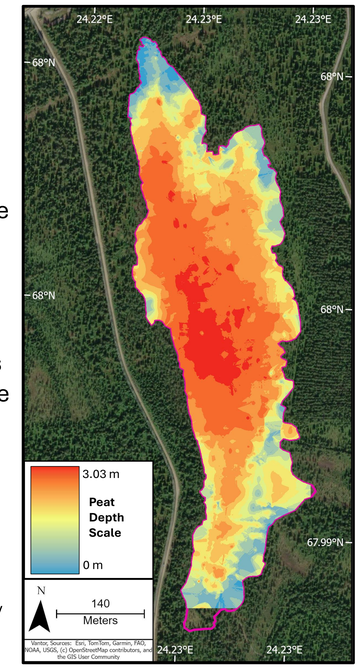


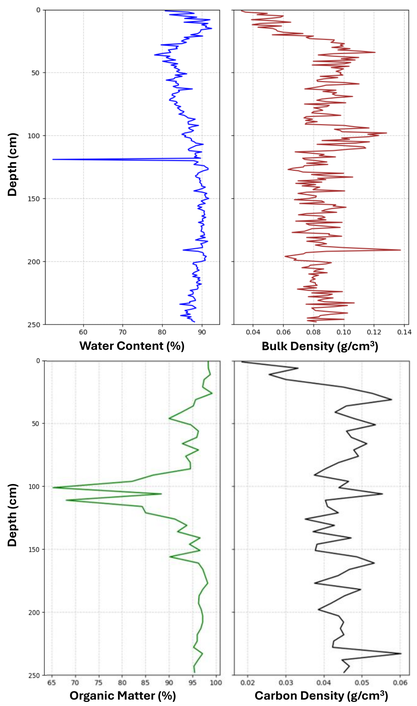
Figure 5. Interpolated bathymetry surface.

Carbon Stock Estimation:

9,338.50 ± 1,585.17 tonnes of C

In the Välisuo Peatland

3. Välisuo Geochemistry & Hydrology



We conducted a peat core loss on ignition analysis to derive peat carbon density (Avg. 0.044 g/cm³). We applied a common C content standard of 58% to isolate C from organic matter.

Figure 6. Peat core characteristics over depth. Includes water content, bulk density, organic matter, and carbon density.

We performed a stable water isotope analysis on 56 water samples. Results detail hydrologic sources and long water residence times in Välisuo, contributing to its role as a peat & C hot spot.

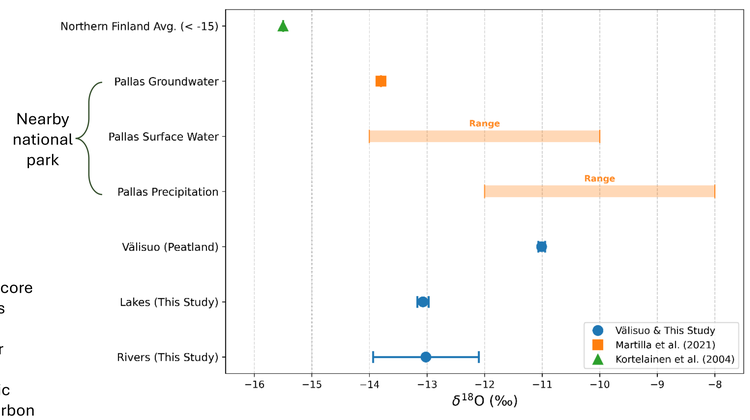


Figure 7. Stable Water Isotope Plot. Compares the peatland value to other known ranges. "Less negative" values indicate higher evaporation (potential longer residence times).

4. Välisuo Peatland Future Implications

This C stock estimate is 5 times greater than regional models predict, proving the importance of individual site studies in capturing local variability. We predict it could take between 332 –1,415 years to fully deplete the C stock based on historical loss rates.

- High C storage in upper peat emphasizes vulnerability to climate change (sea level rise, drought, wildfire).

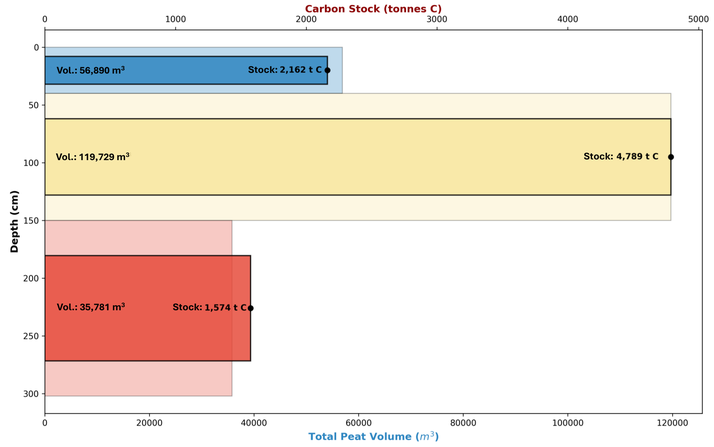


Figure 8. Volume and C stock in the top (0-40 cm), middle (41-150 cm) and bottom (151-303 cm) sections of the peatland using average carbon densities per section from the core.

- Will Välisuo shift from a C sink and climate mitigator to a C source and climate enhancer?

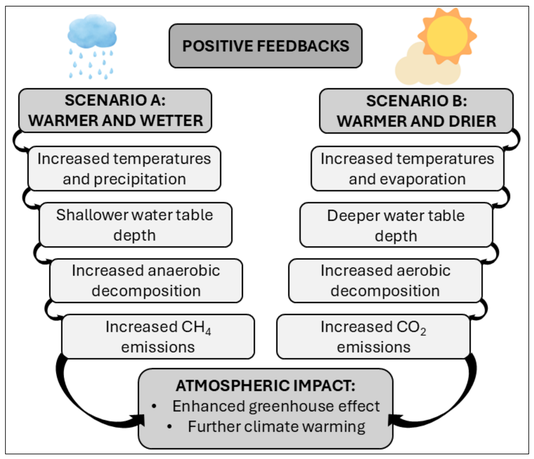


Figure 9. Example Peatland–Atmosphere Positive Feedback Loops.

Supported by NSF (OISE) under Grant Award #2246405 (P.I. Klein)

Acknowledgements:

A big thank you to the IRES 2024 Fieldwork Team for assisting with data collection, the Northern Hydroclimate Lab (UAA) for the stable water isotope analysis, and the NIU team for the loss–on–ignition analysis.

Citations:

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