Quantifying peat carbon mass using ground-penetrating radar (GPR) and probing in peatlands of the Kenai Peninsula, Alaska

Cameron R. Kuhle, Eric S. Klein

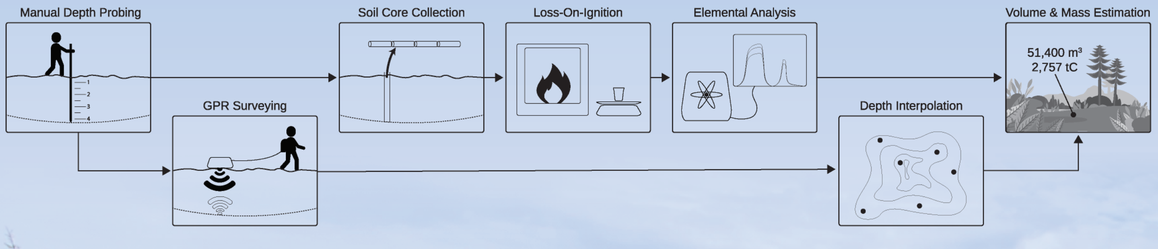
Contact: crkuhle@alaska.edu Dept. Geological Sciences, University of Alaska Anchorage, 3101 Science Circle, Anchorage, AK, USA

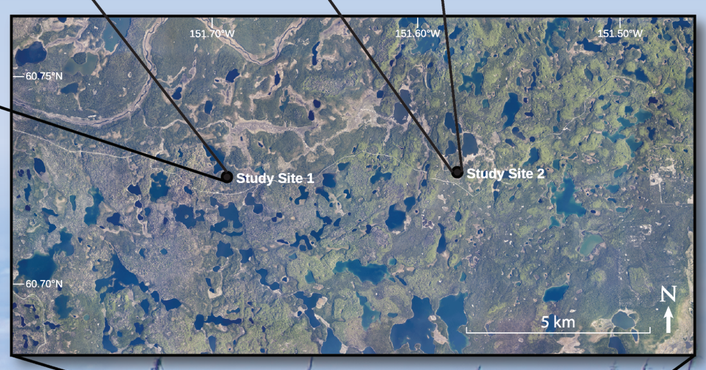
Department of Geological Sciences
University of Alaska Anchorage

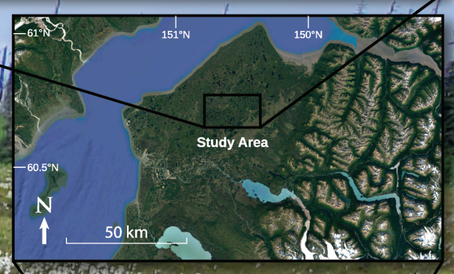
- Peat carbon is **1/3 of global soil carbon**[1] in just 3% of the surface area[2]; over 600 GtC.[3]
- Peatland ecology & carbon sequestration are **increasingly subject to climate change.**[4]
- Carbon stored in Alaska peatlands to date is **not locally quantified**.
- **GPR & probing** provide accurate depth measurements[5]; can be interpolated to volume models and, with elemental analyses, **integrated into carbon mass estimates.**[6]
- We surveyed and collected cores from two peatlands in the Kenai National Wildlife Wildlife Refuge and found them to have similar masses of stored carbon (~1,400 tC/hectare) despite variations in physical and biological characteristics.

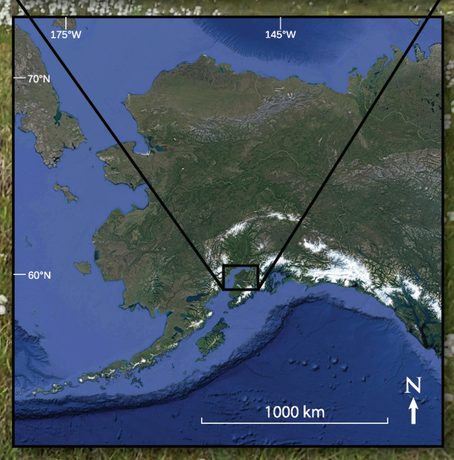
Site 2 - East
Location: 60.7273, -150.5805
Bulk Density: 0.15 g/cm³
Area: 21,565 m²
Volume: 46,526 m³
Carbon: 2,922 tons

Site 1 - West
Location: 60.7262, -150.6931
Bulk Density: 0.12 g/cm³
Area: 20,182 m²
Volume: 51,400 m³
Carbon: 2,757 tons









GPR Field Configuration

Figure 1: Free run configuration of GPR instrumentation and GPS for summer and winter field work, prepared by the research team. The double-pulk sled enables smooth travel over snow and wetland terrain while maintaining the required one meter antenna separation of the PulseEKKO Pro 100 MHz unit. (Photo: E. Klein, Sep. 2022).

Peatland GPR Radargram

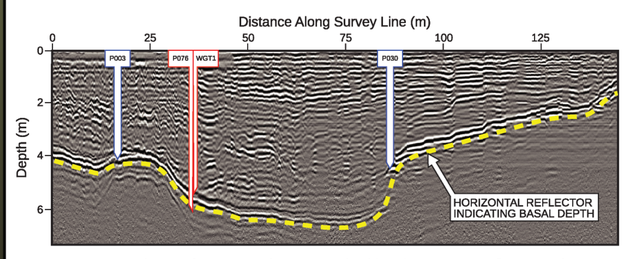


Figure 2: GPR radargram from surveyed KENWR peatland (west). Patterns are reflections indicating differences in dielectric properties of the subsurface, interpreted as interfaces between media. Basal peat depth can be inferred from a linear pattern of strong reflectors. Depth in meters is derived from radar velocity (0.039 m/ns) calibrated with depth-truth probing. Blue outlined probings (P003, P030) are within one meter of surveyline; red probings are approx. two meters from survey line in opposite, perpendicular directions. Processed with time zero correction, idle trace removal, energy decay gain, and dewow.

Site Survey Maps

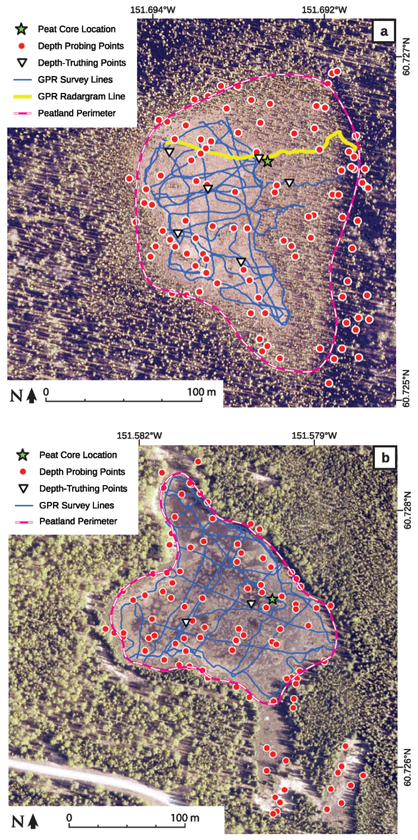


Figure 3: (a) Western and (b) eastern KENWR peatland sites surveyed with GPR and probing. Randomly distributed probe points (n=100) are used for basin surface interpolation and with depth-truthing probe points are used to calibrate radar velocity. Approx. 5 km of GPR survey lines (west: 2.4 km; east: 2.6 km) were collected to augment the probe data, with overall excellent results but some limitations due to vegetative obstacles, surface saturation, open water. Radargram for the bold yellow GPR line is seen in Figure 6. Peat cores were collected from both sites (west: 2.1 m; east: 2.6 m) for carbon content, C/N ratio, and radiocarbon analyses. The peatland perimeters define the surface areas used to generate the estimates of peat volume. (Base Imagery: Kenai Peninsla Borough Mapper).

Interpolated Basin Surfaces

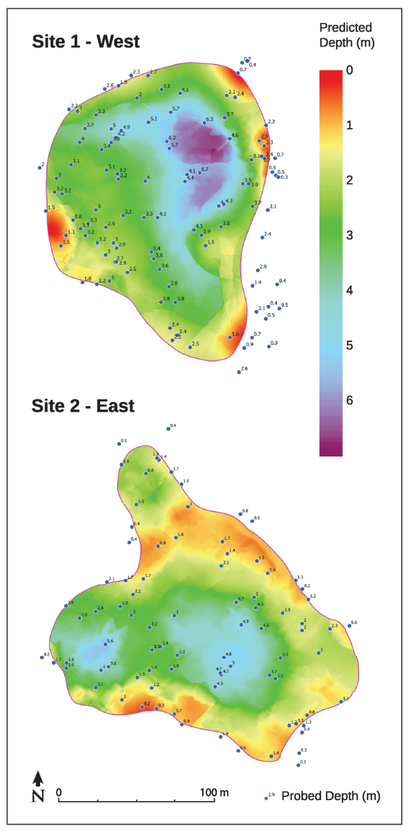


Figure 4: Kriging interpolations for both sites generated using combined GPR and probe point depth data (see Figure 3). Probe point measurements are included for comparison of predicted and actual depths. Volume estimates were calculated from these interpolated basin surfaces and a surface plane, then used for mass estimations. Standard error for west site is 0.48 and for east site is 0.30.

Carbon Content

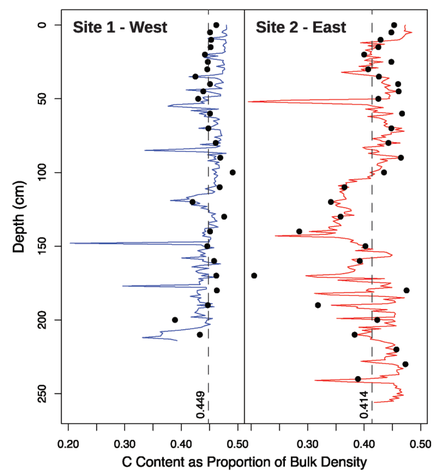


Figure 5: Subsamples from peat cores underwent elemental analysis and Loss-On-Ignition (LOI) testing. Carbon content is evaluated as a proportion of the bulk (dry) density of the sample; results are seen as black dots on the plots above as a function of depth. Vertical dashed lines and adjacent values indicate mean carbon content. Organic matter proportion of bulk density (from LOI) was related to tested carbon values at equivalent depths using linear regression ($r^2 = 0.77$, $p << 0.05$) and the result used to predict carbon content values throughout the depth column. These predictions are plotted as the lines above. There is noticeable variability in the eastern site values, possibly accounted for by its apparent hydrological flux; the spike around 50 cm depth is associated with a tephra layer.

REFERENCES

[1] Scharlemann, J.P., Tanner, E.V., Hiederer, R. and Kapos, V., 2014, Global soil carbon: understanding and managing the largest terrestrial carbon pool: Carbon Management, v. 5(1), p. 81-91, doi:10.4155/cmt.13.77.
[2] Xu, J., Morris, P.J., Liu, J. and Holden, J., 2018, PEATMAP: Refining estimates of global peatland distribution based on a meta-analysis: Catena, v. 160, p. 134-140, doi:10.1016/j.catena.2017.09.010
[3] Yu, Z., Loisel, J., Brosseau, D.P., Beilman, D.W. and Hunt, S.J., 2010, Global peatland dynamics since the Last Glacial Maximum: Geophysical research letters, v. 37(13), doi:10.1029/2010GL043584.
[4] Wang, S., Zhuang, Q. and Yu, Z., 2016, Quantifying soil carbon accumulation in Alaskan terrestrial ecosystems during the last 15,000 years: Biogeosciences, v. 13(22), p. 6305-6319, doi:10.5194/bg-13-6305-2016.
[5] Parry, L.E., West, L.J., Holden, J. and Chapman, P.J., 2014, Evaluating approaches for estimating peat depth: Journal of Geophysical Research: Biogeosciences, v. 119(4), p. 567-576, doi:10.1002/2013JG002411.
[6] Comas, X., Terry, N., Hribljan, J.A., Lilleskov, E.A., Suarez, E., Chimner, R.A. and Kolka, R.K., 2017, Estimating below ground carbon stocks in peatlands of the Ecuadorian páramo using ground-penetrating radar (GPR): Journal of Geophysical Research: Biogeosciences, v. 122(2), p. 370-386, doi:10.1002/2016JG003550.

ACKNOWLEDGEMENTS

Equipment: Jens Munk (University of Alaska Anchorage Electrical Engineering Department), and Mark Laker (USFWS).
Field Assistance: Nolan Vlahovich, Tyler Jones, Joshua Kim (University of Alaska Anchorage).
Technical Guidance: Ed Berg (USFWS, Retired); Esther Babcock (Logic Geophysics and Analytics).
Funding: US Fish & Wildlife Service; American Water Resources Association - Alaska Section; Society of Wetland Scientists.

FUNDED BY: