SHALLOW PEATLANDS AS ECOHYDROLOGICAL SENTINELS OF CLIMATE CHANGE

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BACKGROUND

Northern peatlands are generally resilient to drought and wildfire disturbance due to ecohydrological feedbacks[1].

Most studies have been conducted in large and deep peatlands where ecohydrological feedbacks often have a moderating effect on water table (WT) depth.

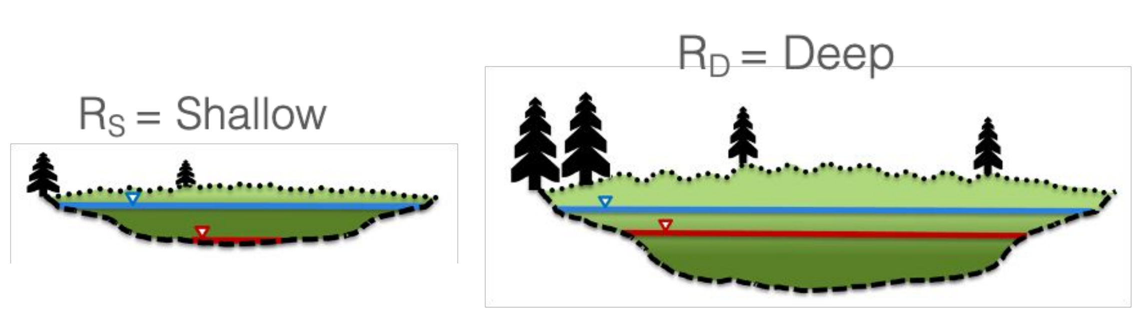
Shallow (depth < 0.5m) peatlands are underrepresented.

Loss of resilience has been observed as a result of degradation or drainage, which often are accompanied with a decrease in peat thickness.

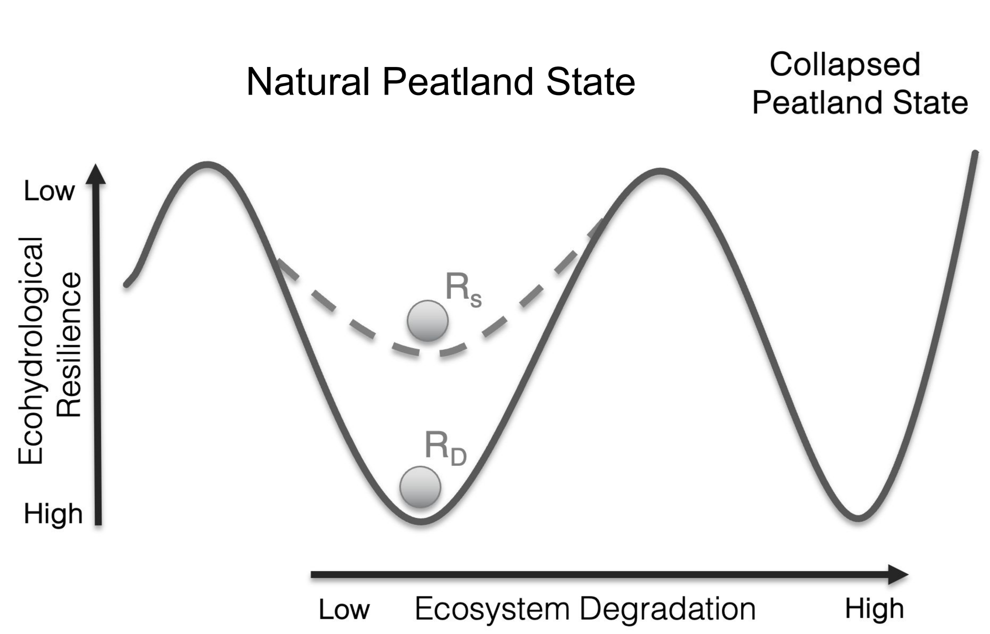
Objective: Determine the presence and relative strengths of ecohydrological feedbacks in shallow and deep northern peatlands.

Survival of the Deepest Hypothesis: Peat depth is correlated to peatland ecohydrological resilience, and that vulnerability disproportionately increases below a threshold peat depth (for a given climate and hydrogeological setting).

CONCEPTUAL MODEL



Water Table Dynamics: WT variability in shallow peatlands can be higher, and they are at risk of 'losing' their WT where it falls below the peat layers.

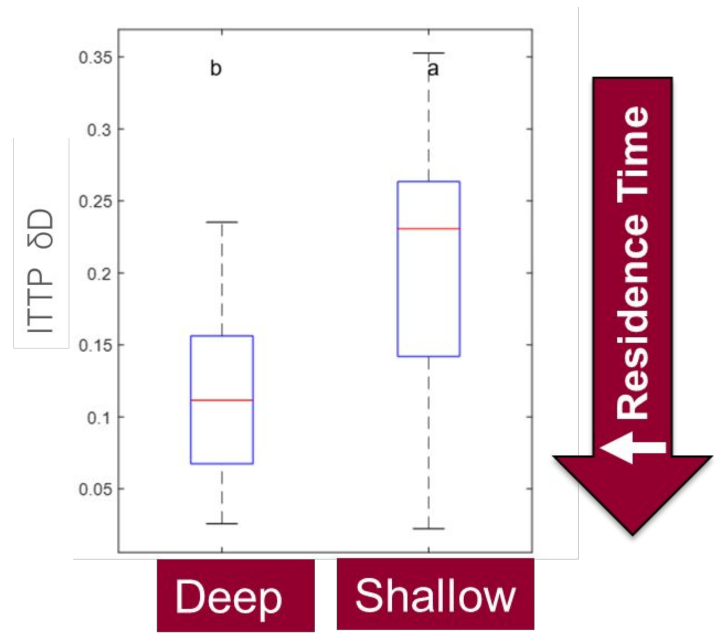


Resilience: Ball-and-cup model of ecohydrological resilience in shallow (R_S) and deep (R_D) peatlands, where the former may undergo a regime shift with lesser disturbance or forcing.

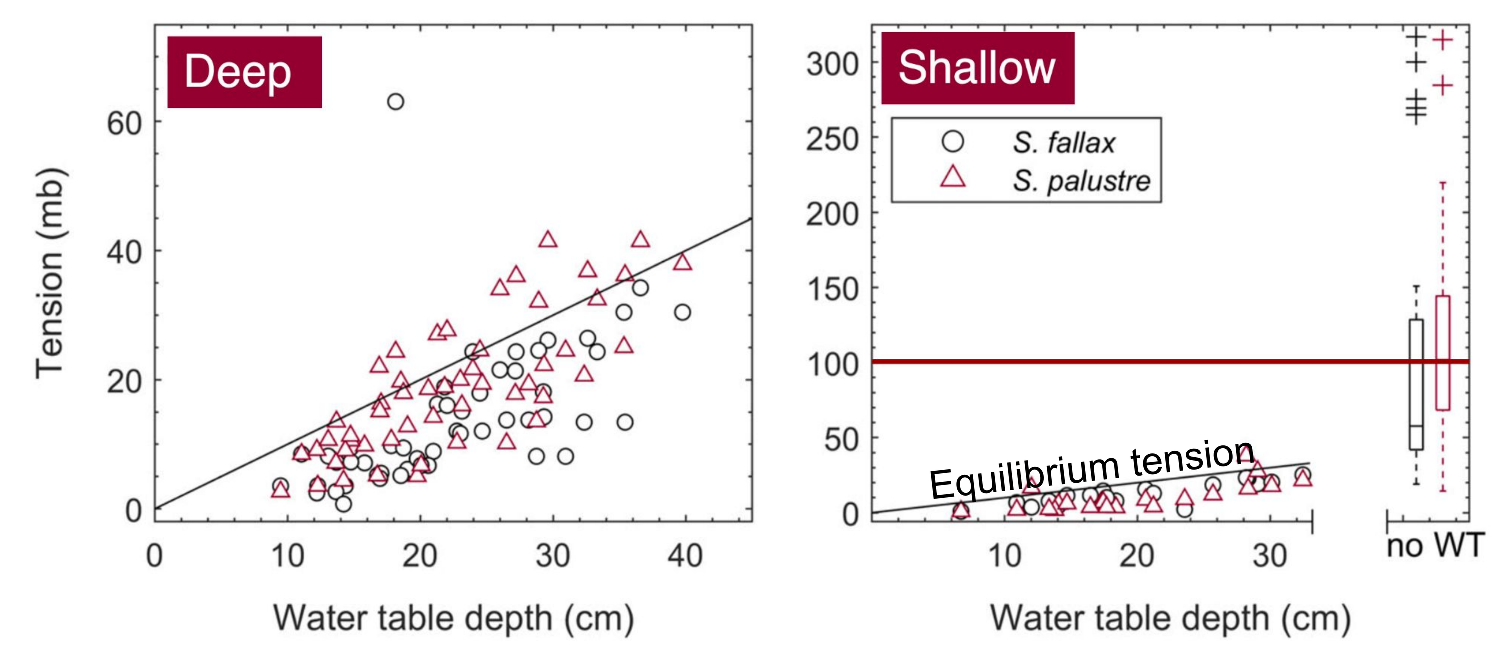
SURVIVAL OF THE DEEPEST

Survival of the Deepest Evidence: We show results from three studies that support our Survival of the Deepest Hypothesis.

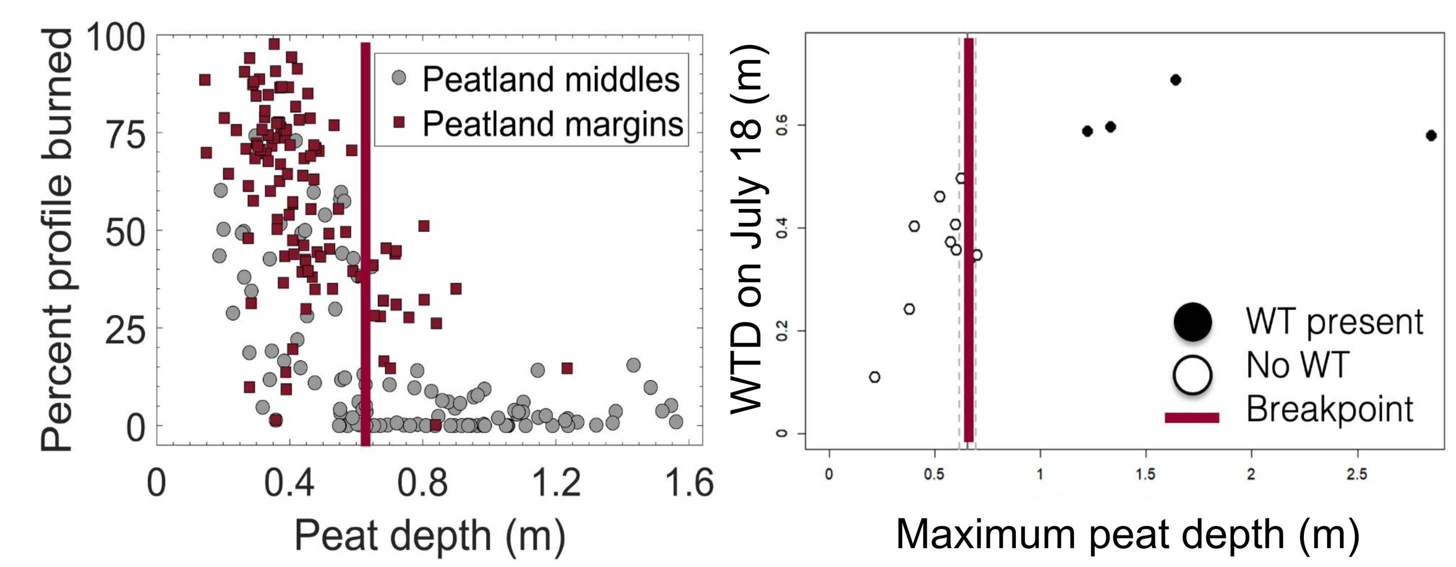
1. **RESIDENCE TIME**
2. **DROUGHT**
3. **COMBUSTION**



Residence Time: Deep peatlands had longer relative residence times, which confer resilience to decomposition[3].



Drought: During drought, shallow peatlands lost their WT, which increased soil tension past the *Sphagnum* moss moisture stress threshold of 100 mb[2].



Combustion: A ~0.66 m pre-fire peat depth breakpoint was identified for the proportion of the peat profile burned post-wildfire, also linked to lost WTs[4].

HYDROLOGICAL FEEDBACK STRENGTH

	Shallow	Deep
(A) WTD—afforestation and/or shrubification feedback		
A1. Transpiration and interception	+++	++
A2. Shading and evaporation	– – –	– –
(B) WTD—moss surface resistance & albedo feedback	–	– – –
(C) WTD—transmissivity feedback	0	– –
(D) WTD—peat deformation feedback	0	–
(E) WTD—specific yield feedback (falling WT)	+++	++
(F) WTD—peat decomposition feedback		
F1. Water residence time—porewater chemistry	0	– – –
F2. Water residence time—entrapped gas	0	– –
(G) WTD—moss productivity feedback		
G1. Moss species moisture retention	–	– – –
G2. Decomposition—peat moisture retention	0	–

Shallow and deep peatland ecohydrological feedback direction and strength (following Waddington et al., 2015)[1].

IMPLICATIONS

Shallow, or 'young', peatlands have demonstrated greater susceptibility to moisture stress, decomposition and depth of burn, which may be enhanced by a warmer and drier climate.

We suggest that shallow peatlands are sentinels of climate change, as climate change may shift previously resilient deep peatlands towards an increasingly vulnerable state.

We argue for the need to develop simple, standardized metrics of feedback strength and resilience for peatland monitoring.

Further, it is necessary to quantify confidence in these predictions based on the quality of evidence found within published works, theses, unpublished data, or modelling.

Confidence	Evidence
5	Direct from published work
4	Direct from theses, unpublished data
3	Indirect from published work/theses (e.g. drainage, harvest)
2	Suggested from exploratory modelling
1	Inferred

SURVEY & FEEDBACK

To refine our predictions, we are seeking input from a wider range of perspectives. Please complete this survey when time permits: https://forms.gle/zQscCfP1zXrtpSts9

REFERENCES

[1] Waddington JM, Morris PJ, Kettridge N, Granath G, Thompson DK, Moore PA. 2015. Hydrological feedbacks in northern peatlands. *Ecohydrology*, 8(1), 113–127.
[2] Moore PA, Didemus BD, Furukawa AK, Waddington JM. 2021. Peat depth as a control on Sphagnum moisture stress during seasonal drought. *Hydrological Processes*, 35(4), e14117.
[3] Furukawa A. 2018. Pore-Water Feedbacks and Resilience To Decay in Peat-Filled Bedrock Depressions of the Canadian Shield [M.Sc thesis]. McMaster University.
[4] Wilkinson SL, Tekatch AM, Markle CE, Moore PA, Waddington JM. 2020. Shallow peat is most vulnerable to high peat burn severity during wildfire. *Environmental Research Letters*, 15(10), 104032.