Hydrology of Peatland Restoration at the Matorova Site

Modeling Insights

LIFE PeatCarbon Project Steering and Scientific Group Meeting Nov 14, 2025

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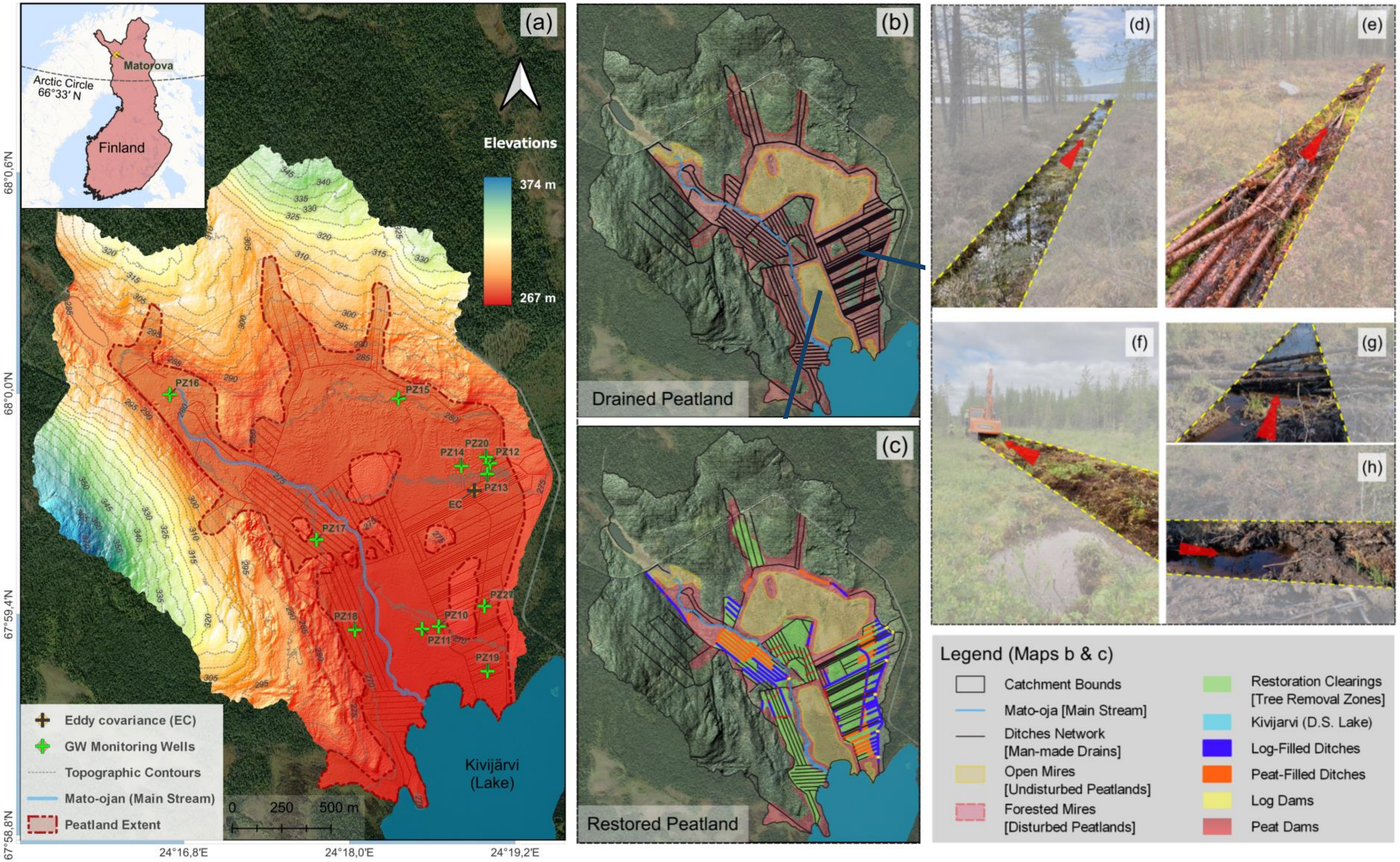
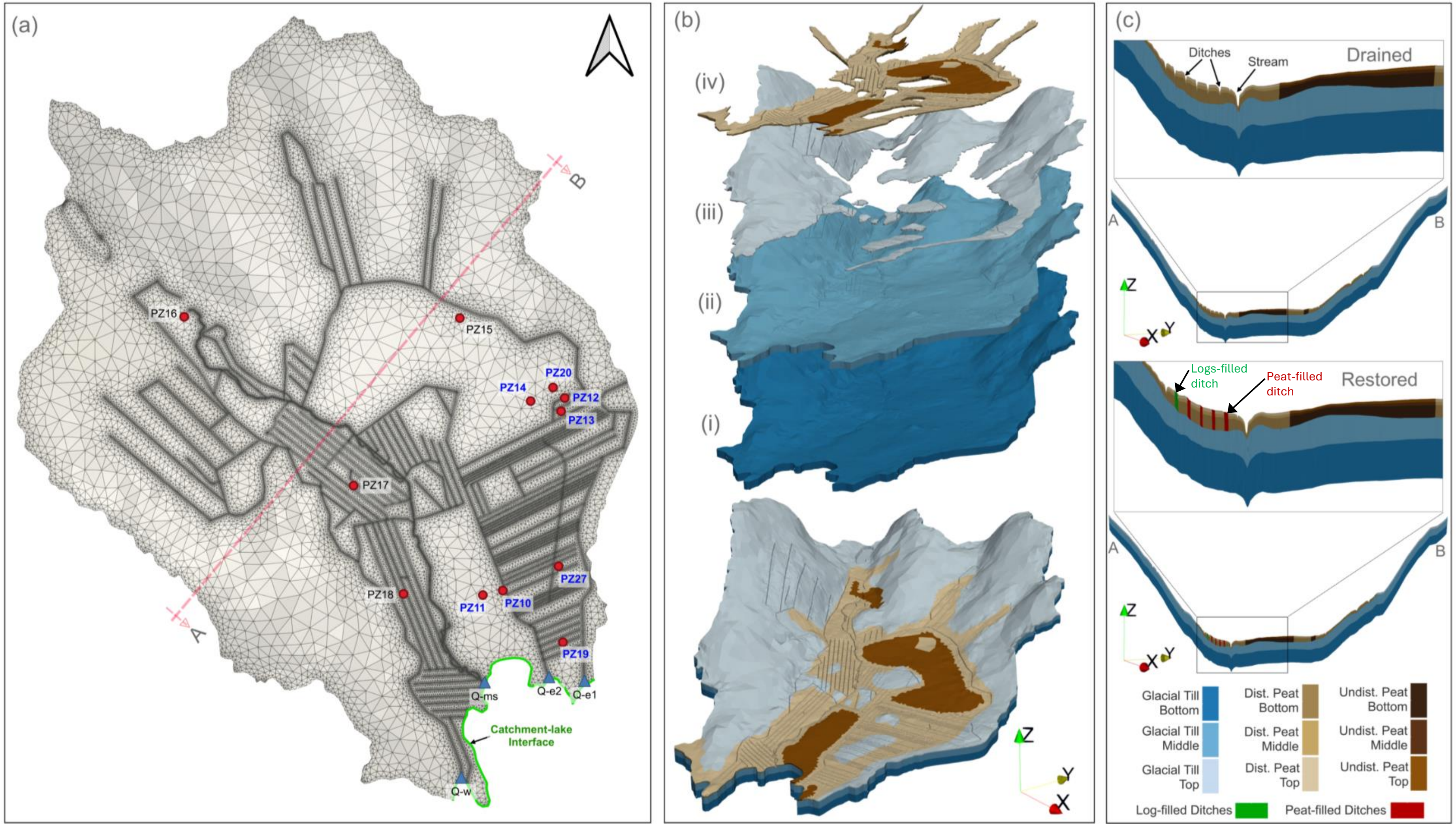
Study Site Overview – Matorovansuo



- **Aapa mire** (patterned fen, groundwater-fed)
- Mosaic of 40% undisturbed open fen & 60% drained pine–sedge fen
- **Peat depth: 0–4 m**
- **Restoration in 2023:** ditch blocking & flow-slowing dams
- **Modeling** targets to assess understanding hydrological shifts

Modeling Approach –

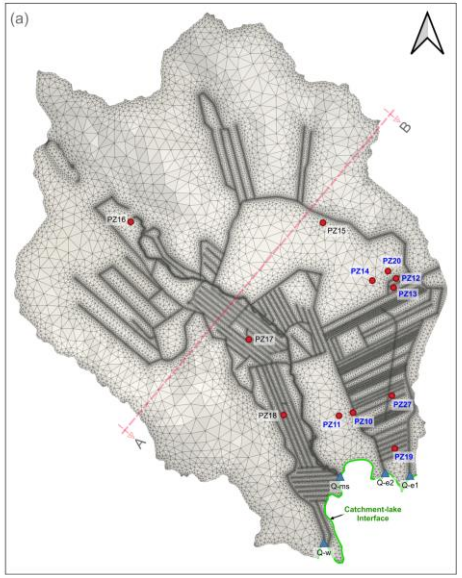
Fully distributed, physics-based, integrated surface–subsurface (**H**ydro**G**eo**S**phere)

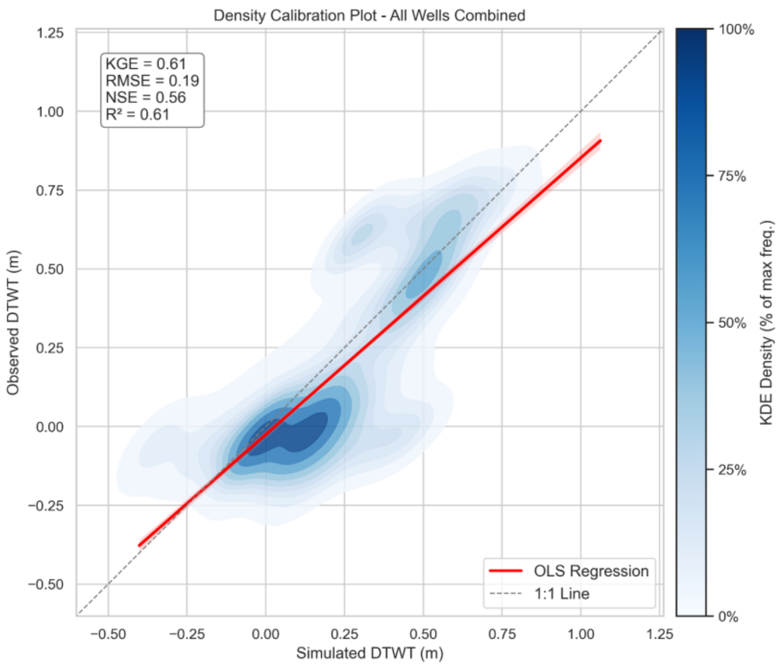


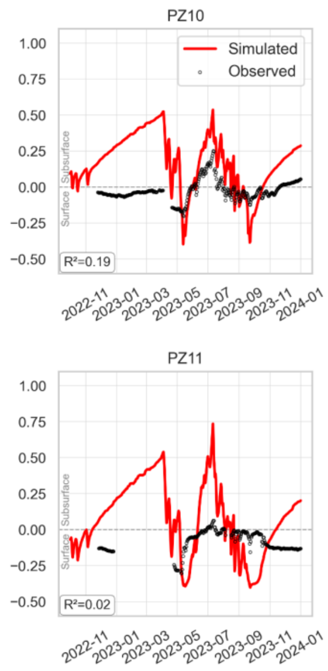
- **High-resolution 2D mesh** (fine near ditches)
- **6-layer** vertical structure (peat + till)
- **Disturbed vs. undisturbed peat soils**
- **Geology** from geophysics & field data
- Restoration represented **via material infilling**

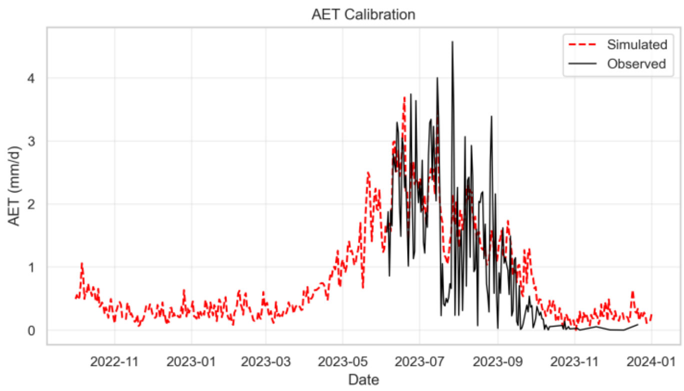
Model Calibration

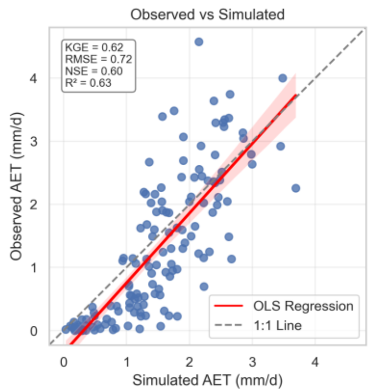
- **Calibrated against WT levels (12 GW wells → 8 transient)**
- **AET calibration using FMI Latent Heat data, from EC**
- **Snow depth calibration (FMI Open-data)**

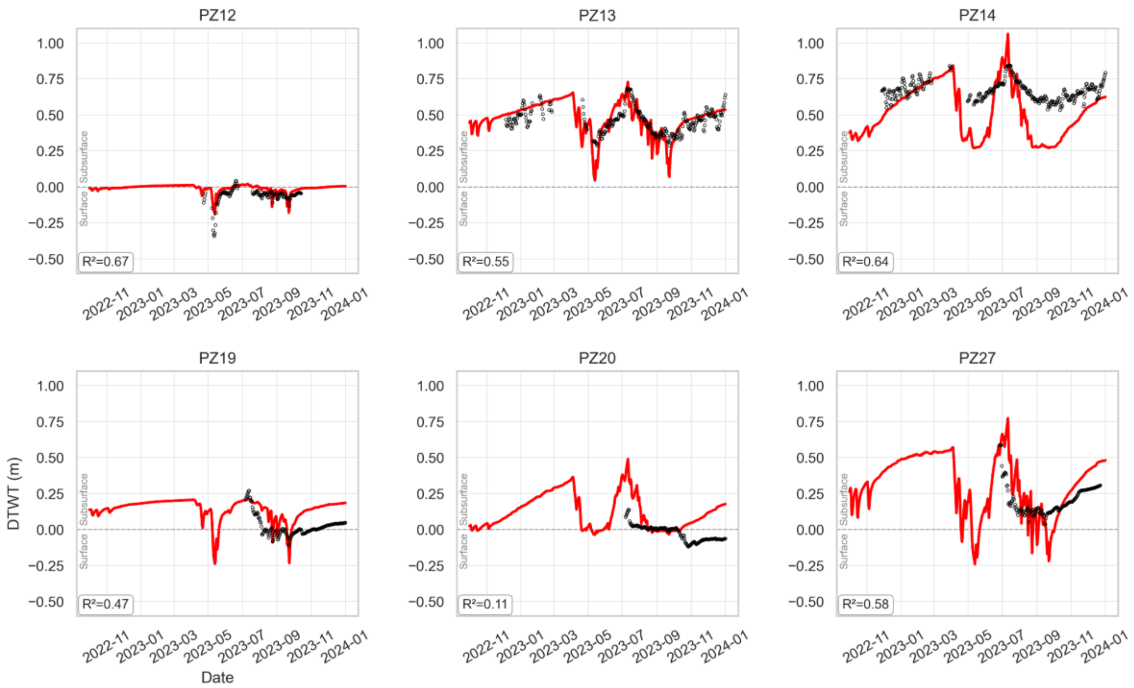


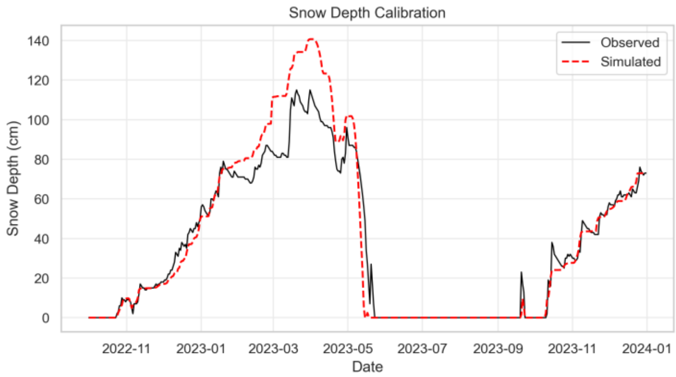


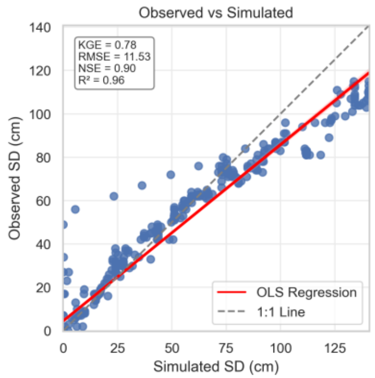








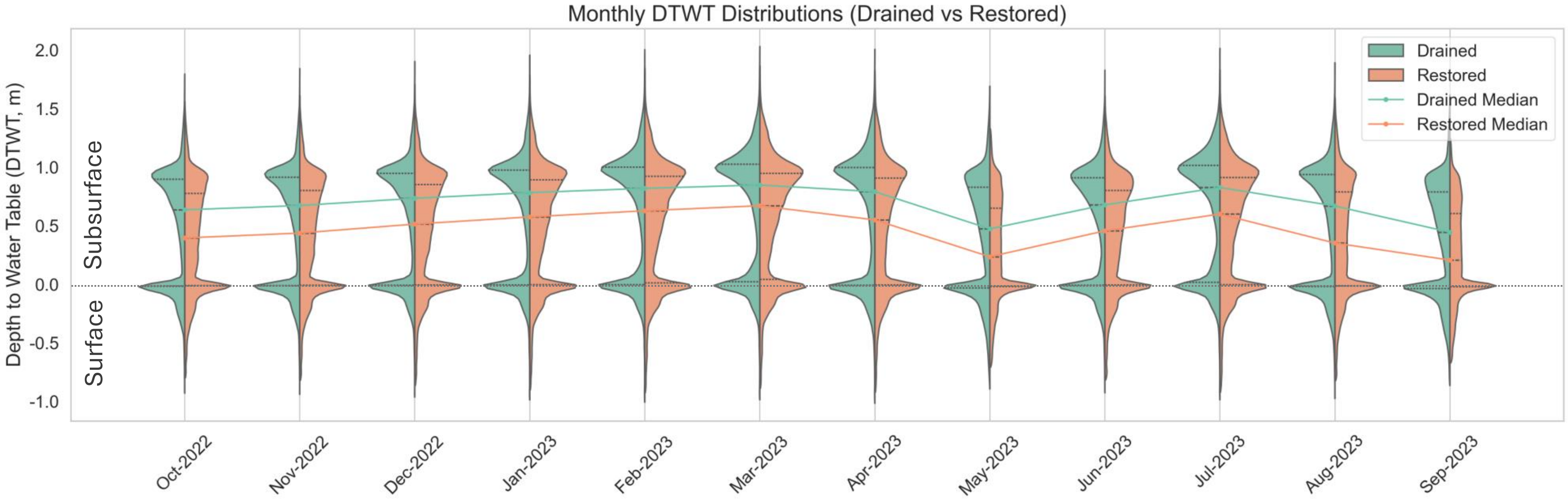




Temporal distribution of Depth-to-Water-Table (DTWT)

How Does Restoration Change Water-Table Dynamics Over Time?

- **Green =** drained condition
- **Orange =** restored condition
- **Negative (-ve) =** WT above surface
- **Lines =** monthly medians trend
- Restoration **shifts** WT upward & smooths variability



Is restoration equally effective throughout the year (?)

Does the restoration do same good job constantly (?)

How strongly restoration performs through the year(?)

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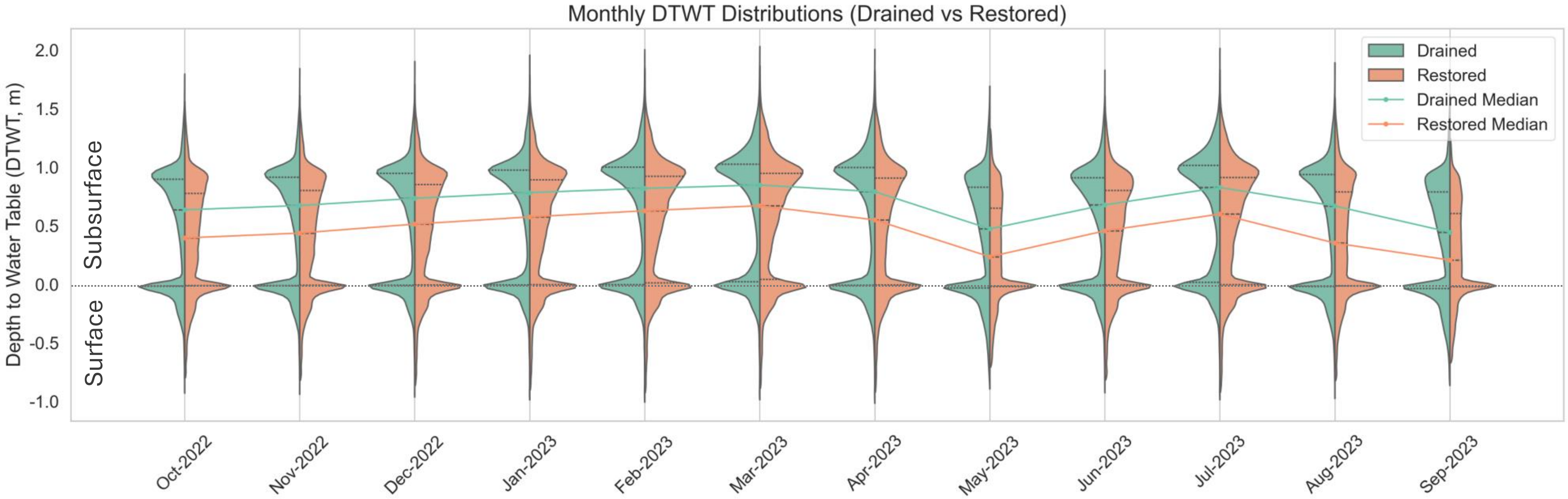
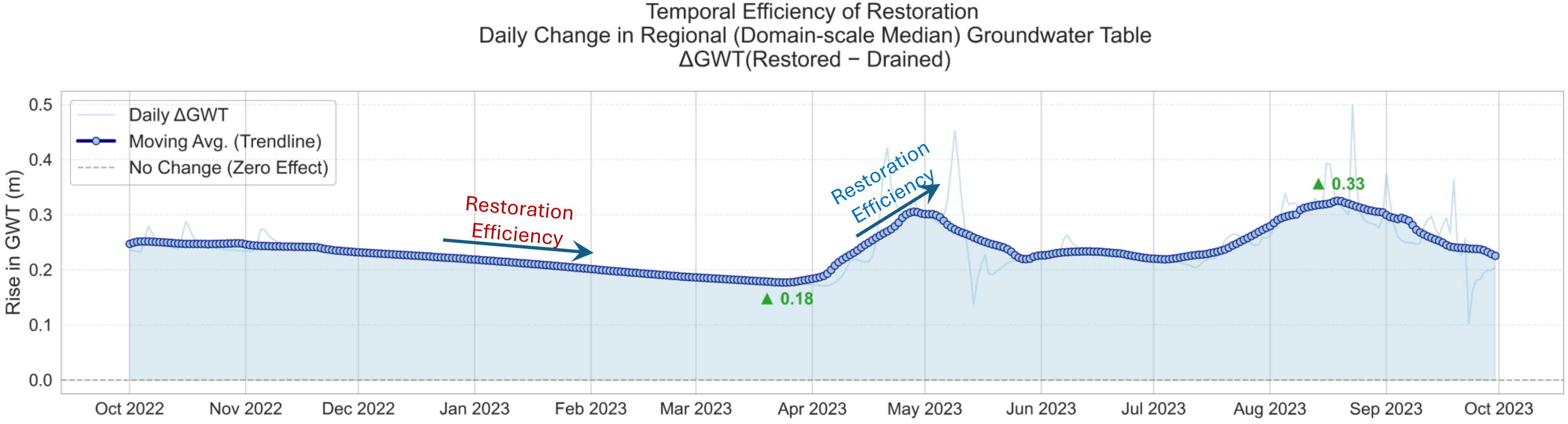


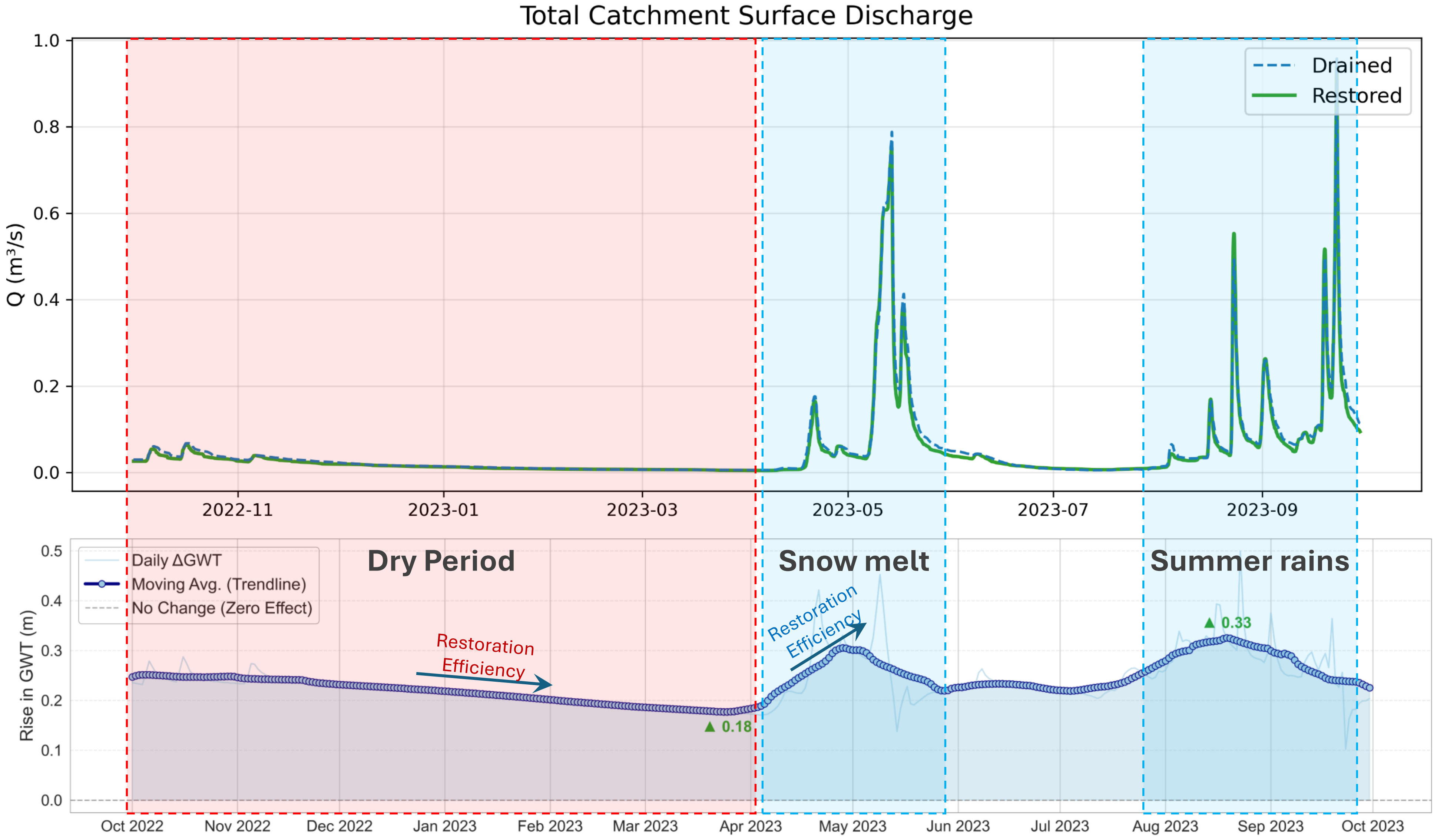
- **Restoration raises the water table in every month of the year.**
- **The strength of this rise changes over time, but it never drops below zero**



Temporal Dynamics of the Depth-to-water-table (DTWT)

When Is Restoration Most Effective Through the Year?

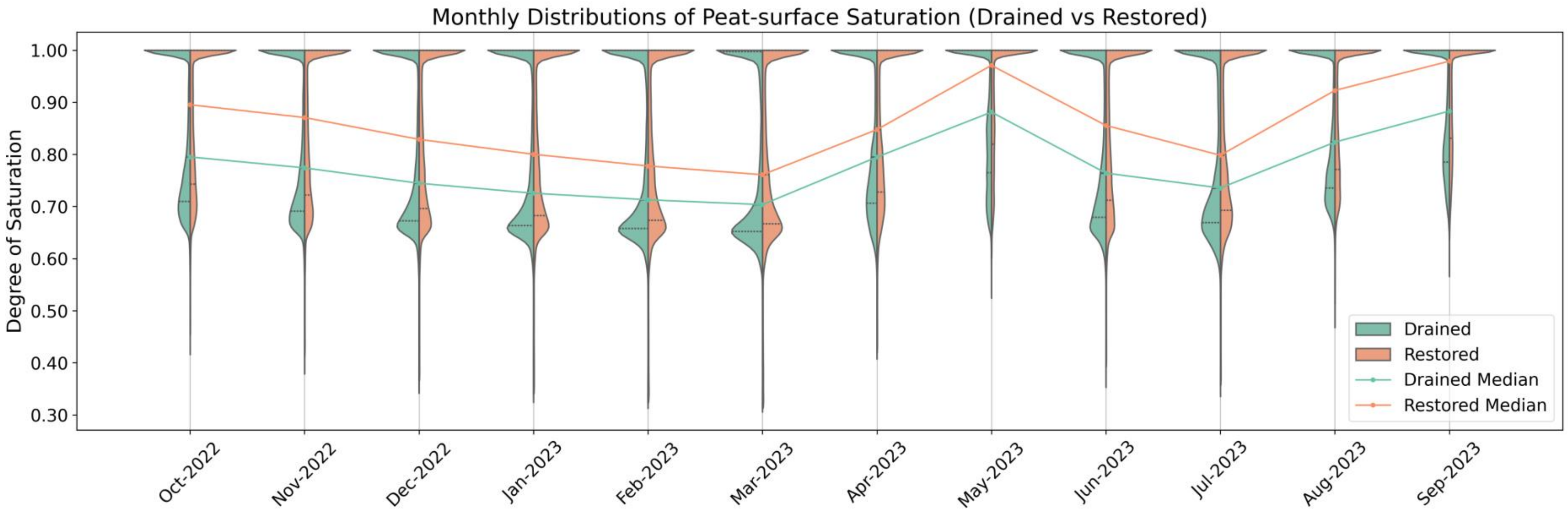
- **Restoration Functions with highest efficiency in wet periods (spring melt & summer rains)**
- **Lower efficiency during dry winter months**
- **Seasonal rise: ~33 cm vs. ~18 cm**



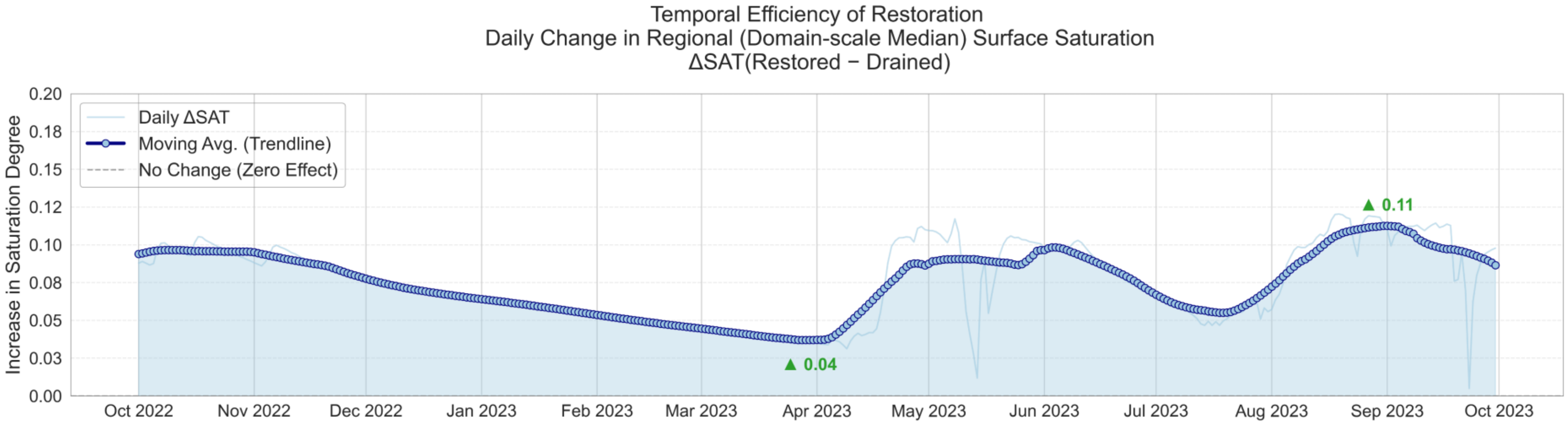
Temporal Dynamics of the Peat-surface Saturation (SAT)

How much does restoration increase the saturation level?

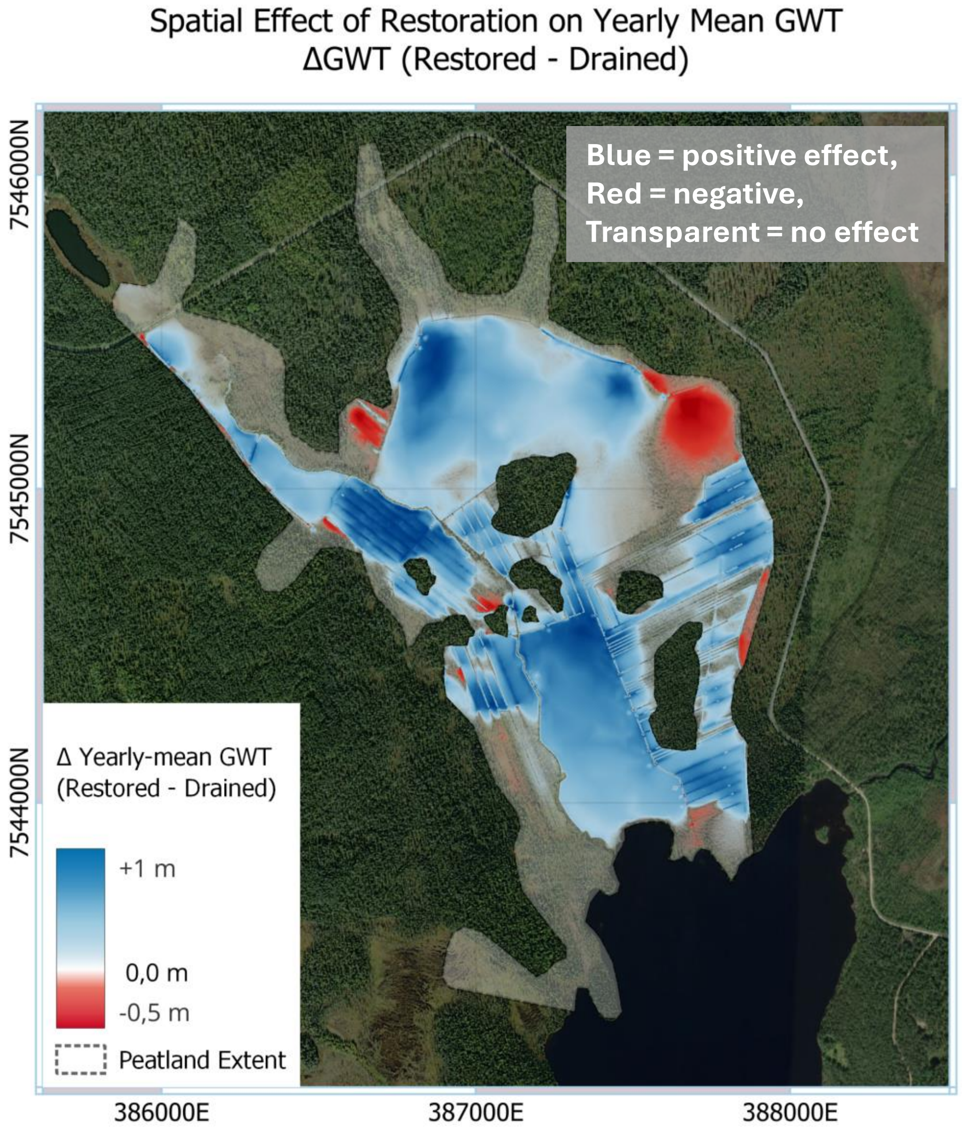
- **Restoration shifts peat surface toward wetter conditions**

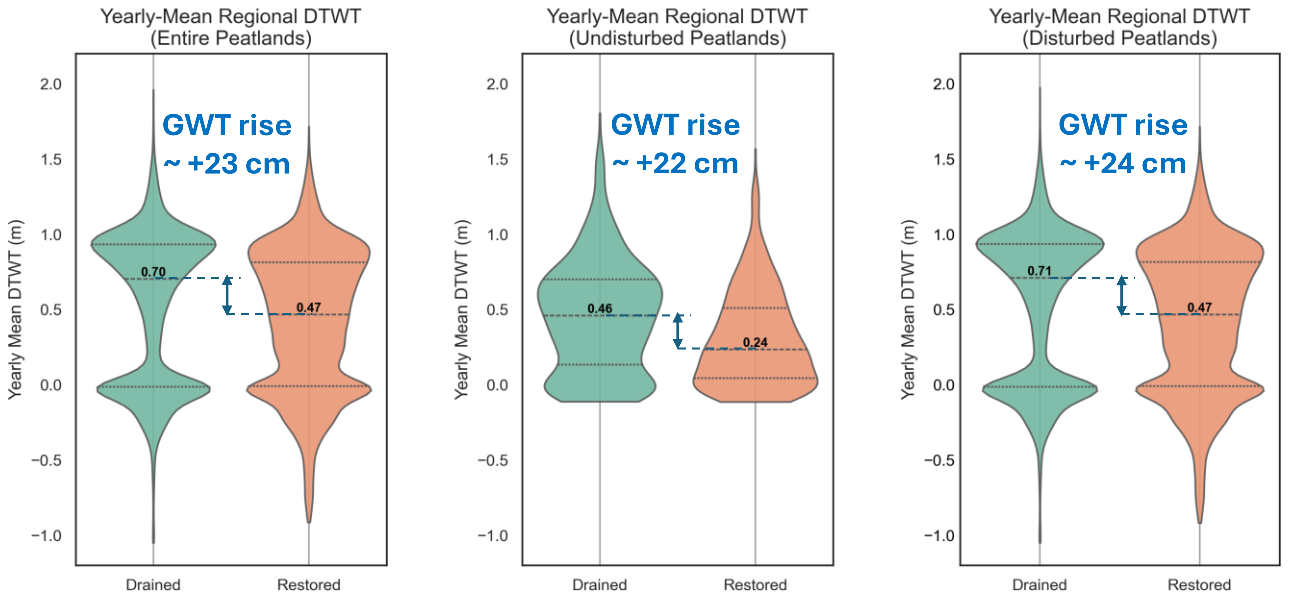


- **Seasonal improvement: 4% (dry) → 11% (wet)**



Spatial Map for the GWT rise – Some Important Numbers



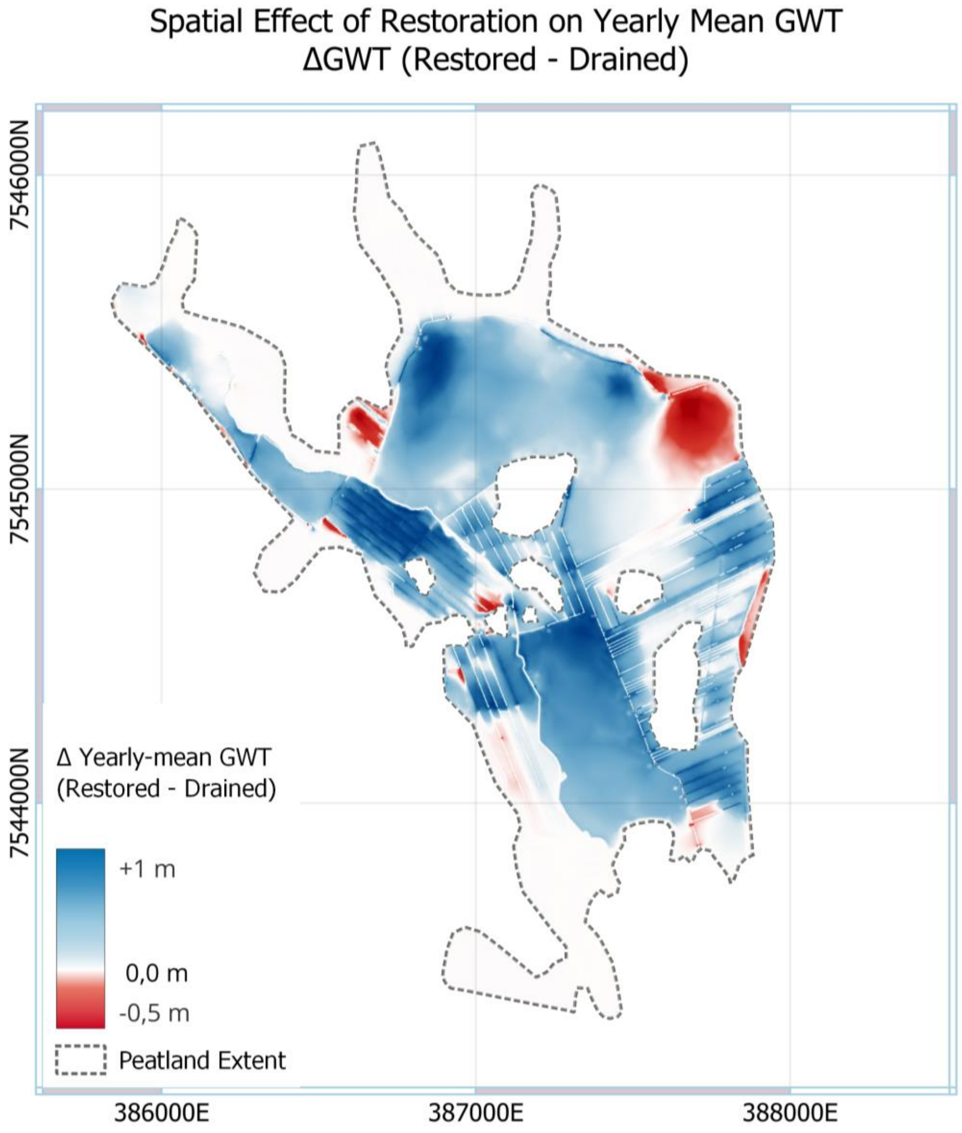


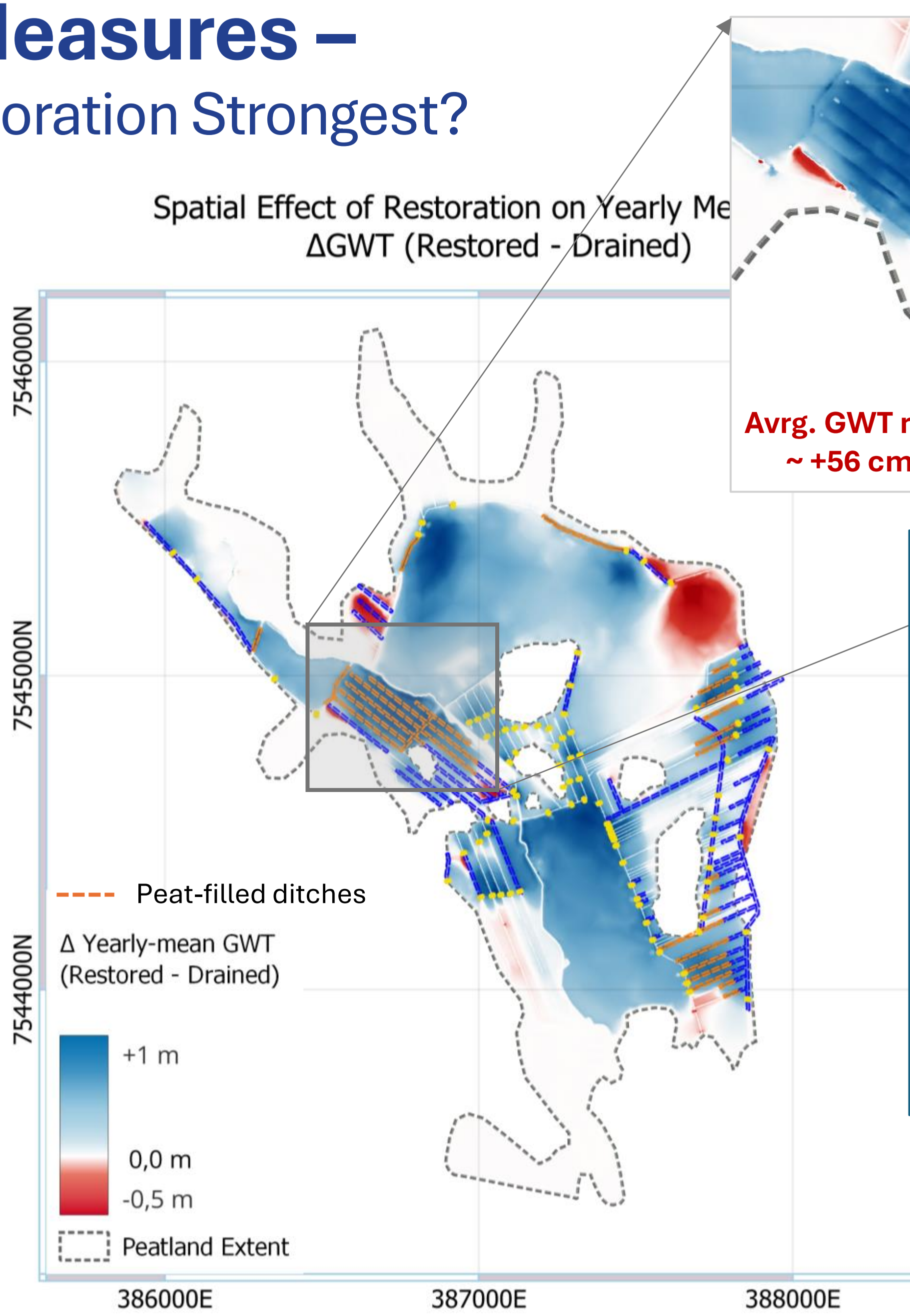
Entire Peatland

Undisturbed Peatland

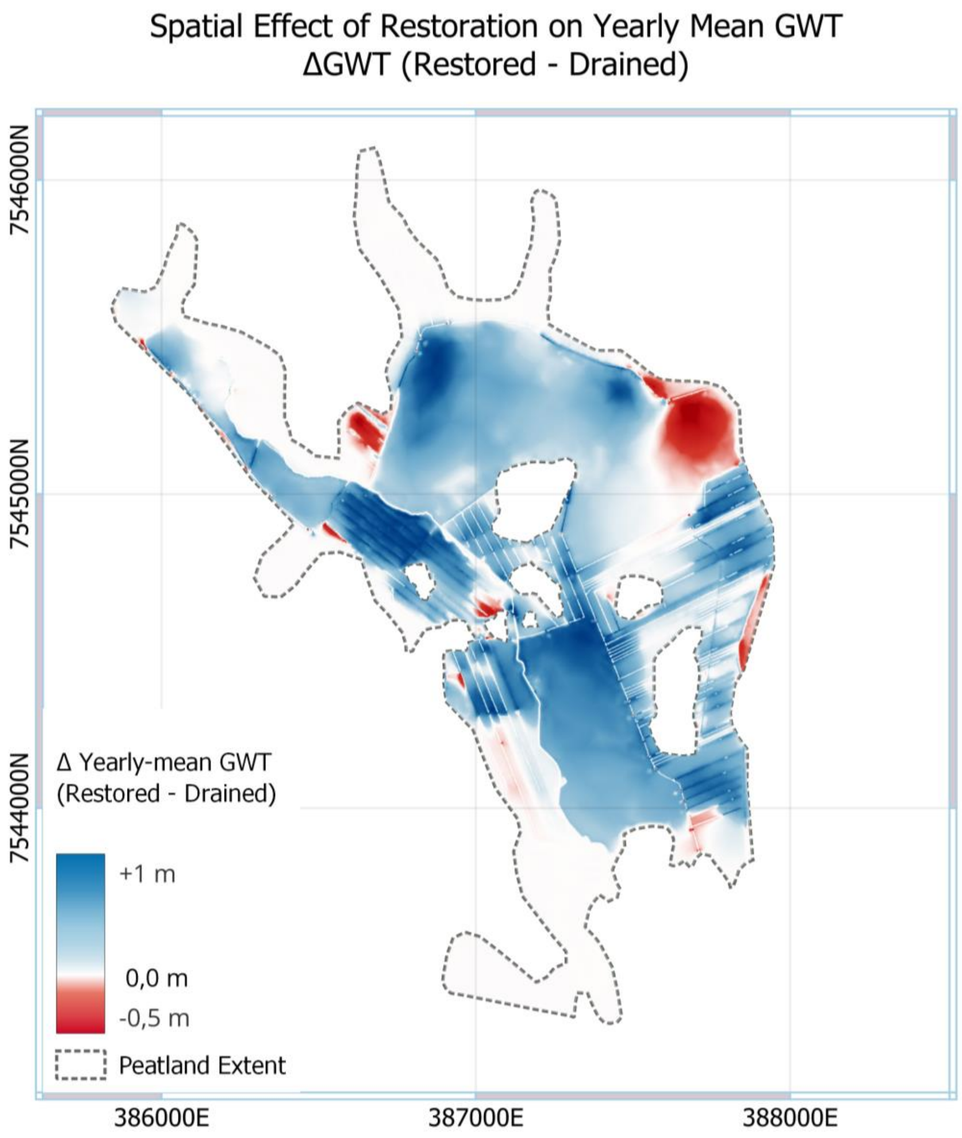
Disturbed Peatland

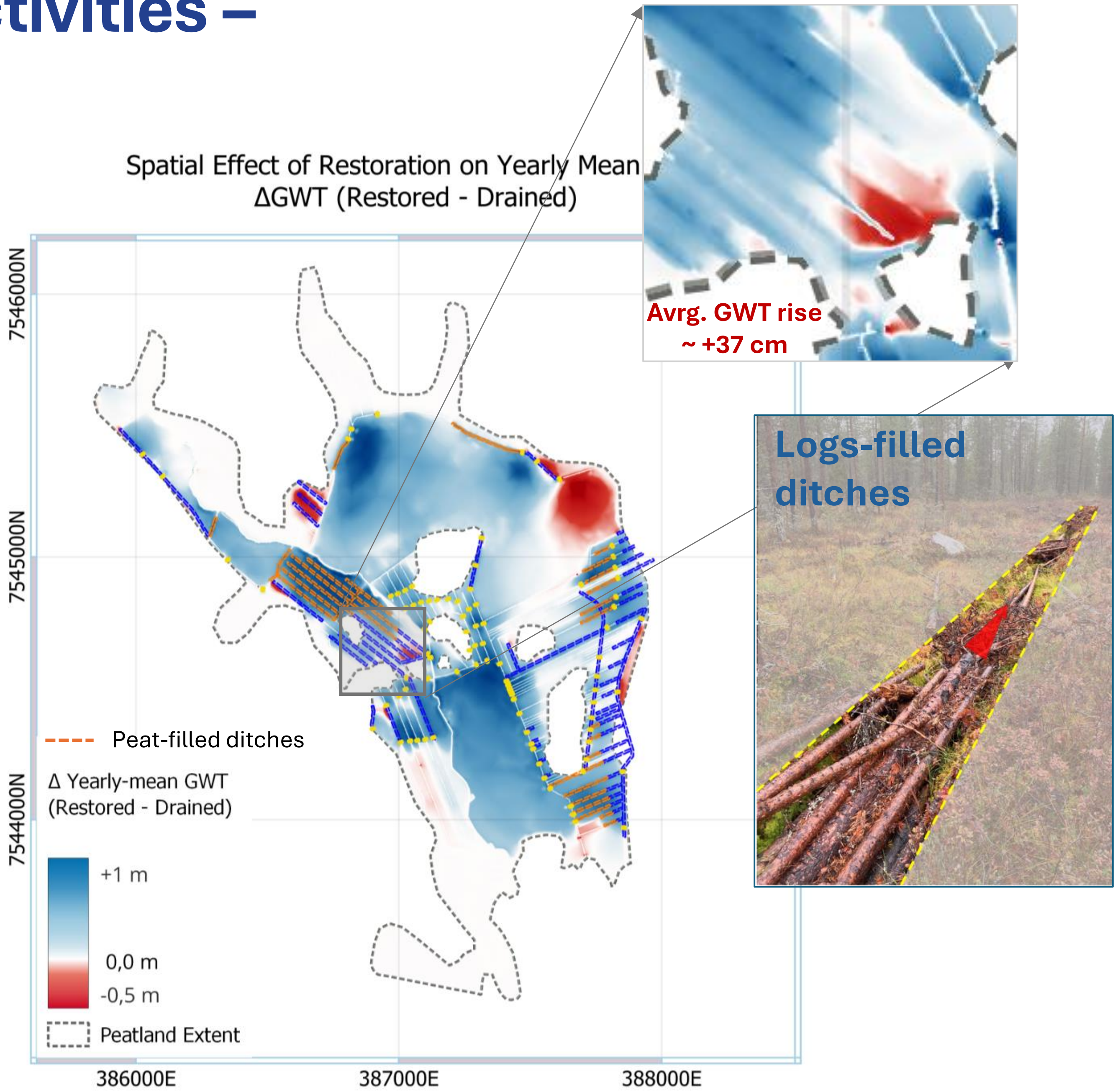
Effect of Restoration Measures –
Where Are Local Effects of Restoration Strongest?





Effect of restoration activities – Local Effects





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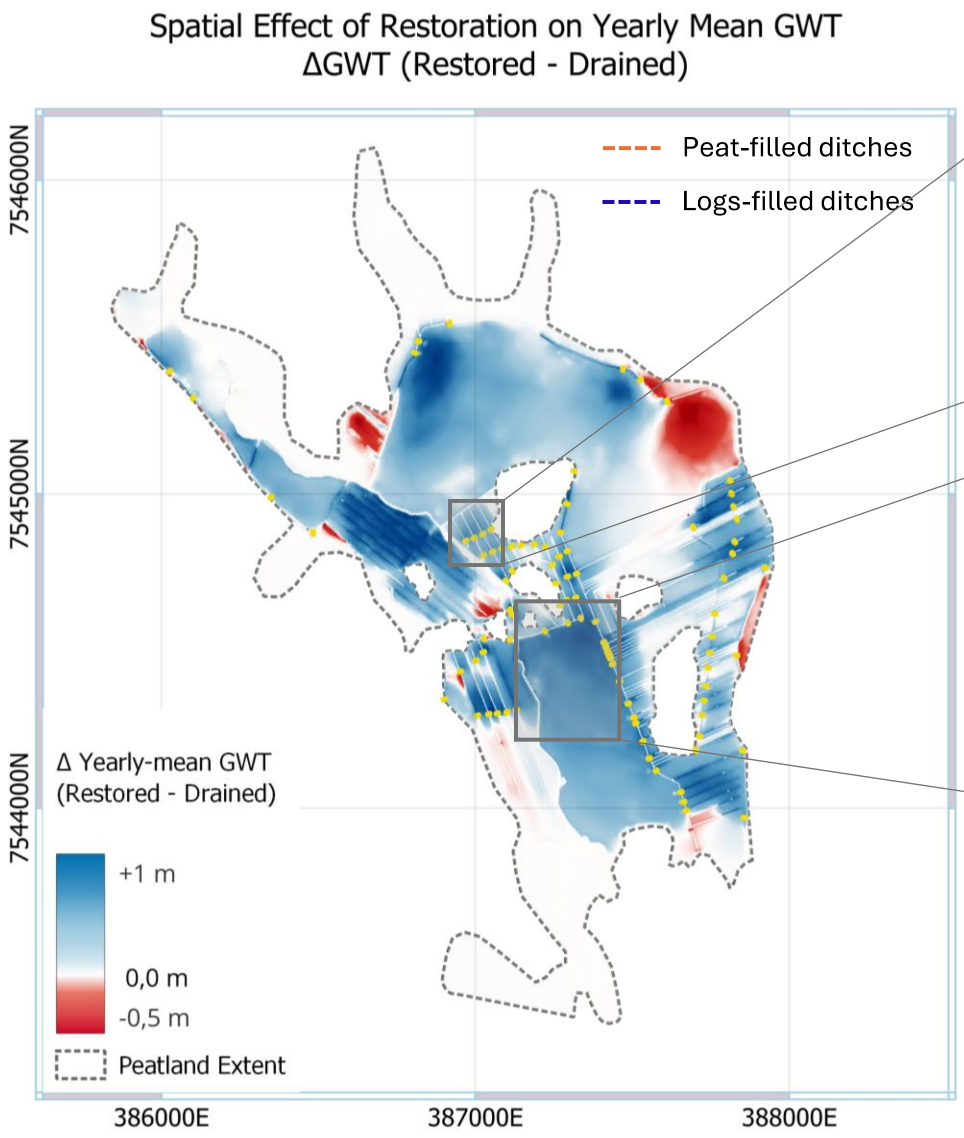
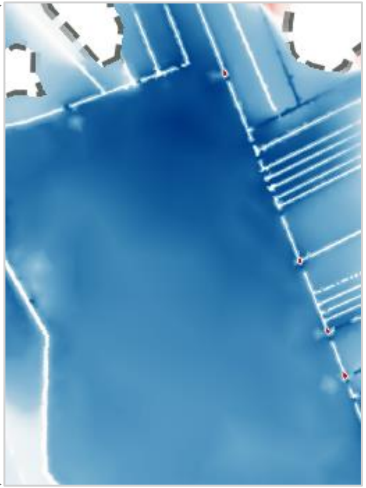
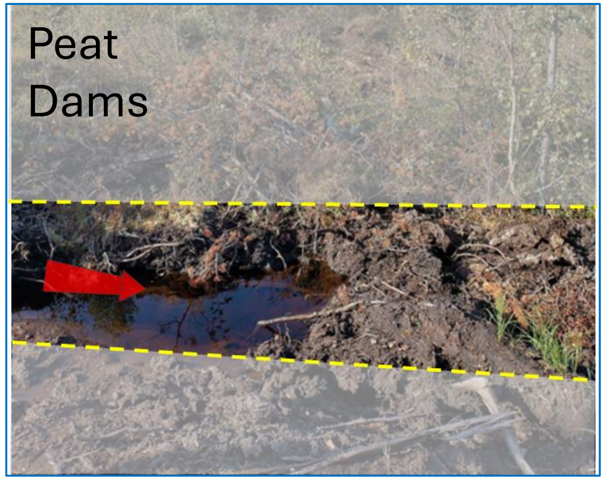


Add average number here!

Strong local effect, particularly on the local U.S ground water level

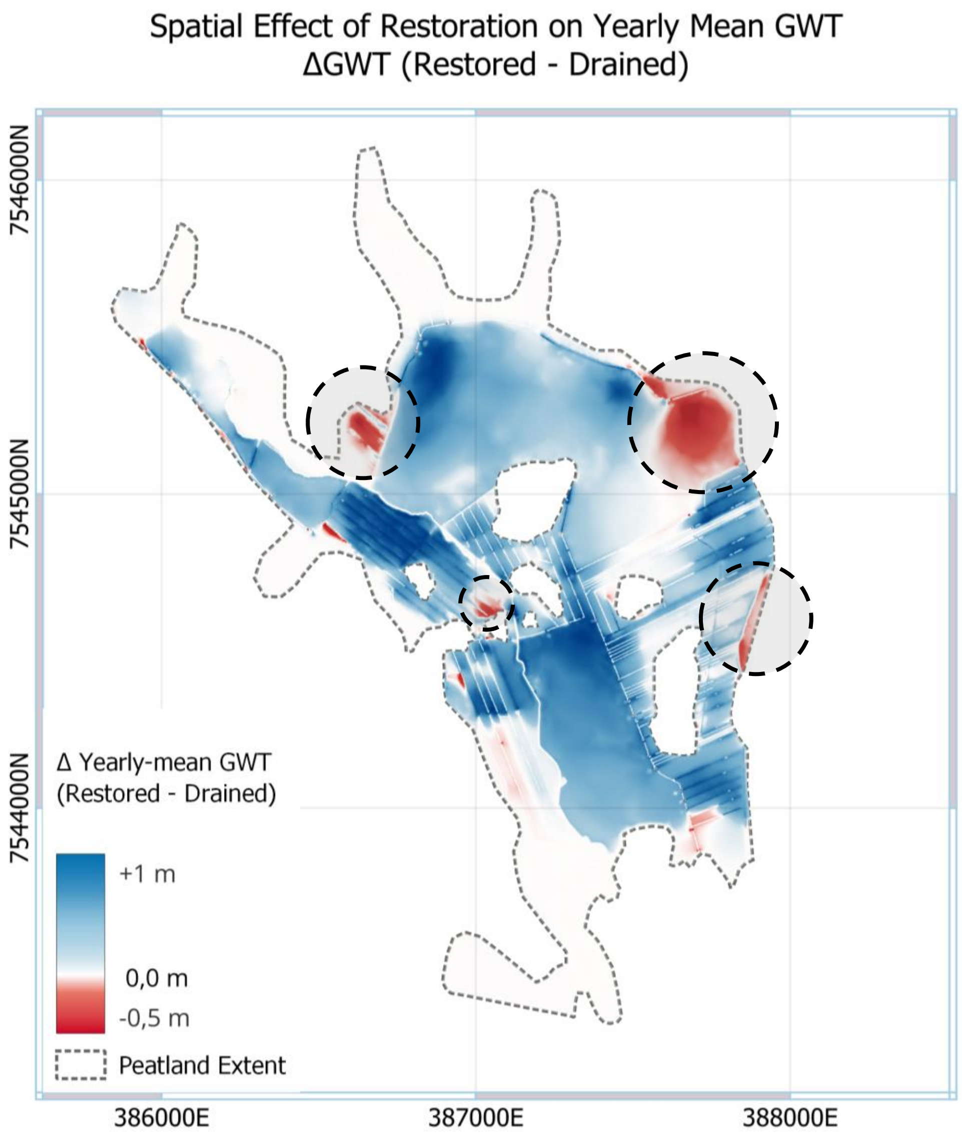


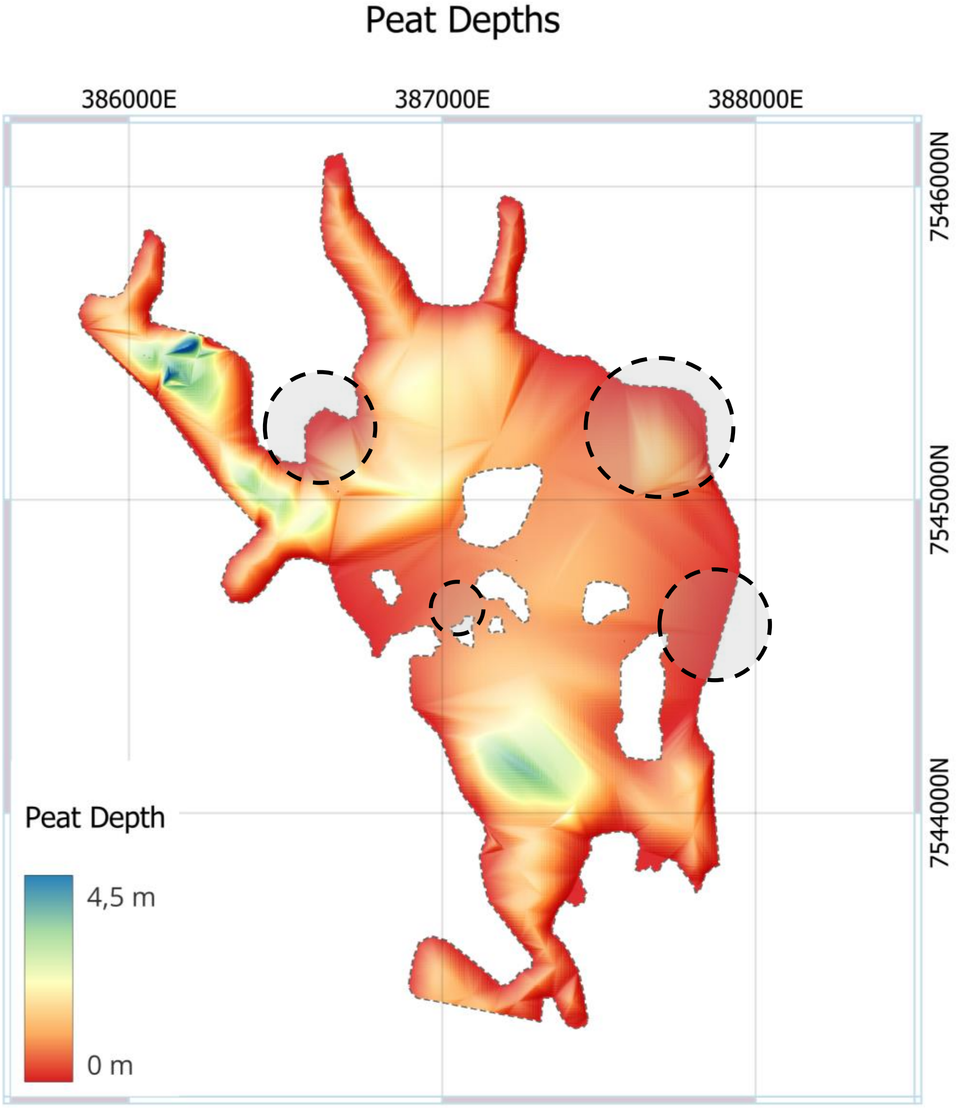
Regional far-field effects on the undisturbed area help rising GWT significantly



Effect of restoration activities – Regional Effects

Why does GWT drop in some locations, post-restoration? (Fen or Forest?)

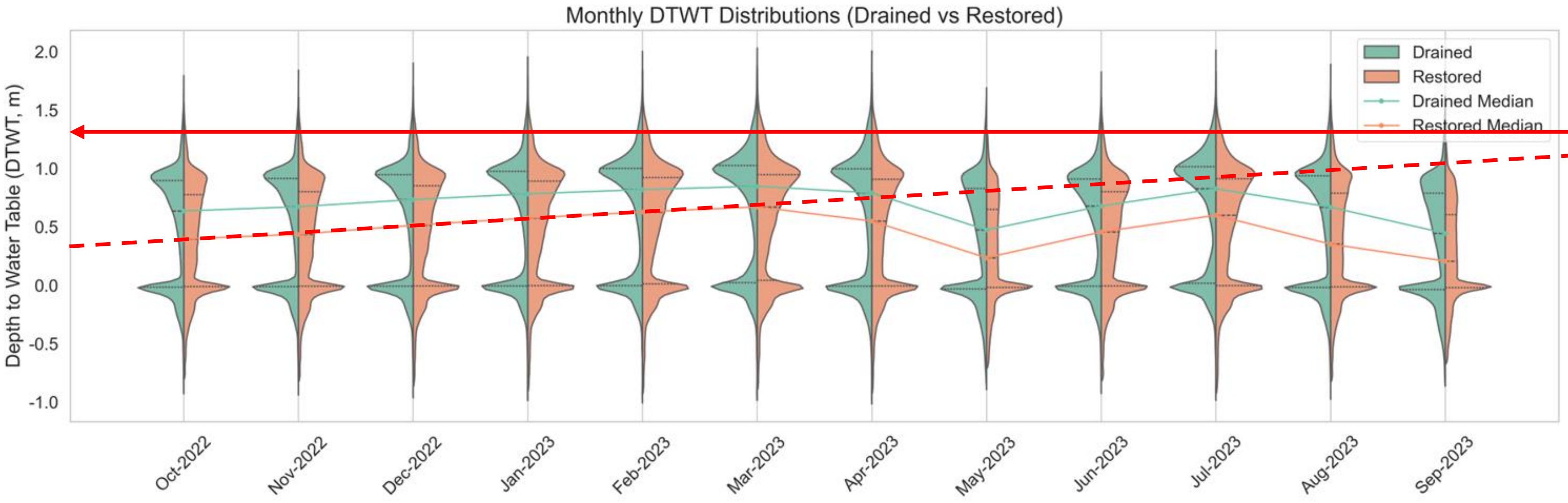




- Groundwater drops post-restoration in some peatland edges
- Occurs at peat–mineral soil transition zones (hillslope breaks)
- Pre-restoration: ditches kept water table high at the margins of the peat formation
- Post-restoration: blocked ditches redirect water fluxes
- Thin peat & steep formation slopes, when meets mineral soils cause hydraulic discontinuities

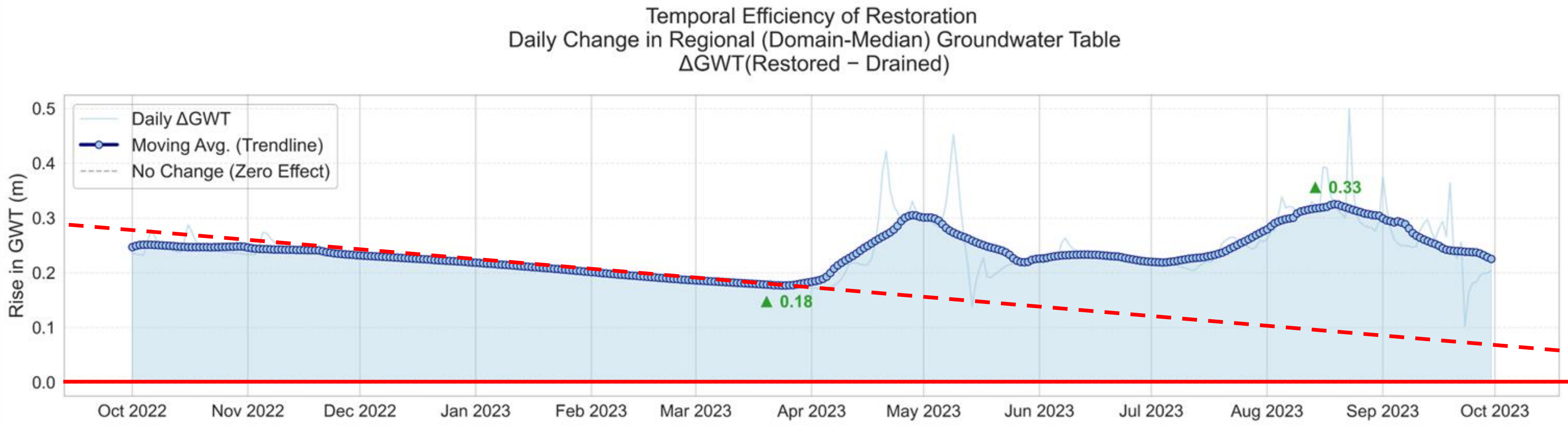
Is there a threshold of regional water depth at which restoration is useless?

Restoration loses its efficiency the drier it gets in the catchment.



Restoration is likely useless if median regional GWT drops to less than (≈1.35m) below ground surface

Well, neither the drains :D (the water wouldn't interact with the drains, you dump!

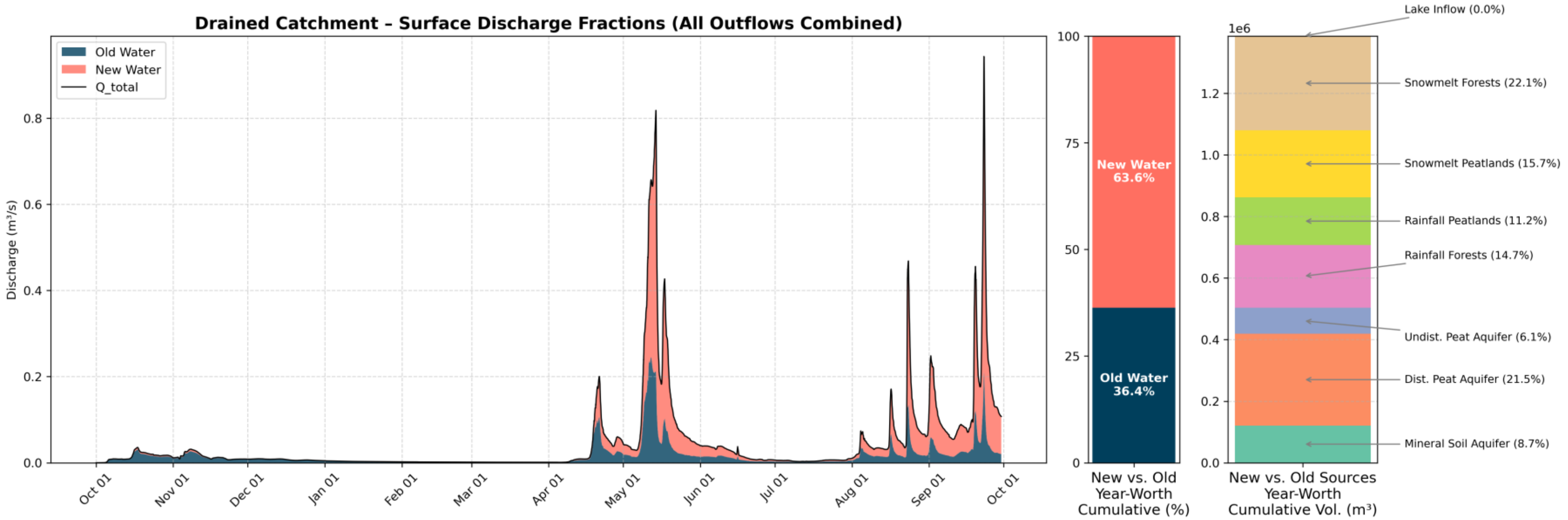


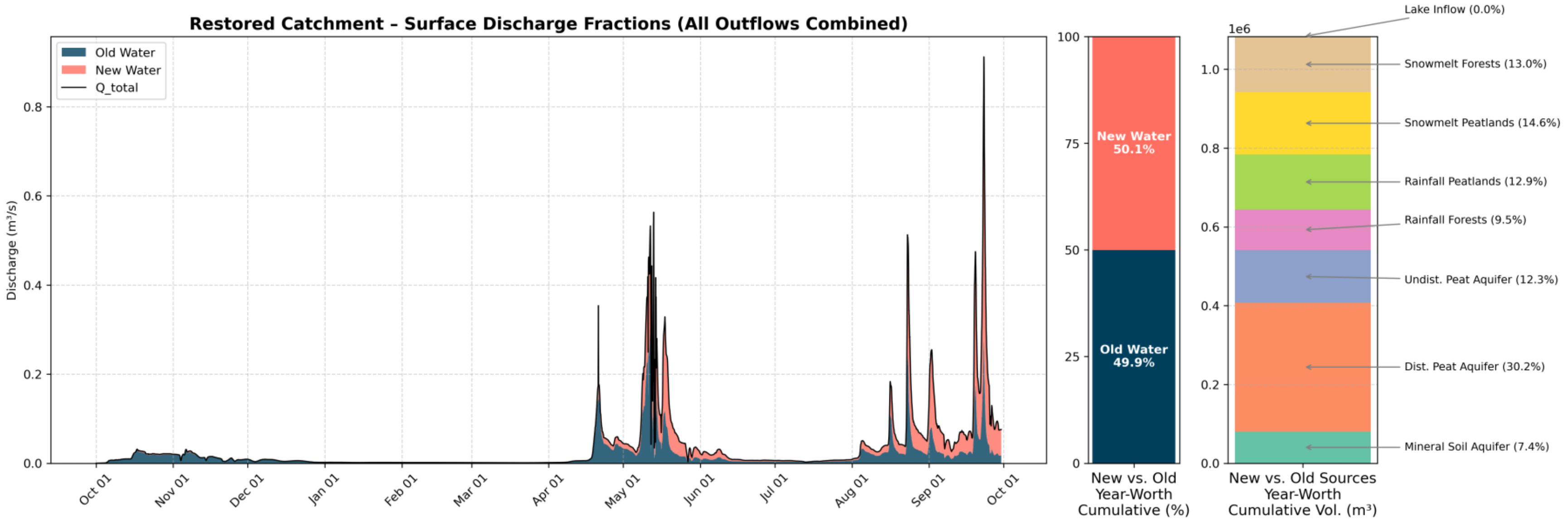
the system apparent to be linearly proportional in this aspect

Zero Effect

Extended dry period

Thanks for listening





Disentangling the contributions of new versus old water to surface runoff across these management states;

New Water

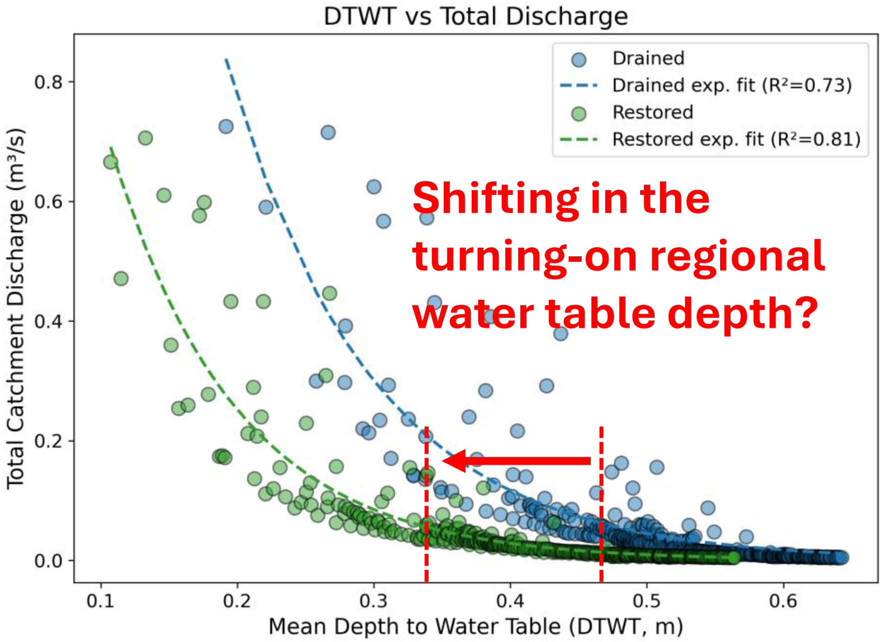
- Inputs from **rainfall**, **snowfall/melt**, **or lake inflow** within **one hydrologic year**
- Any water reaching the stream, from these previously mentioned sources, as runoff in **< 1 year**

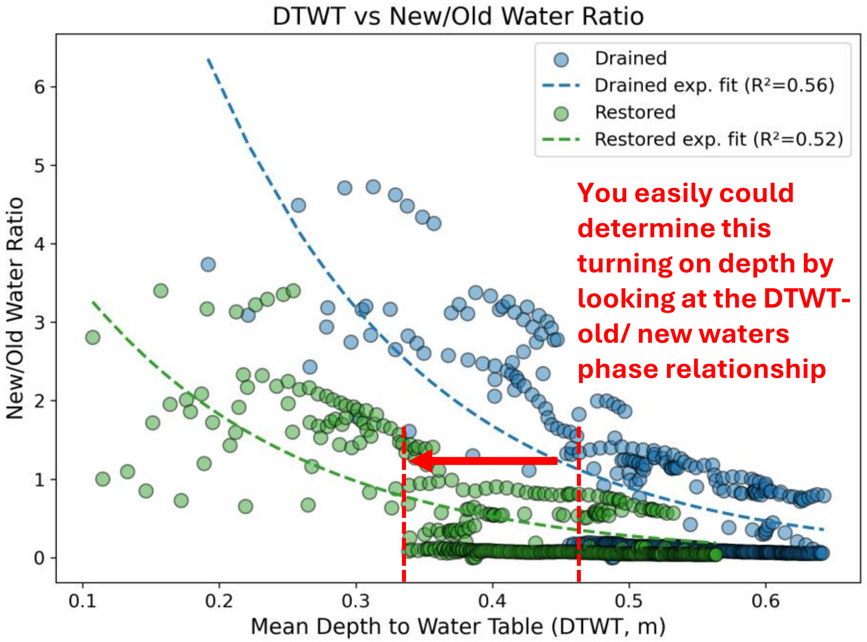
Old Water

- Stored in the **catchment subsurface** before simulation begins
- Any contribution to runoff from this storage is considered **old**

Results suggest that restoration slightly increased the old water contribution to stream and decreases volume of new water leaving the catchment. More new water is kept in catchment storages

When does the catchment discharge turn on?
Disentangle the contributions of new versus old water to surface runoff across these management states;





In **Intact peatlands**, high storage often means more old water dominates runoff in surface streams.

- In **drained systems**, shallow /or deep antecedent WTD strongly affects whether new rain/ melt bypasses storage.
- In **restored systems**, the relationship should shift back toward more old-water contributions at higher WTD.

A clear threshold with different value where the stream starts dealing with both water sources (old and new). When WT is 0.46cm below ground in drained, and 34cm in restored condition, the stream starting getting active in carrying newwaters.

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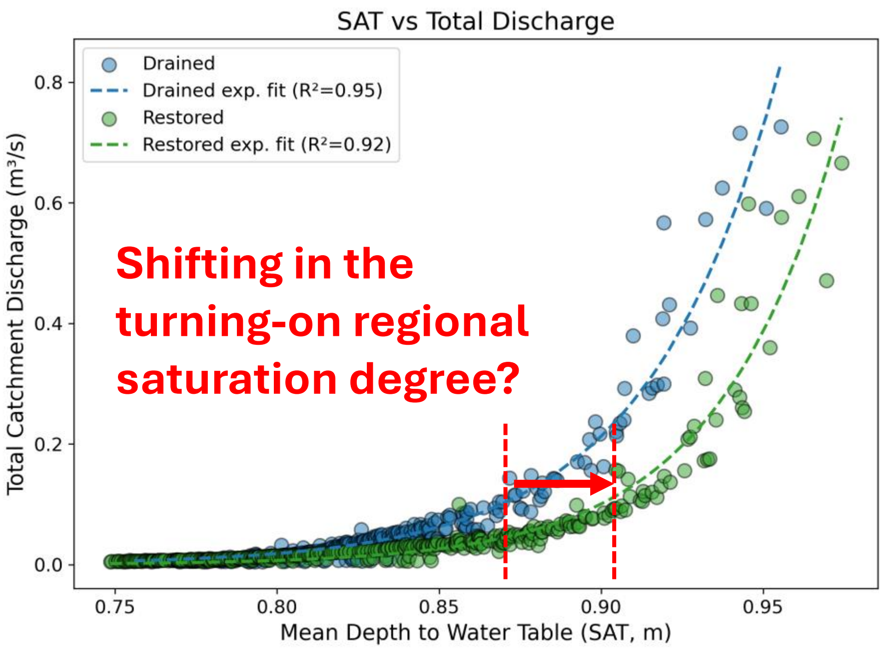

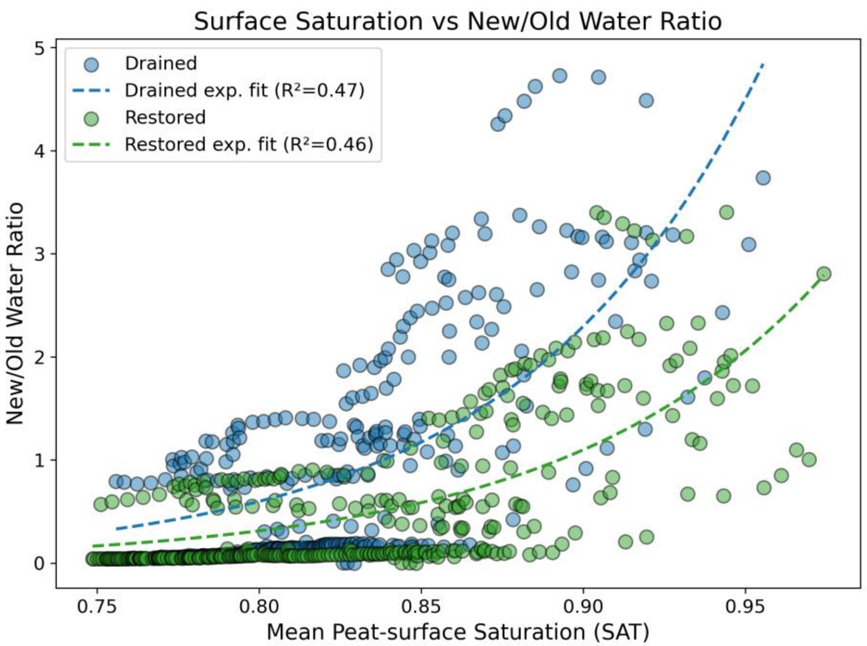

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Summary – Key Takeaways

- **Restoration consistently raises water tables**
- **Efficiency varies seasonally (**nearly twice as effective during wet periods compared to dry ones)
- **Efficiency varies Spatially (**strong local impacts near intervention sites, particularly peat-filled ditches)
- **Some edge zones show declines due to boundary hydrology**
- **Overall: ~23 cm average rise across the peatland**

Thanks for listening

Any thoughts ?

Any questions you may be interested in, and needed to be answered by the models ?