For peat’s sake

Representing the largest terrestrial carbon store

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Peat

- Historically a small sink, but thousands of years of non-equilibrium → large store
- ~3% of the global land surface (12% in the UK) but 1/3 of the soil carbon

- Peatlands have been degraded everywhere
- Emissions (even excluding fire) make up 4% of anthropogenic emissions
- Restoration of peatlands could be important

It's wet

↓

Inputs exceed decay

↓

Peat accumulates

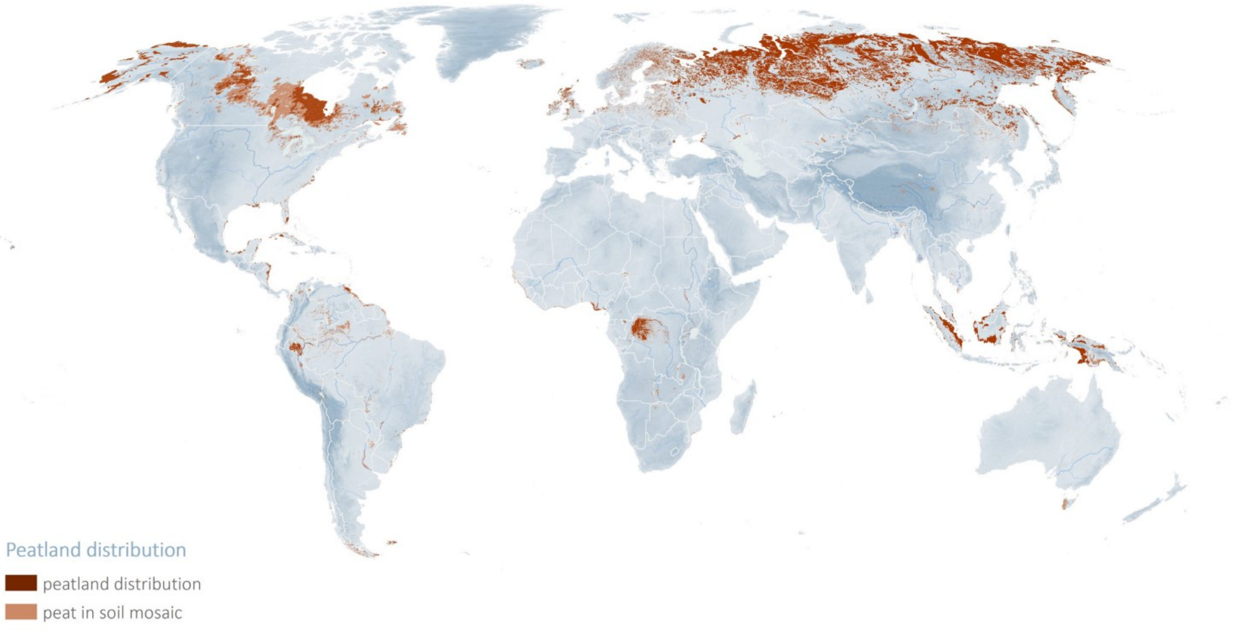


Figure 0.2: The Global Peatland Map 2.0.
Source: Global Peatlands Assessment data retrieved from the Global Peatland Database compiled by the Greifswald Mire Centre.

MOTHERSHIP project

Questions:

- Impacts of climate and land use change on temperate peatlands
- Optimal strategies to deliver net zero

(Some) parts of the project:

- Setting up an observation network
- Developing modelling tools to predict future resilience (including JULES-Peat)
- Sharing knowledge

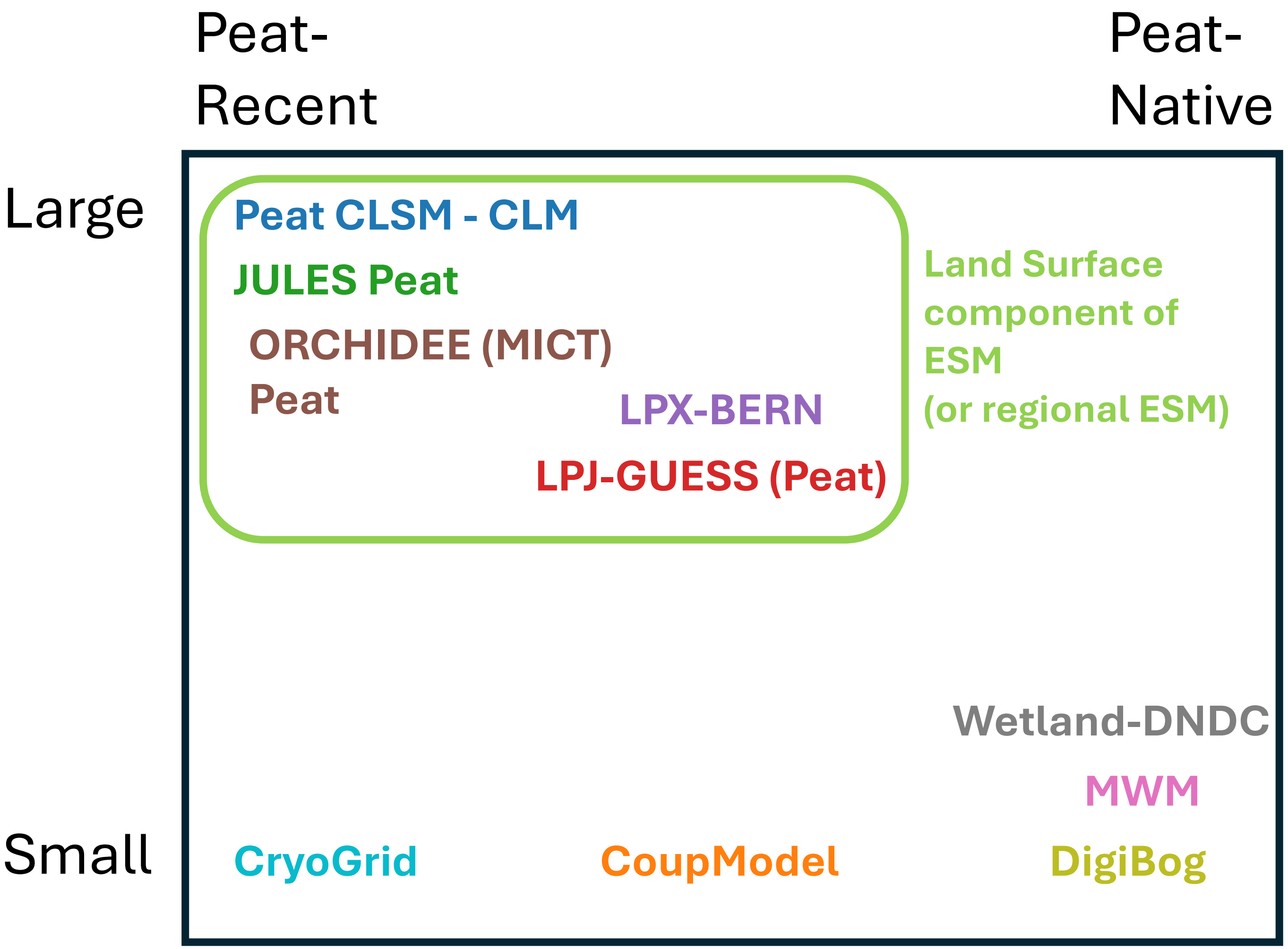
Earth System Models have neglected peatlands

- Historically a small carbon sink
- Long timescales affected by past climate
- Non-equilibrium
- A small area
- Non-productive land
- Unique PFTs, drivers and feedbacks

But, there are opportunities to rectifying this:

- **New means of evaluation:** virtual cores, bog breathing
- **Interactions**: physical soil properties – vegetation – hydrology – fire – permafrost, drainage / rewetting
- **Ecosystem services:** water quality and availability, carbon

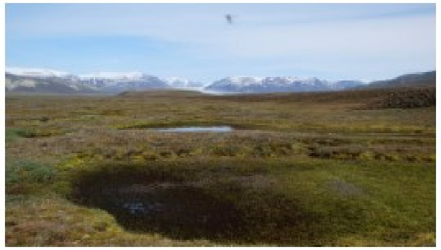
JULES
Joint UK Land Environment Simulator



Peat modelling workshops

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

Peat sector



Sarah Chadburn

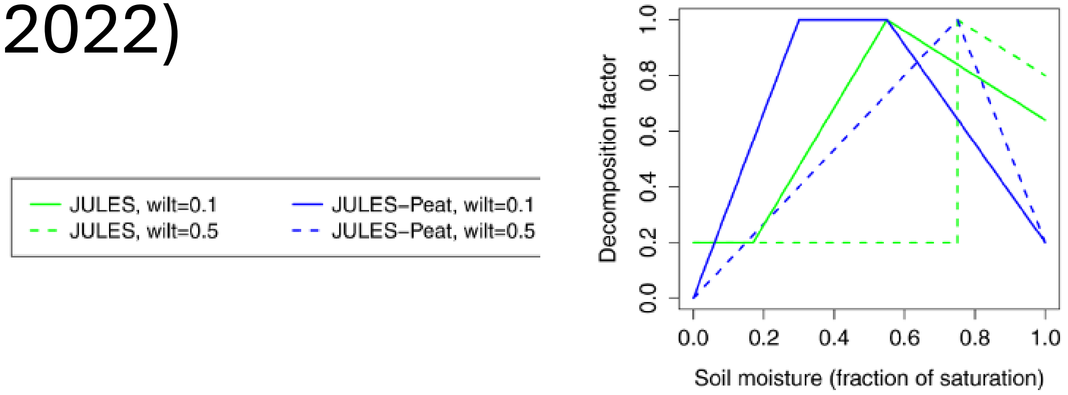
Angela Gallego-Sala

Noah Smith

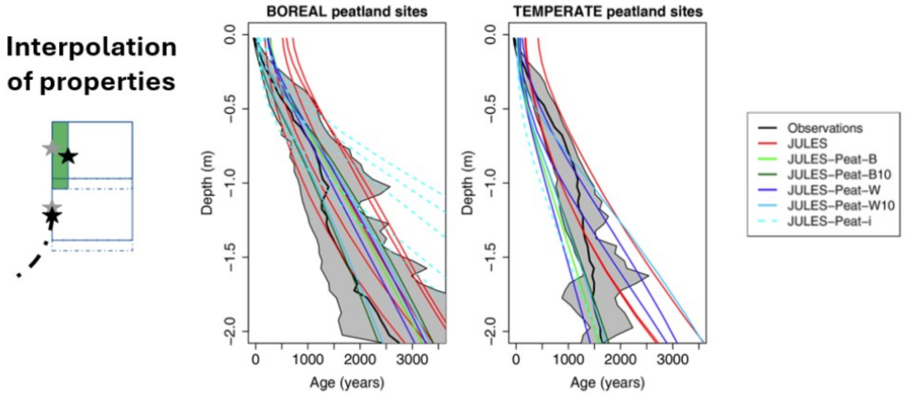
Michel Bechtold

JULES-Peat Chadburn et al. (2022)

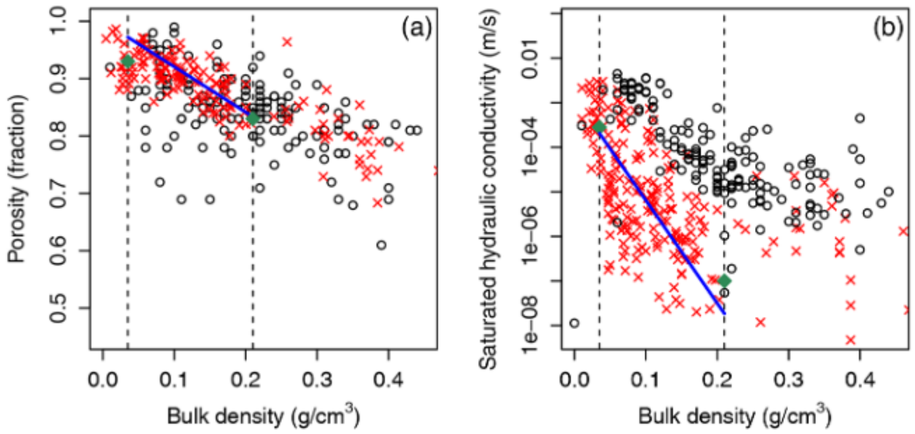
Limit decomposition when wet



Allow soil to accumulate



Change physical soil properties based on undecomposed / decomposed carbon



What are we missing?

It's wet

↓

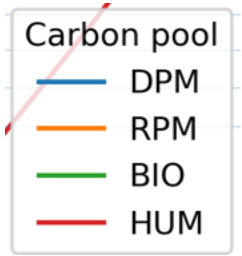
Inputs exceed decay

↓

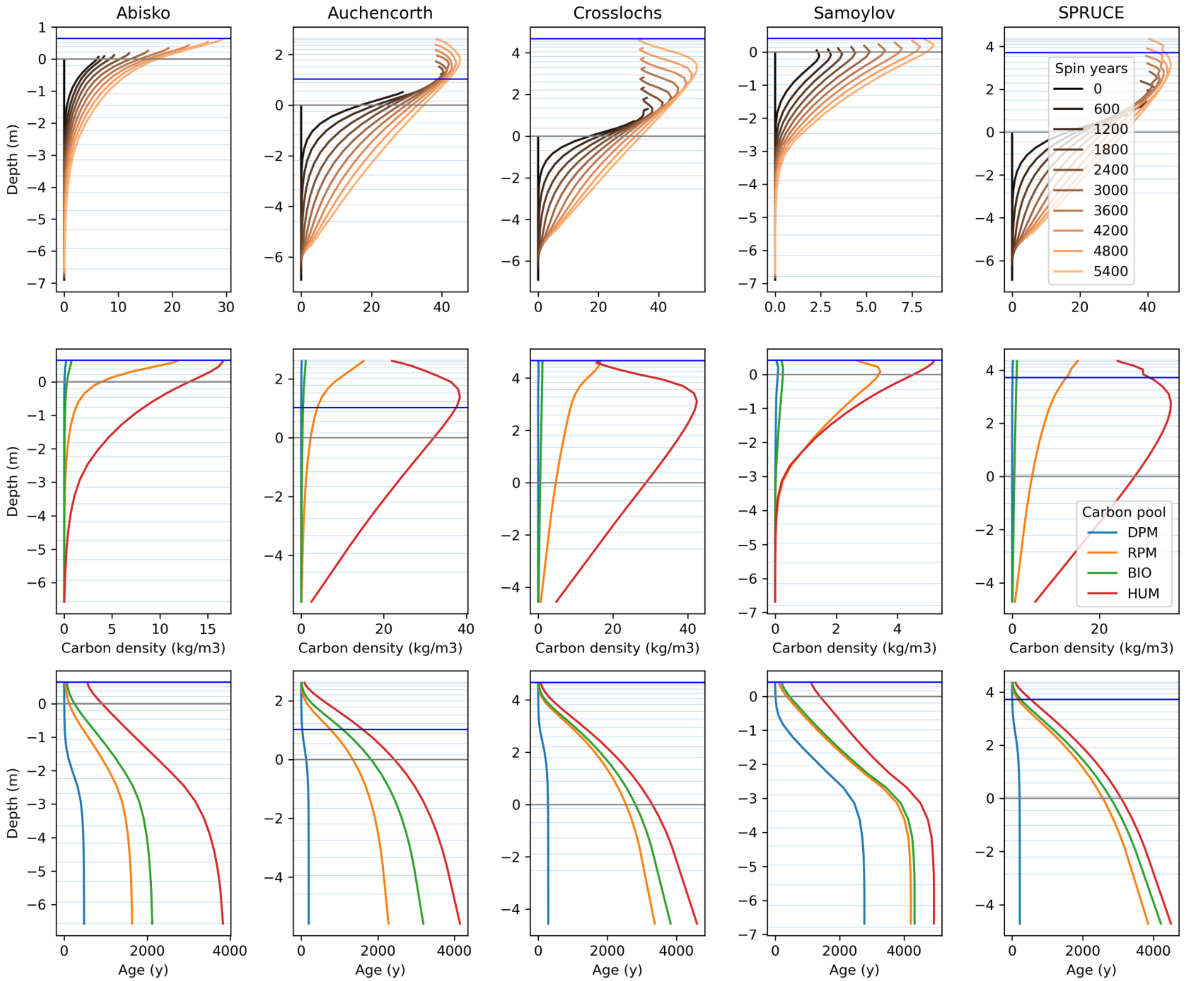
Peat accumulates

Peat accumulates

Carbon density by spin year (kg/m3)

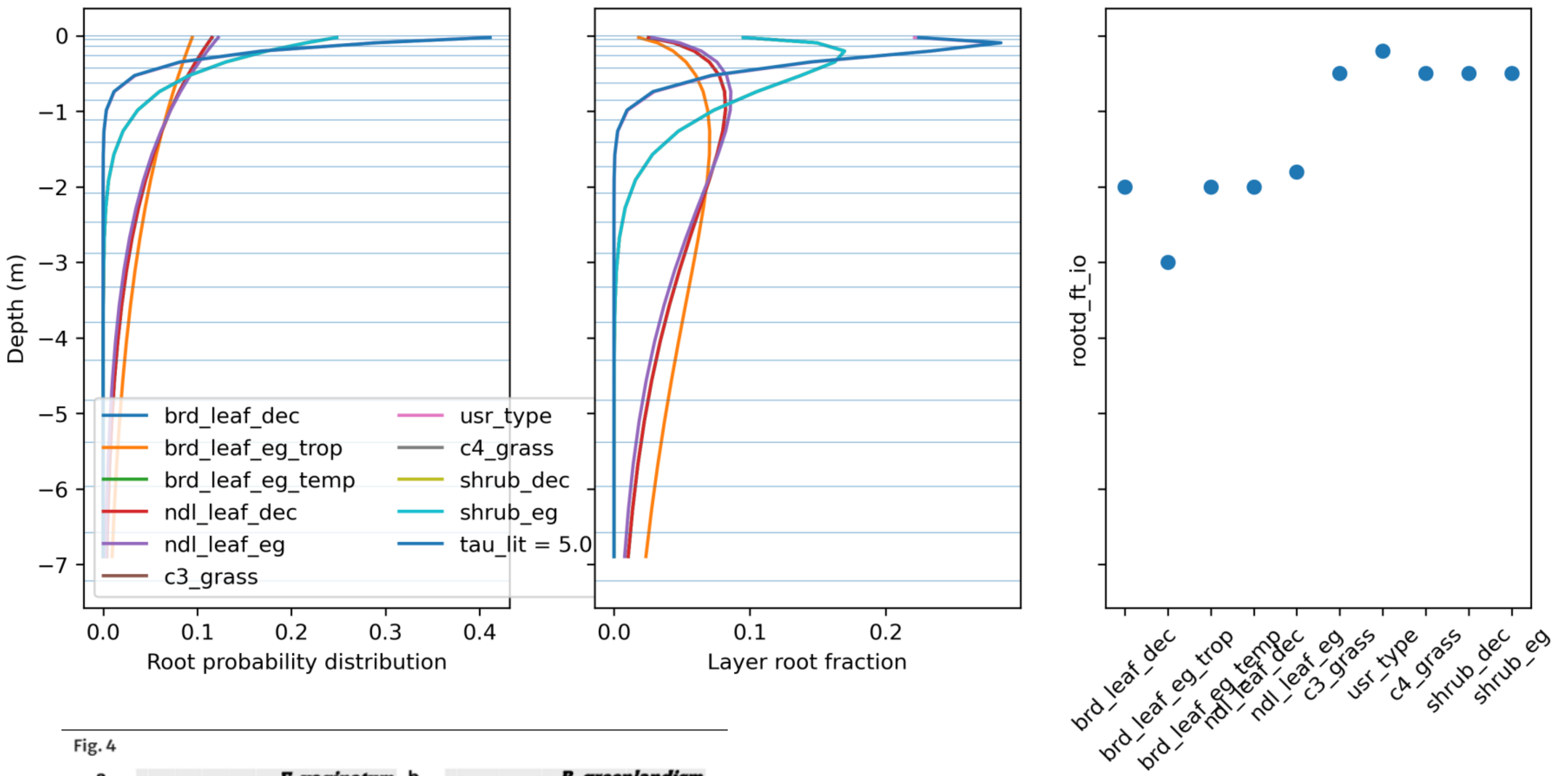


Age (y)



- RPM and HUM pools most important
- Where is the carbon going?
- What about depth dependence of respiration?

JULES root fractions

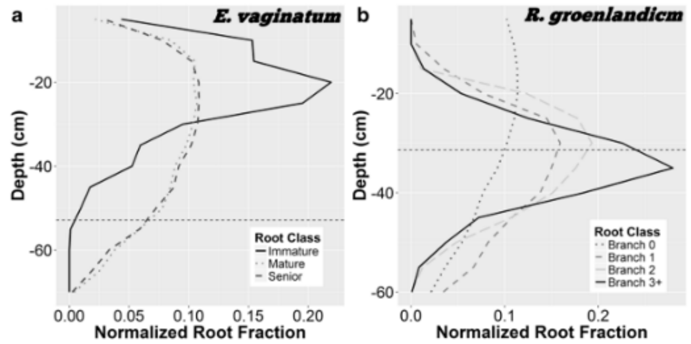


- Need PFT–dependent rooting depth
- Do we need a water table dependence of roots?

But is this even the right shape? (top and cutoff?)

...And are these even the right plants?

Fig. 4



a Normalized average root fraction by depth for each root class of *E. vaginatum*. b Normalized average root fraction by depth for each root class of *R. groenlandicum* . Dotted line indicates the average depth of root tips for all root classes (*E. vaginatum*) and fine roots defined as branch order 3 to 5 (*R. groenlandicum*)

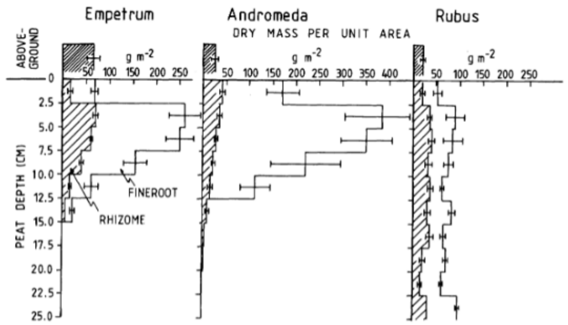


Fig. 1. Distribution (±SE) of biomass of the three dominating vascular plants on a raised area of *Sphagnum fuscum* at Stordalen. Hatched bars indicate above ground fractions or rhizomes, open bars indicate fine roots (<0.5 mm).

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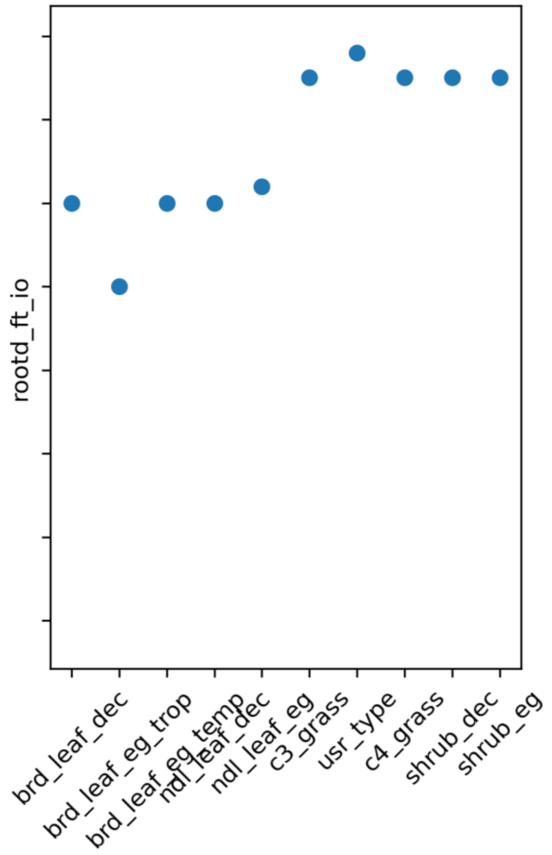
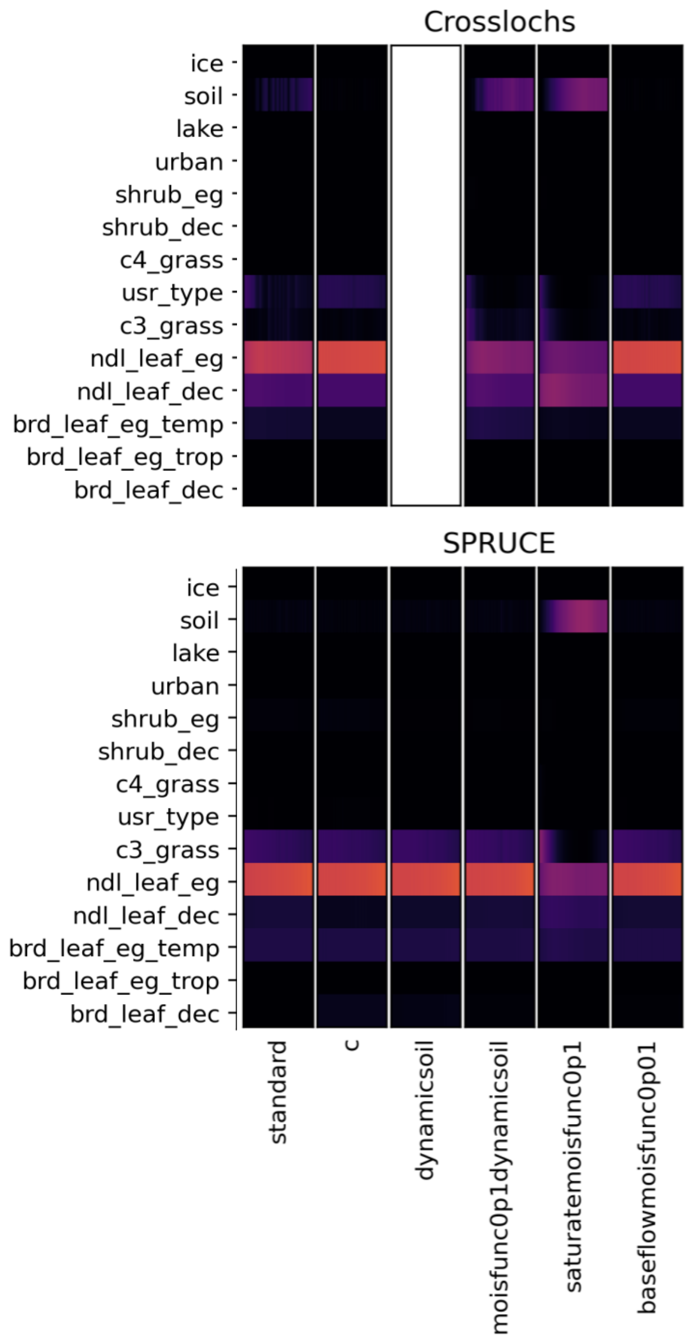
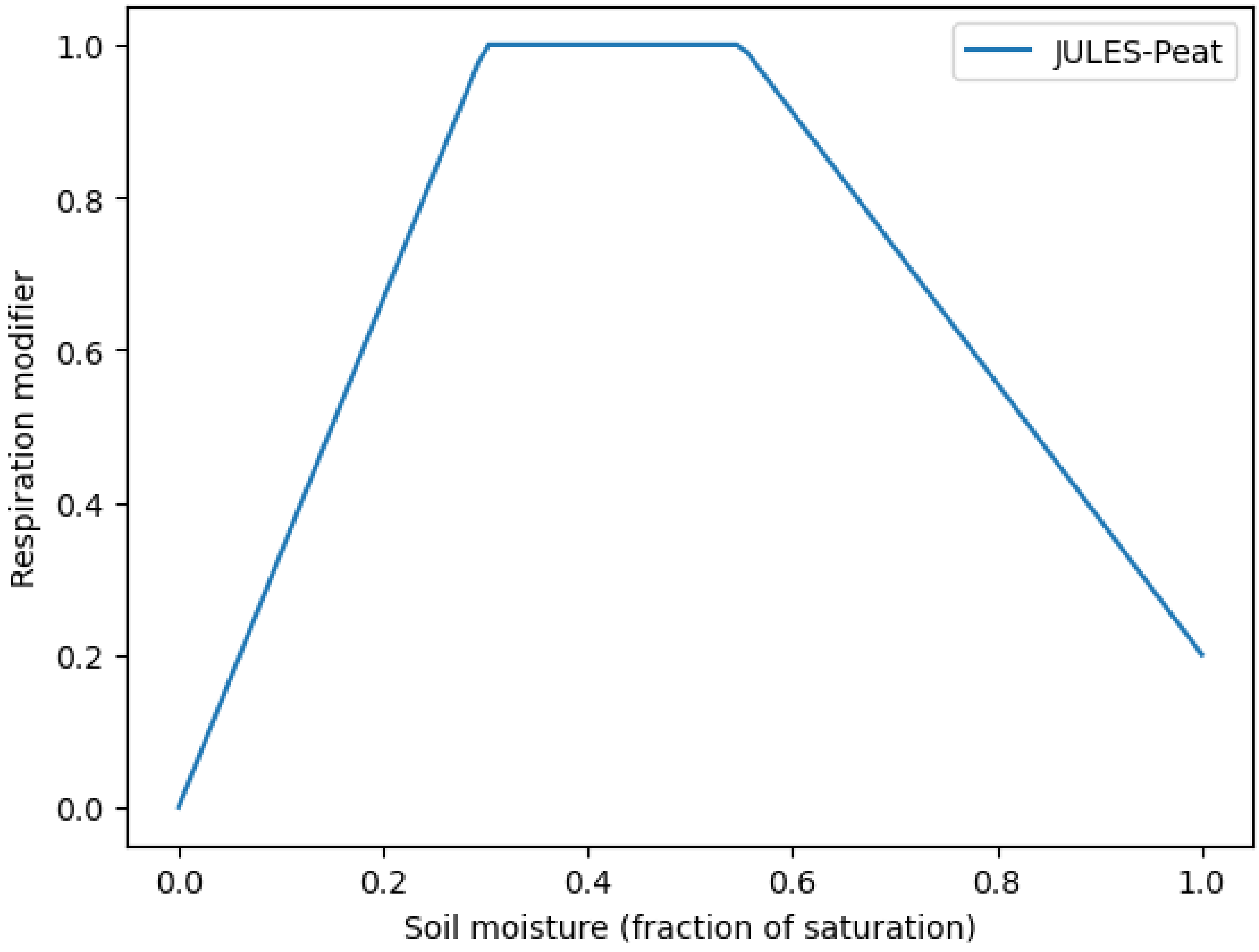
OIKOS 46:1 (1986)



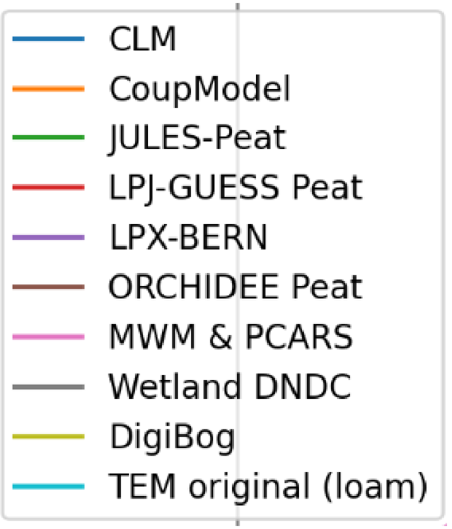


- We need moss!
- We also need waterlogging
- Do we need to think in assemblages?

Inputs exceed decay



Respiration modifier - Moisture



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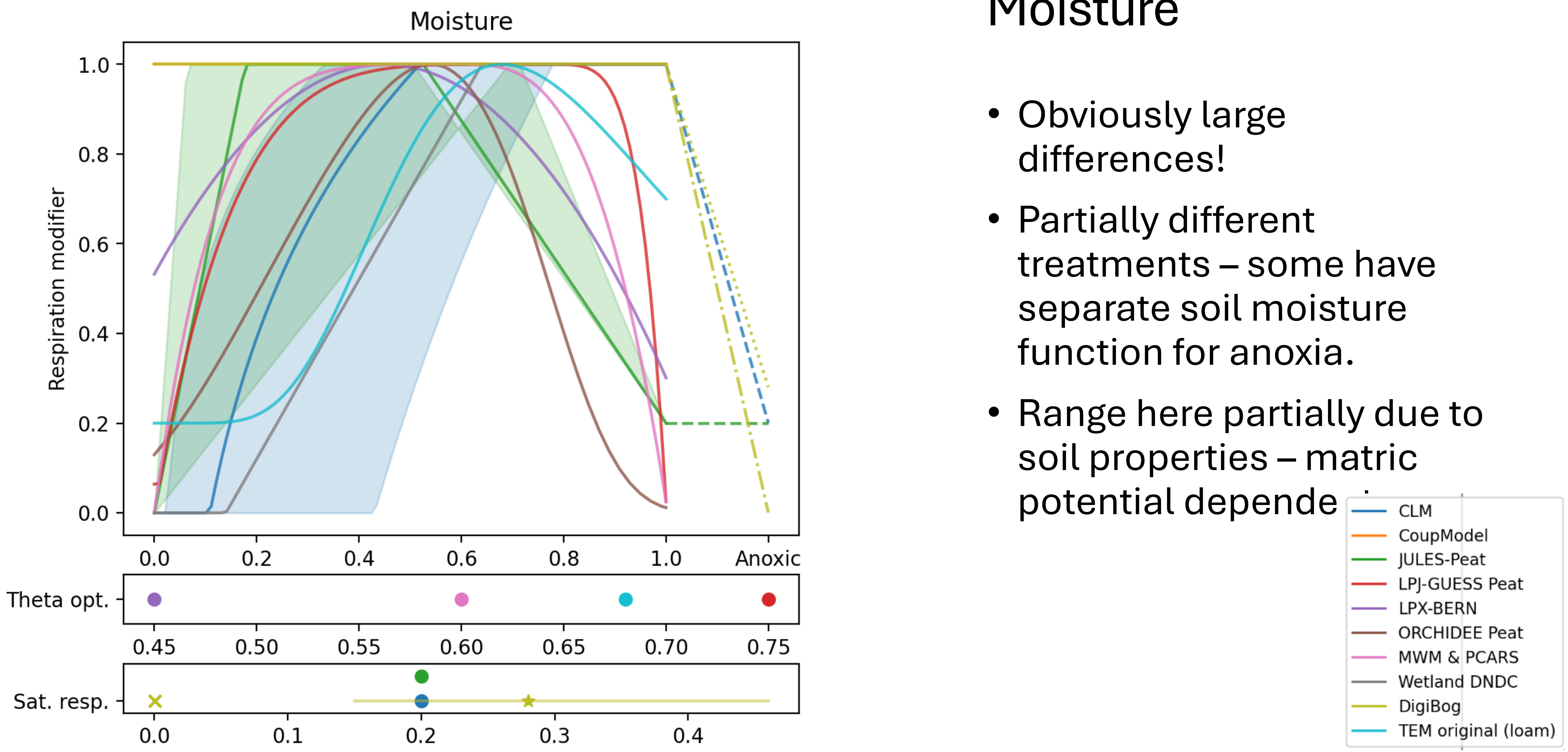
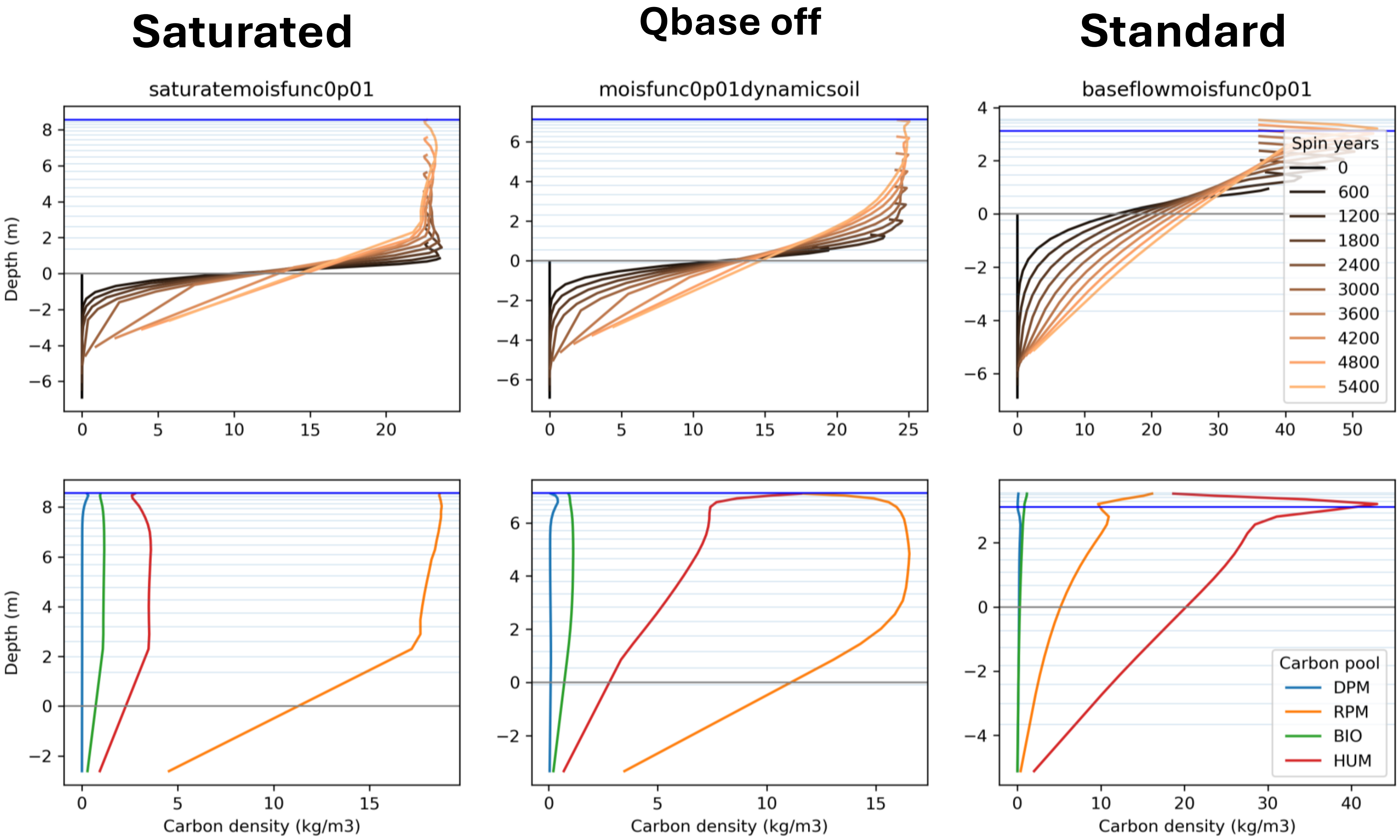


Respiration modifier - Moisture

- Obviously large differences!
- Partially different treatments – some have separate soil moisture function for anoxia.
- Range here partially due to soil properties – matric potential depende

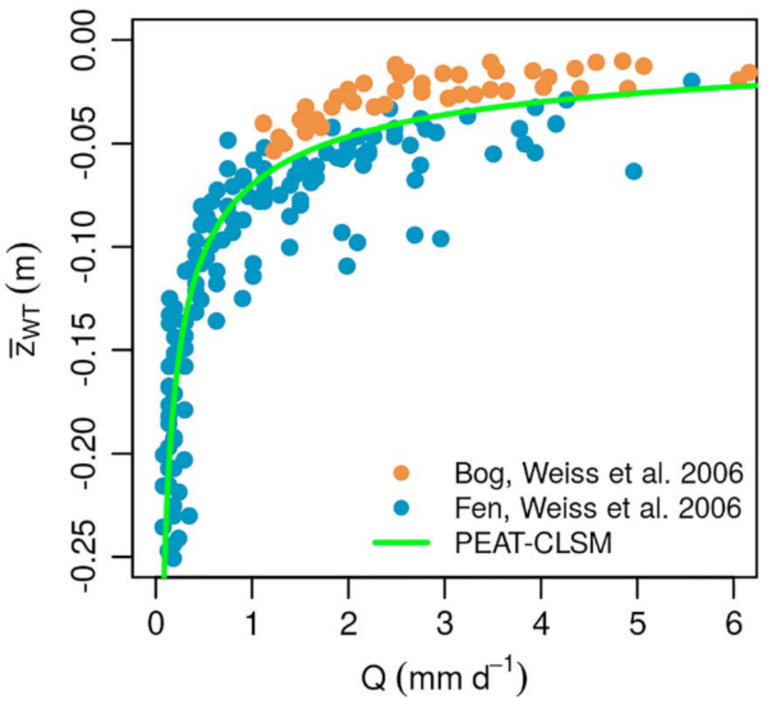
It's wet


Saturated
Qbase off
Standard
saturatemoisfunc0p01
moisfunc0p01dynamicsoil
baseflowmoisfunc0p01
Depth (m)
Carbon density (kg/m3)
Spin years
0
600
1200
1800
2400
3000
3600
4200
4800
5400
Carbon pool
DPM
RPM
BIO
HUM

It’s wet

- Moss ‘has no roots’
- Soil properties depend on decomposition
- Increased storage (and decreased surface runoff) from ponding and bog breathing
- Runoff depends on peatland form and water table depth

Bechtold et al. (2019)



Van der Schaff (1999)

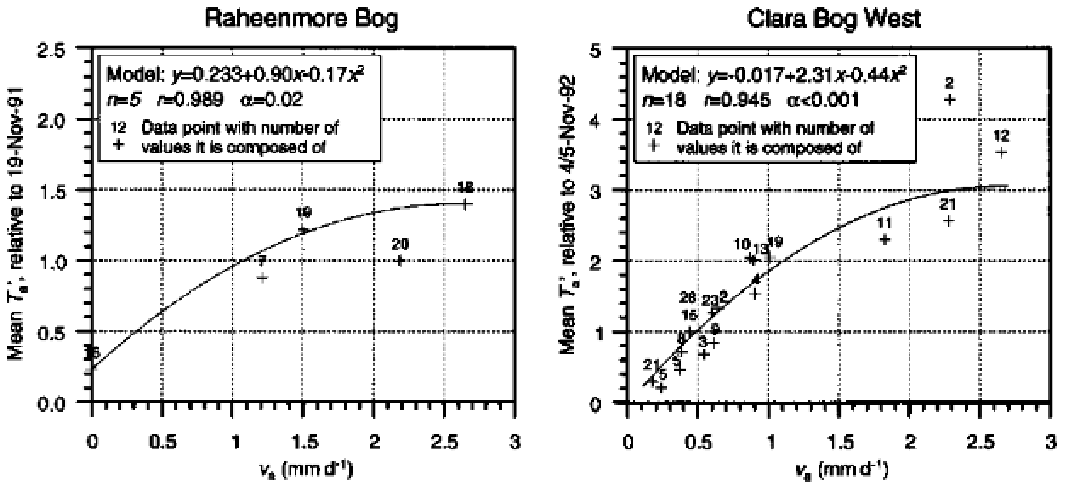
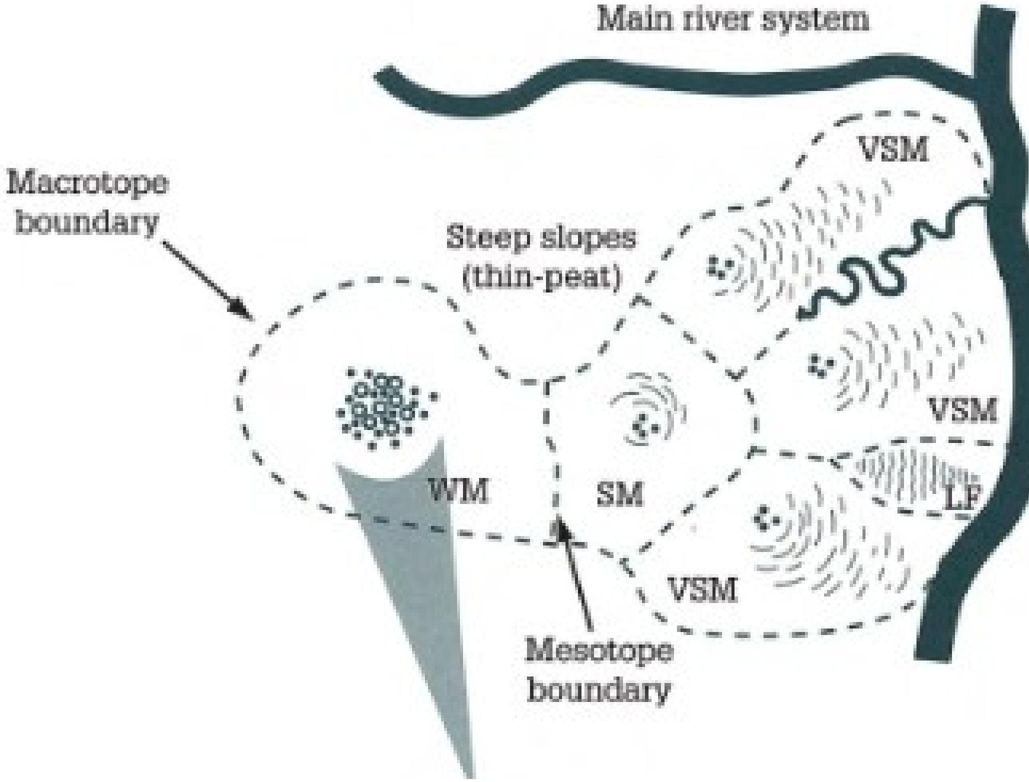
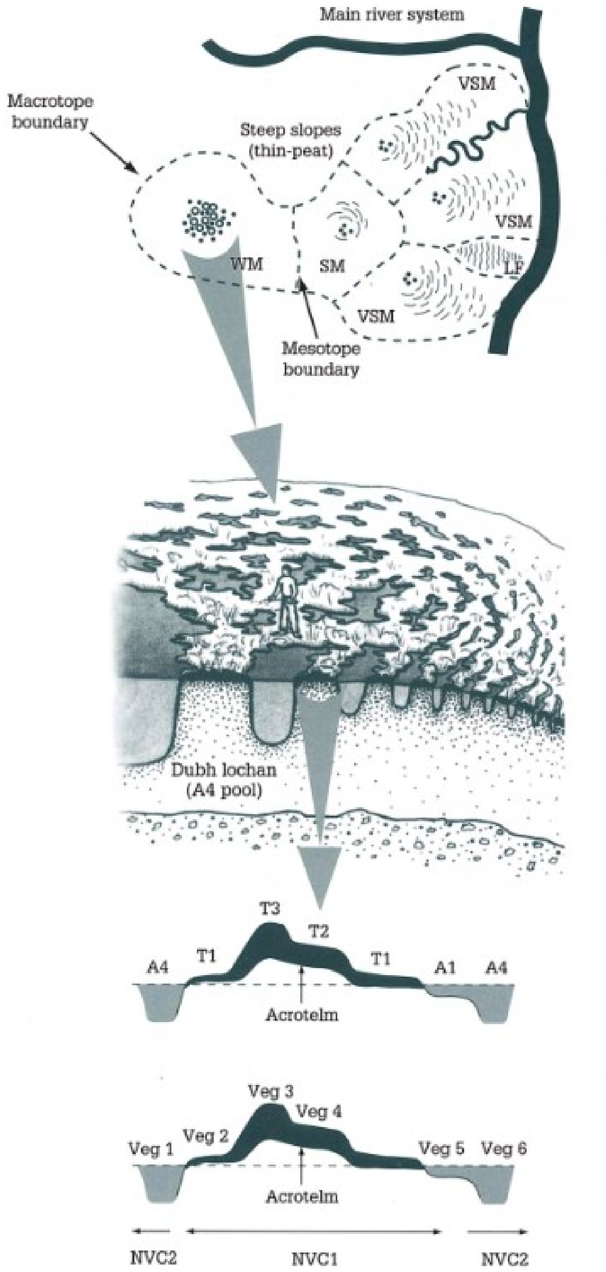


Fig. 6.16. Mean normalised acrotelm transmissivity T_a' (*cf.* Eq. 6.17) versus specific acrotelm discharge v_a.

Peatland scales



A gridcell may contain multiple distinct and/or independent hydrological units



Macrotope and component mesotopes: [Plan view of macrotope complex illustrated in Figure 2.] VSM = valleyside mire, SM = spur mire, WM = watershed mire, LF = ladder fen.

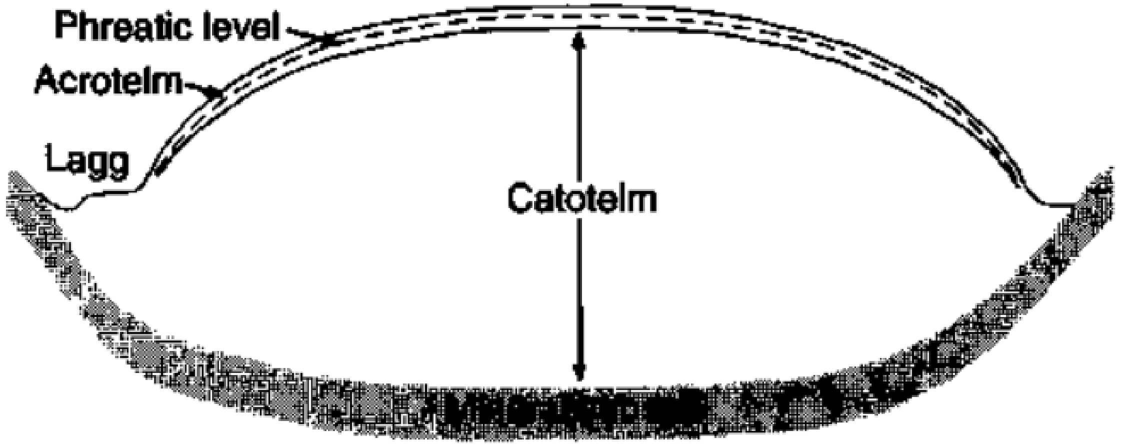
Part of the watershed mire **mesotope**, displaying **microtope pattern** with open-water pools (T3/T4)

Microforms, coded according to Lindsay *et al.* (1988): T3 = hummock, T2 = high ridge, T1 = low ridge, A1 = *Sphagnum* hollow, A4 = permanent pool. (A2 & A3 pools are not present in the area taken from Figure 2.)

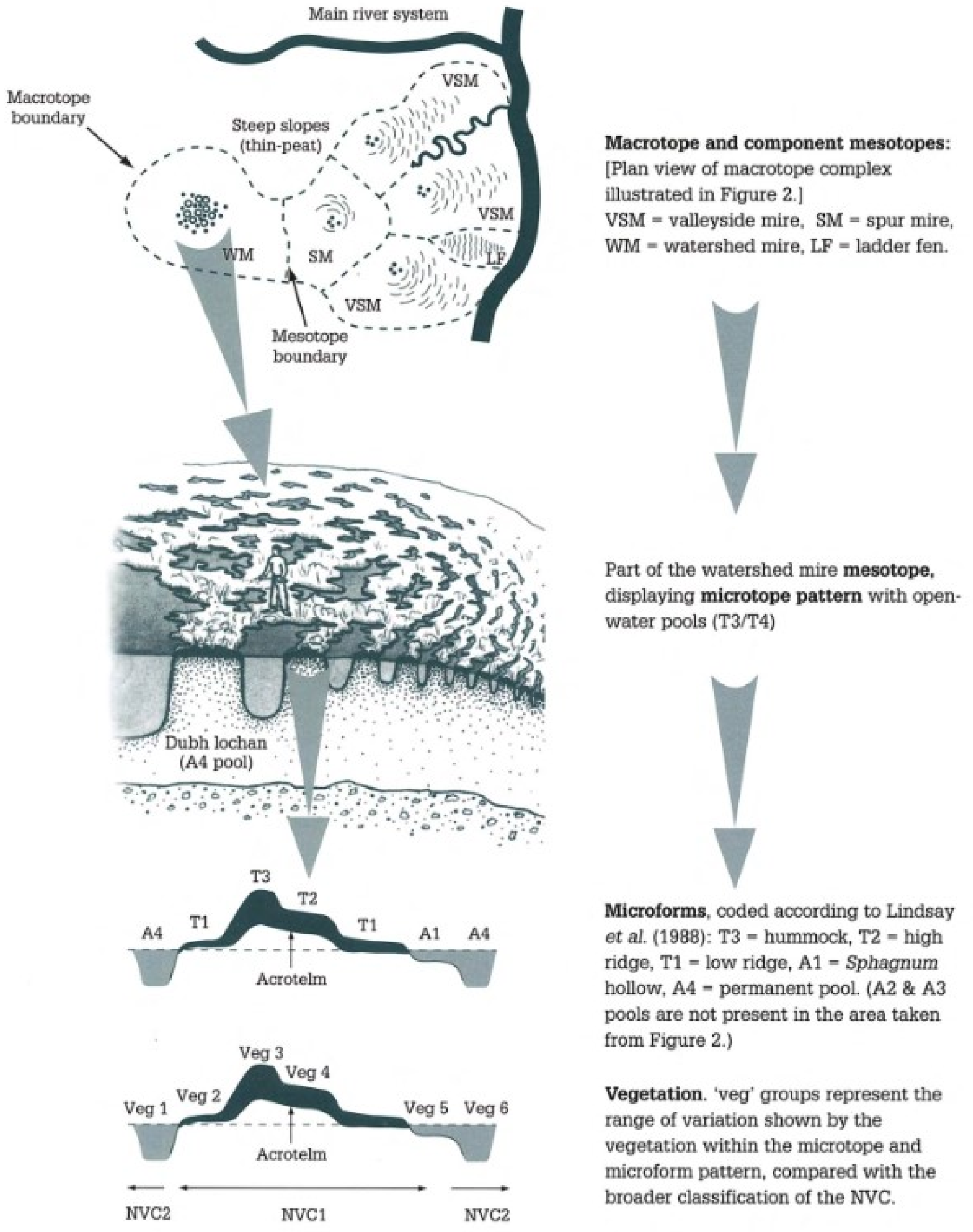
Vegetation. 'veg' groups represent the range of variation shown by the vegetation within the microtope and microform pattern, compared with the broader classification of the NVC.

Figure 6.
The hierarchy of features used by the country conservation agencies to classify bog systems.
Terms are derived from Ivanov (1981) and are described in the accompanying text.

Peatland scales



The flow of water through each of those units depends on the large-scale form and variation of properties



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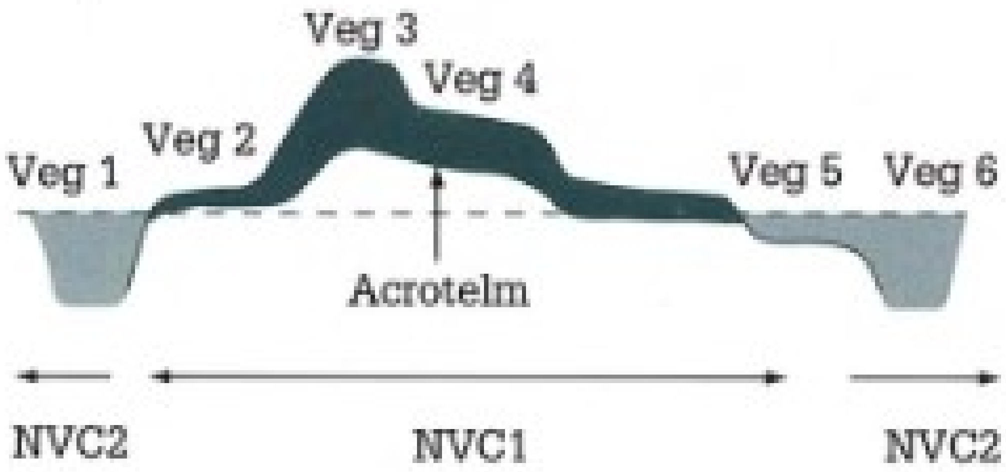
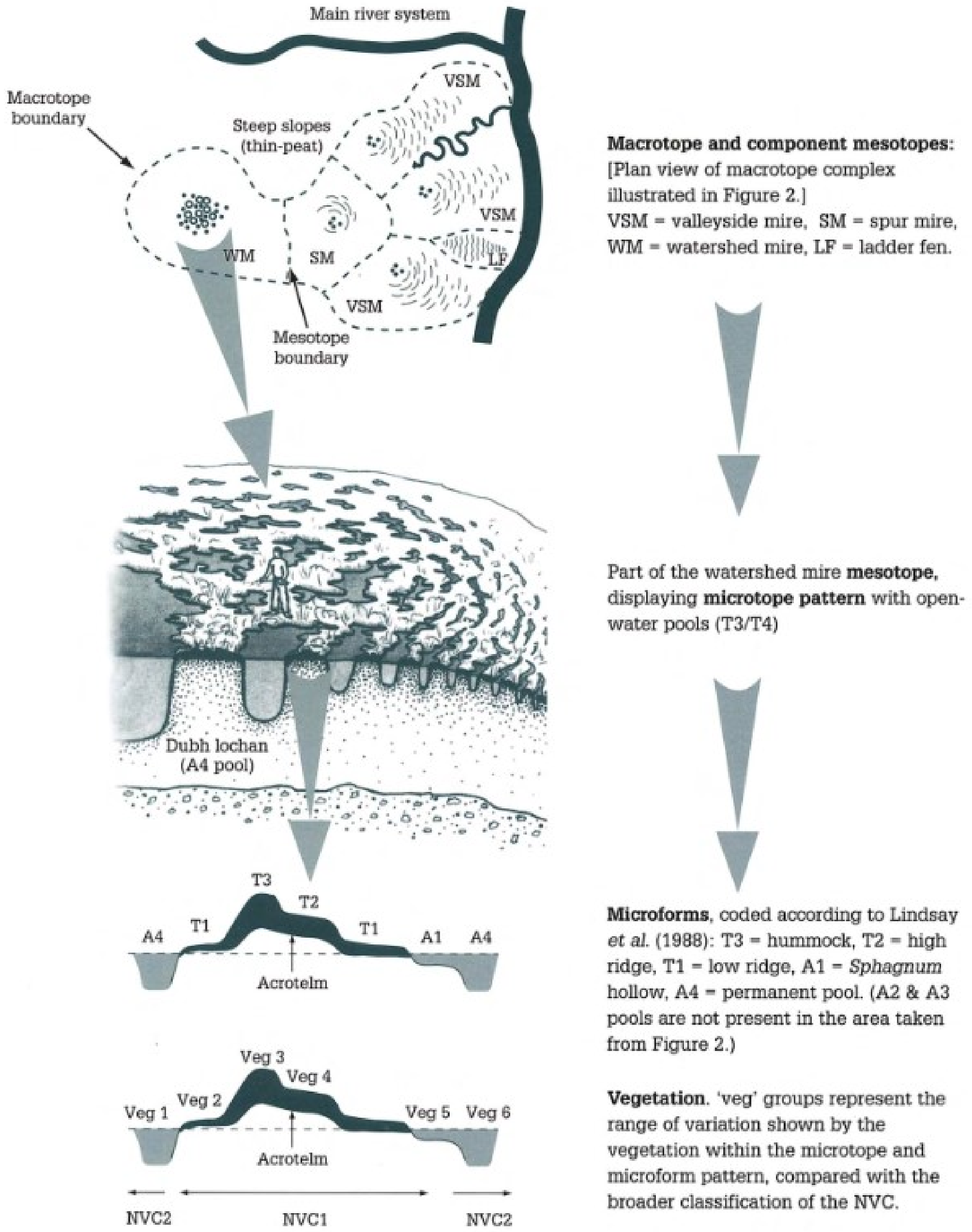


Feedbacks between water table depth, vegetation and litter inputs can operate on the smallest scales



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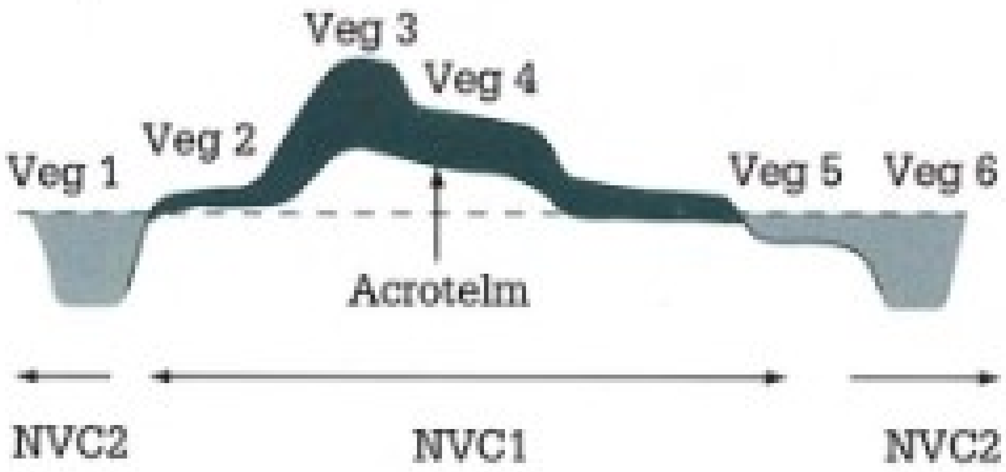
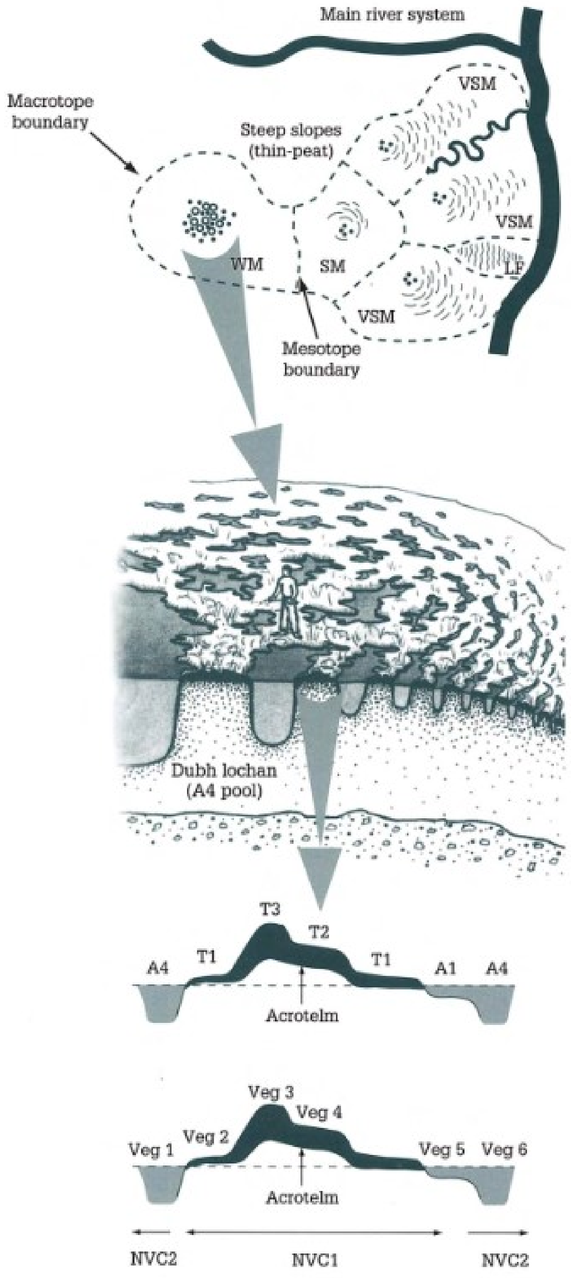
Is all lost?

Peatland scales



In a functioning peatland, feedbacks are self-regulating.



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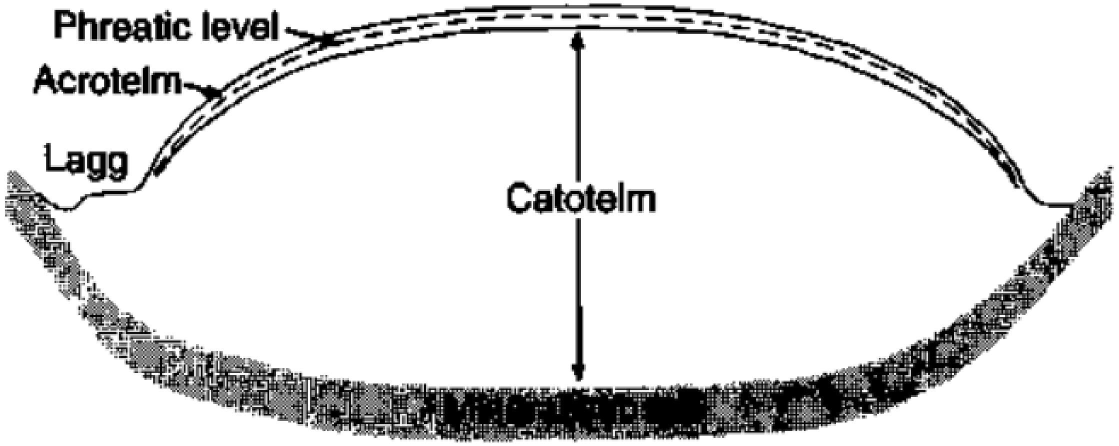
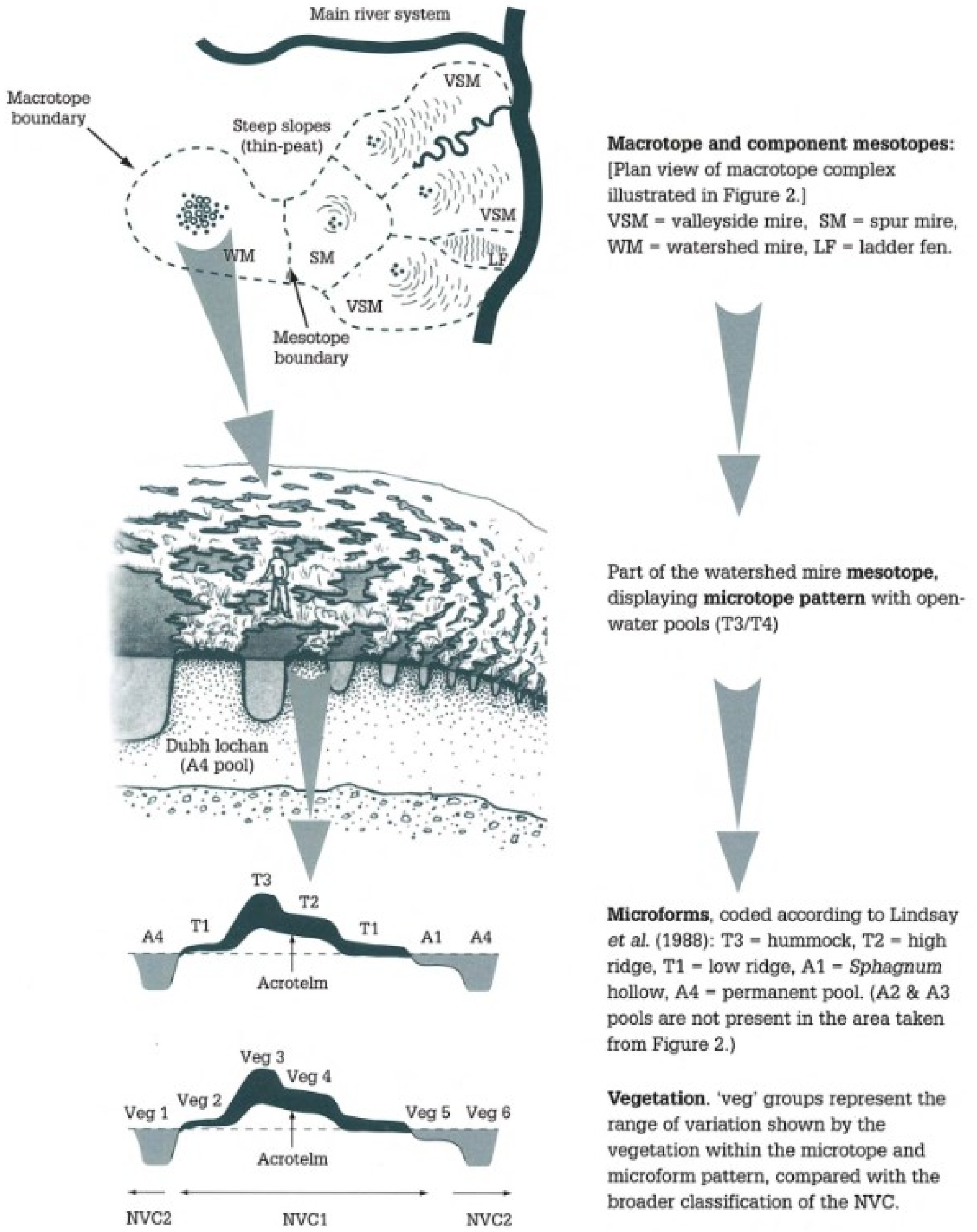


It is reasonable to take a single representative column if the large scale hydrology is known.



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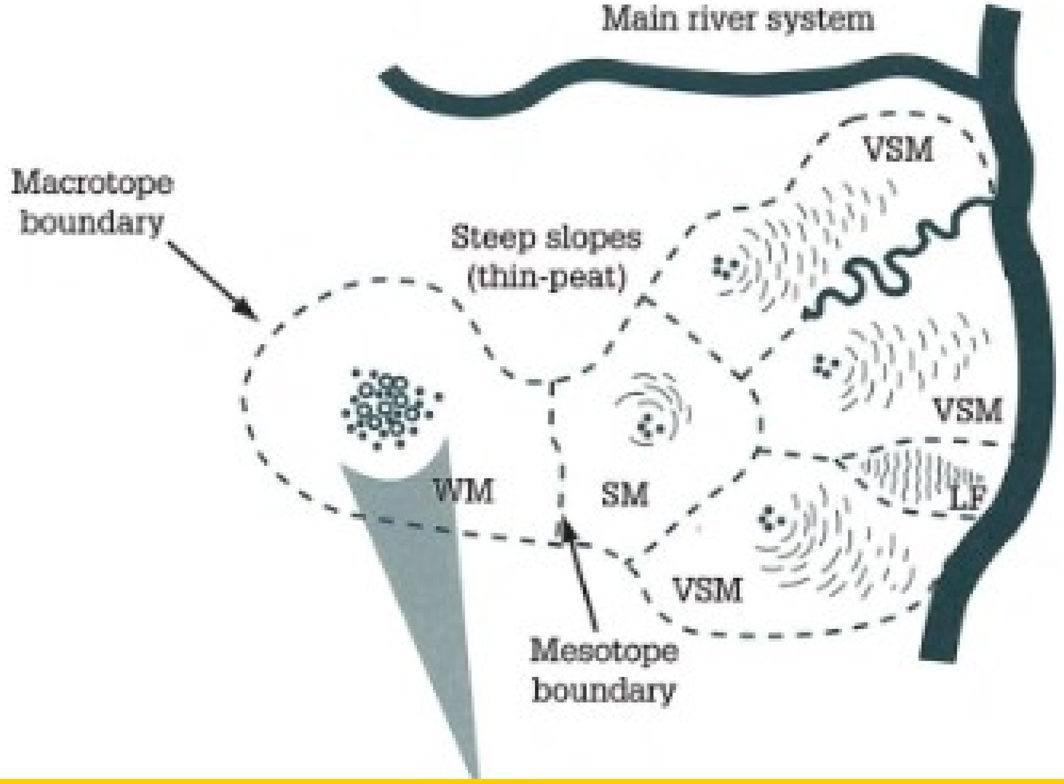
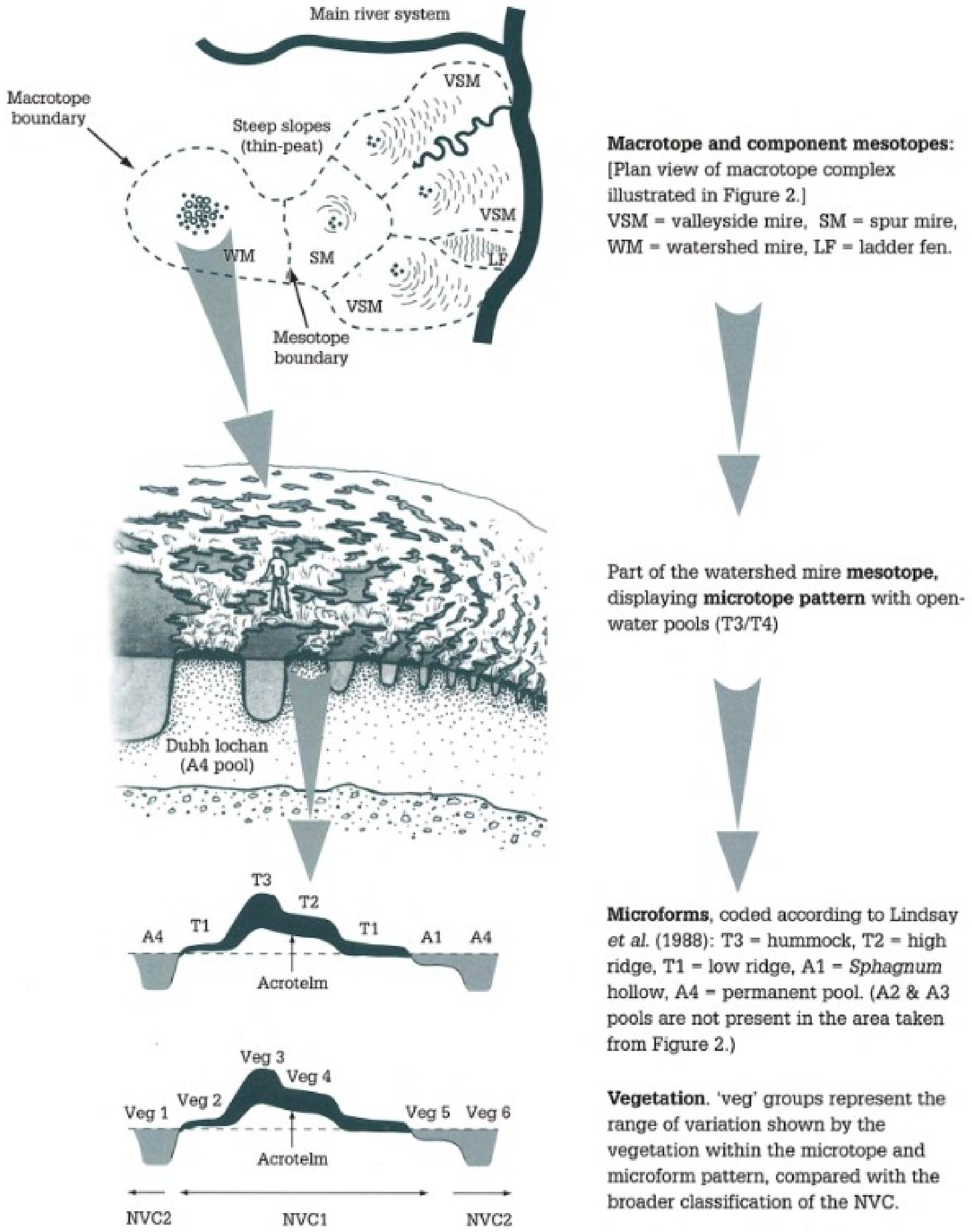


We already use self-similarity and topographic indices to model water table distribution.
can we do this more dynamically and discretise according to water table depth?



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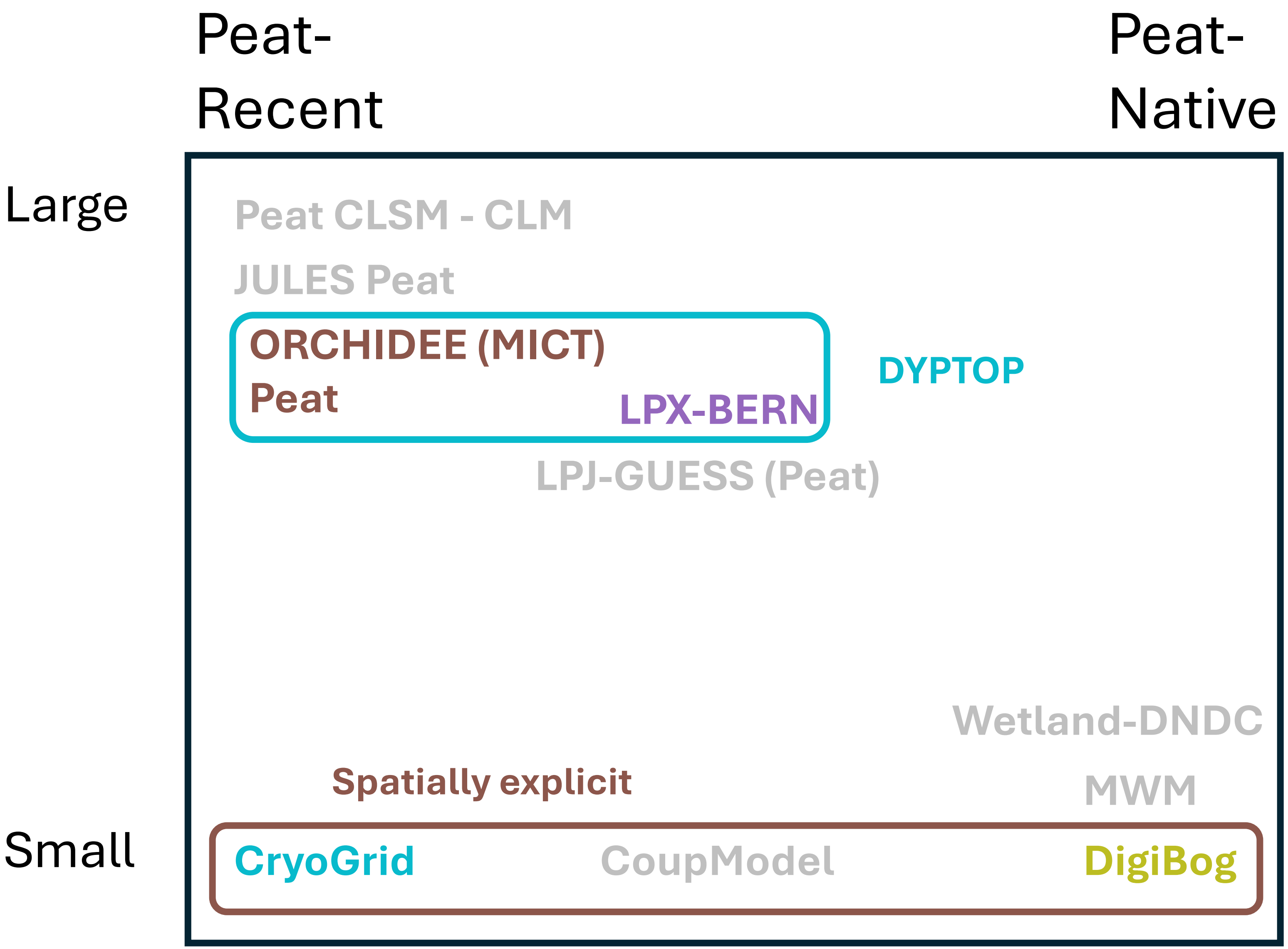
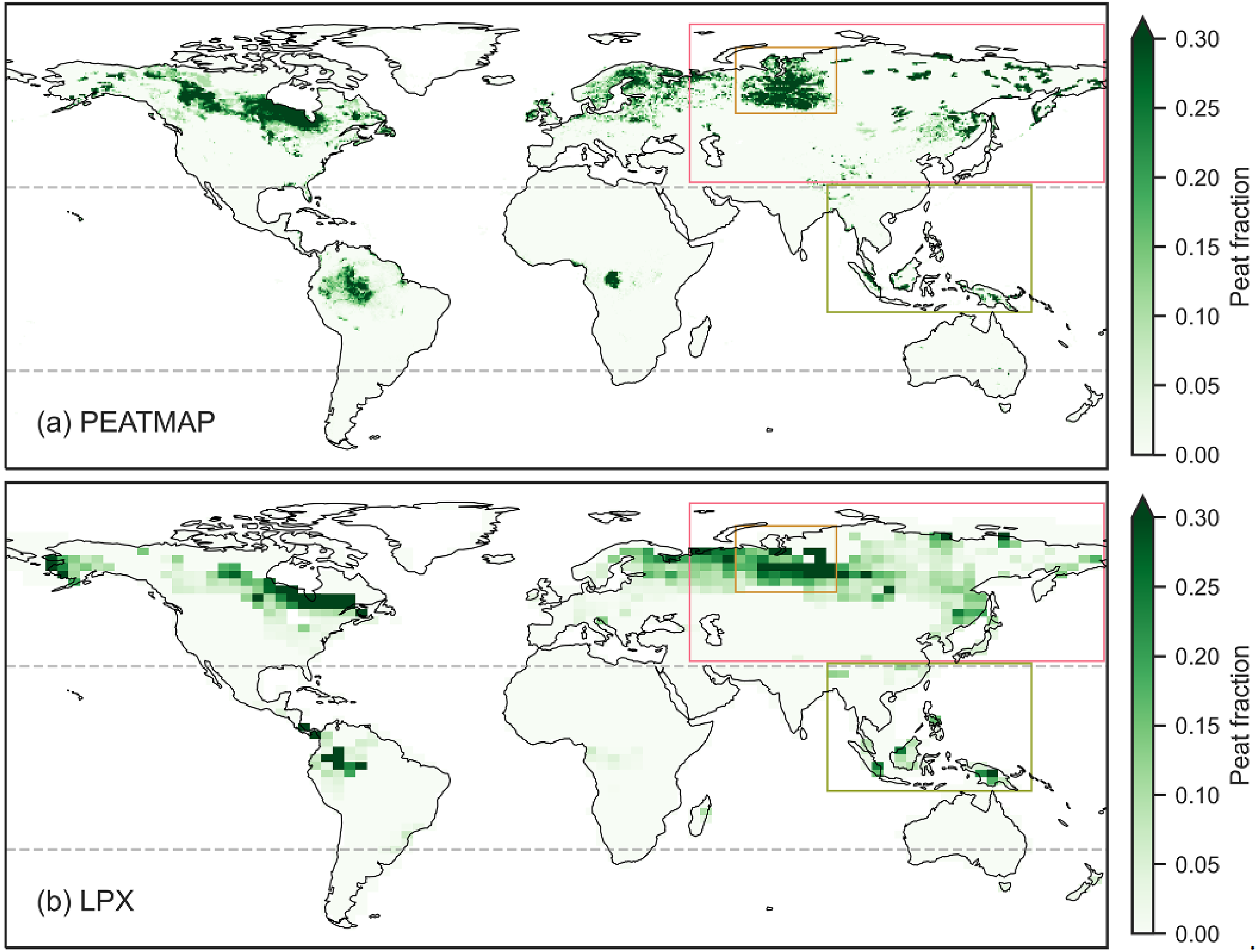


Can peat grow wherever?

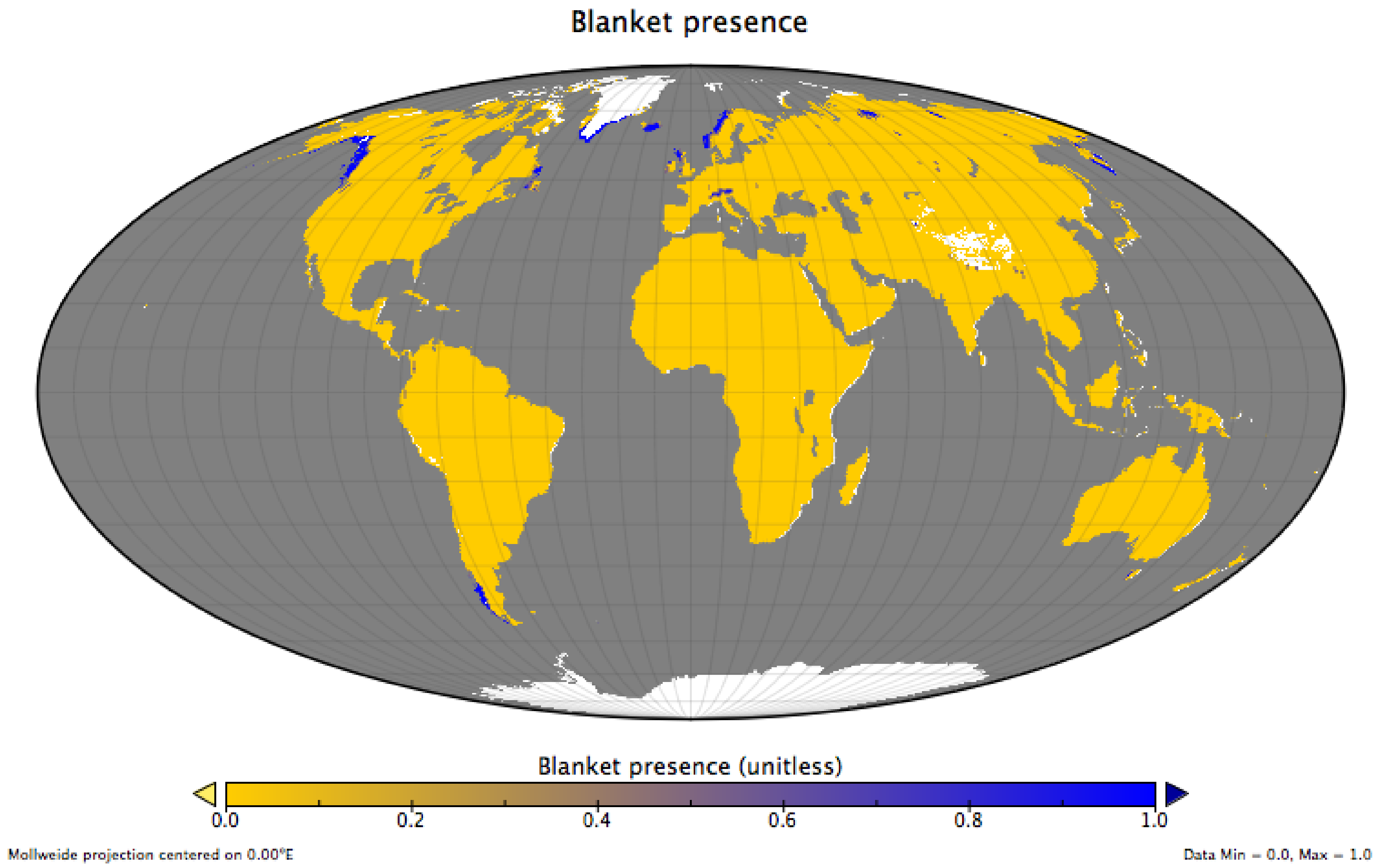
DYPTOP

TOPMODEL-based extent



Muller and Joos (2020)

Global extent of Northern mire complexes: BLANKET BOGS



Gallego-Sala and Prentice, 2013

What's next?

Vegetation

- Root depths
- Waterlogging
- Moss

Hydrology

- Implement basic function for runoff
- Add extra storage (microtopographic ponding and bog breathing)

Carbon

- Calibrate decomposition

Think about:

- Sub-grid hydrology and groundwater / flooding
- Direct human forcing (drainage / rewetting)
- Fire?