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Modeling peatland carbon dynamics on decadal to millennial time scales

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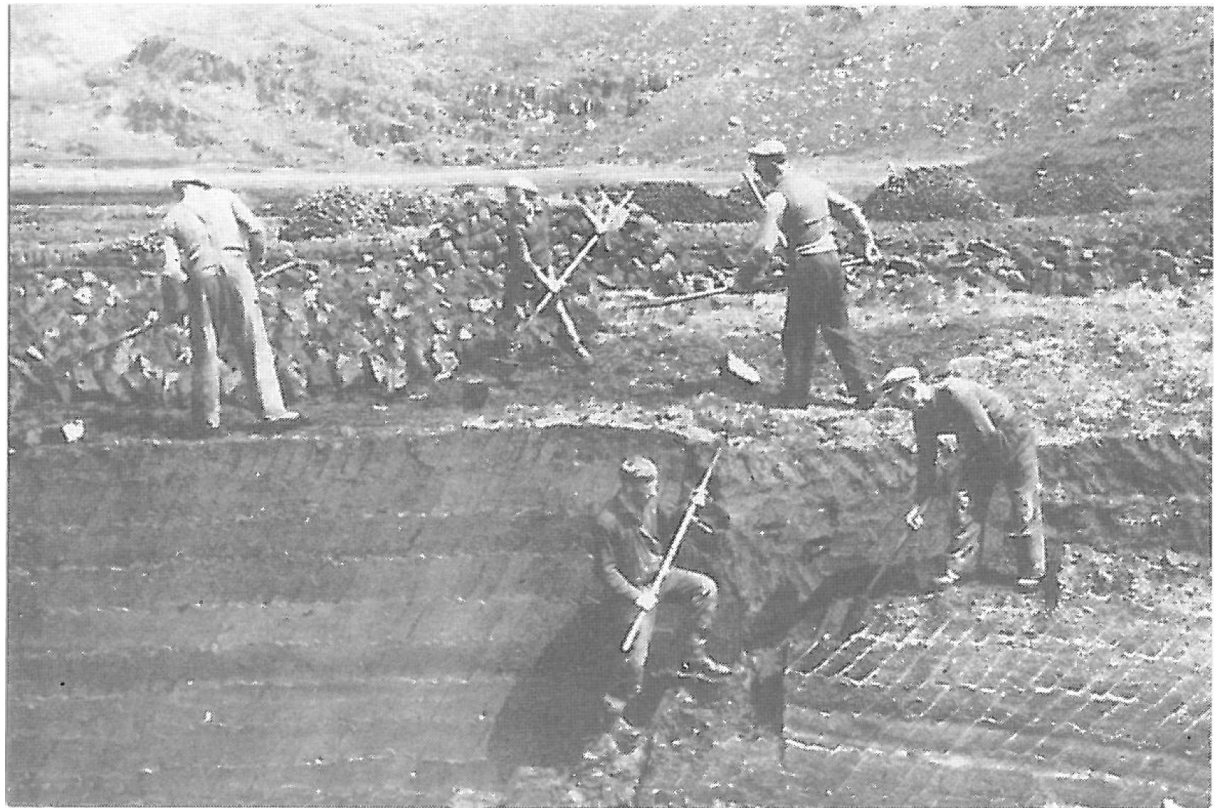
Modeling peatland carbon dynamics on decadal to millennial time scales

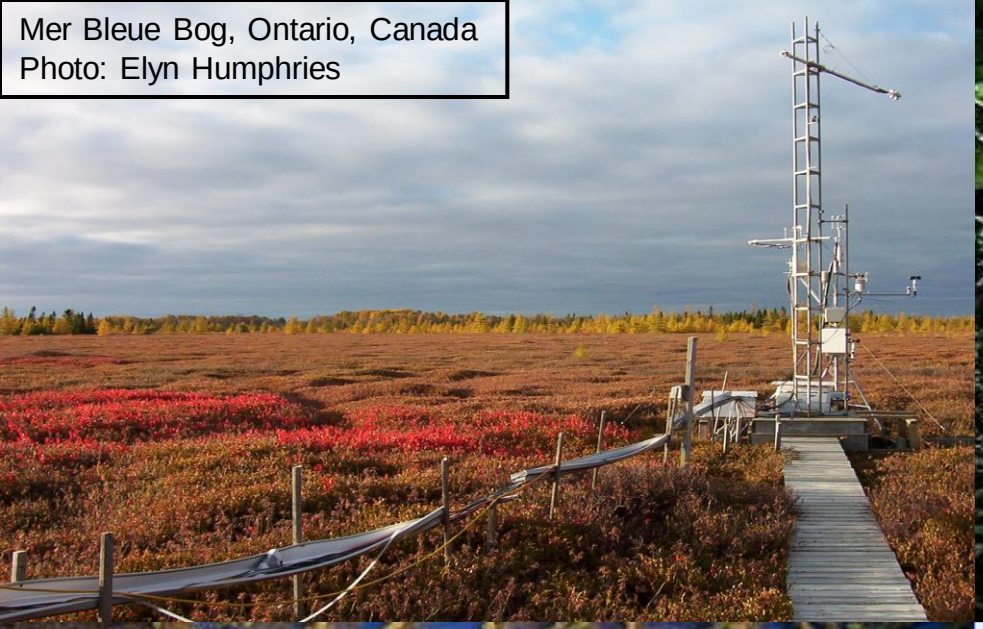
Steve Frolking & Julie Talbot (*University of New Hampshire*)

Nigel Roulet (*McGill University*), Eeva-Stiina Tuittila (*University of Helsinki*),

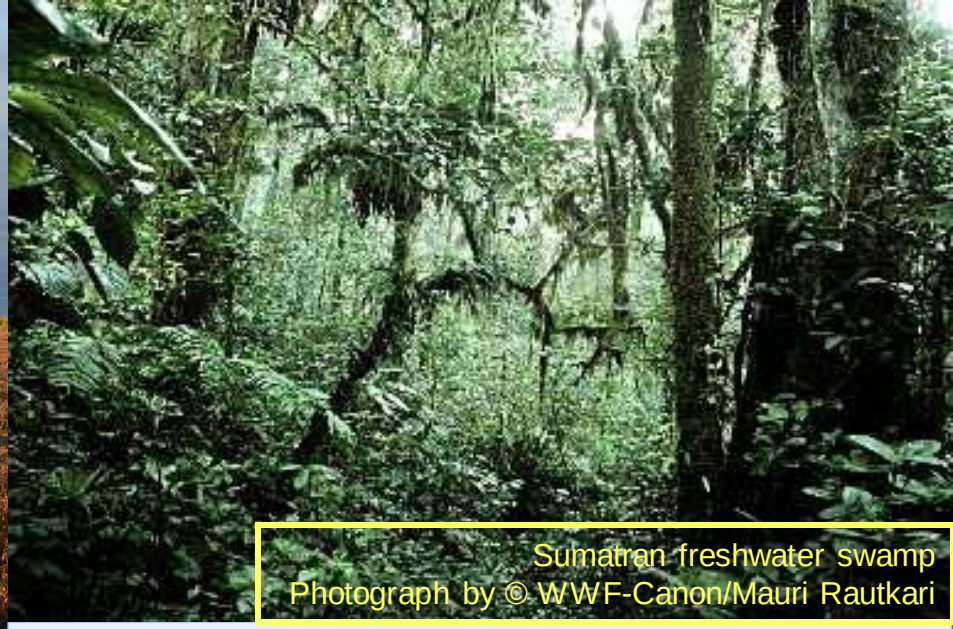
Jill Bubier (*Mt. Holyoke College*)



Postcard of peat cutting for fuel, Co. Galway, Ireland



Mer Bleue Bog, Ontario, Canada
Photo: Elyn Humphries



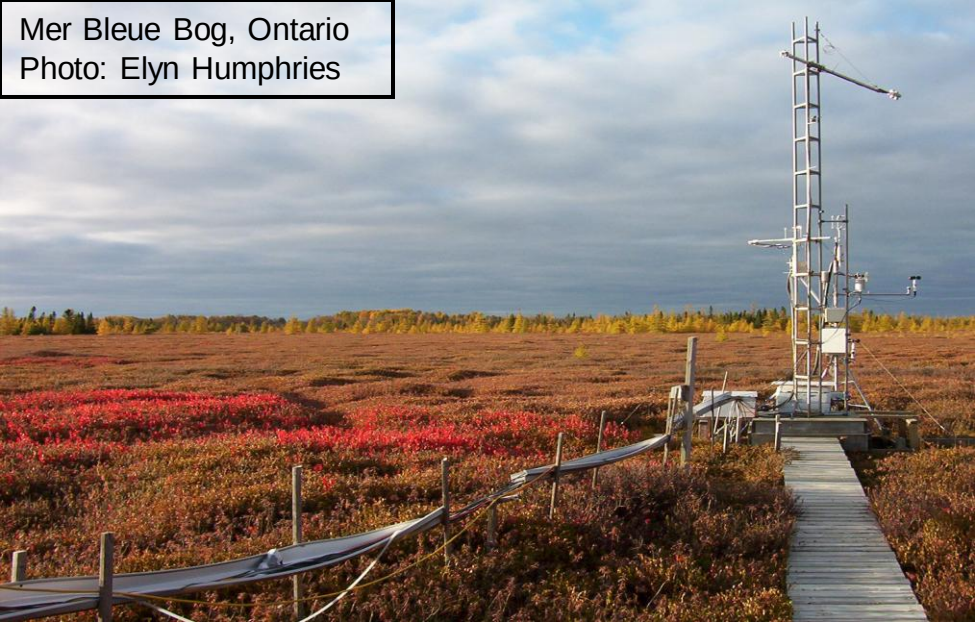
Sumatran freshwater swamp
Photograph by © WWF-Canon/Mauri Rautkari

Boreal fen, Finland
Photo: Peter Essick

Peatlands are complex ecosystems:

- hydrology & biogeochemistry
- vegetation dynamics & interactions
- spatial heterogeneity
- microbial communities, decomposition
- role of landscape setting & disturbance

What do scientists typically do?



Mer Bleue Bog, Ontario
Photo: Elyn Humphries

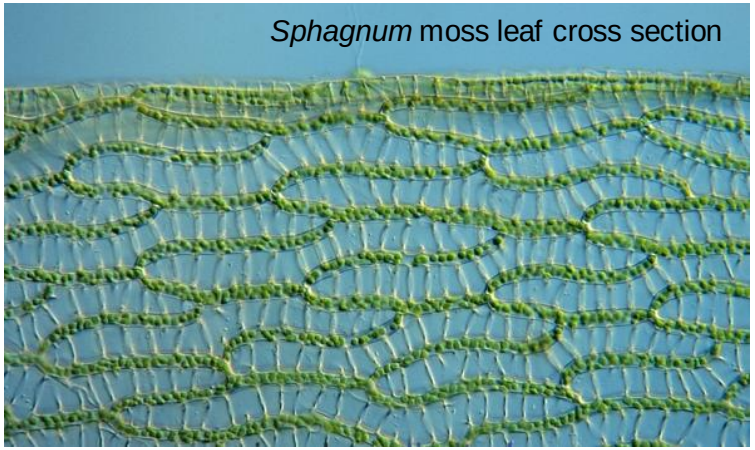
Look more closely.

Describe more features.

Identify more interactions.

Raise more questions.

Photo: CJ Fallon Ltd.



Wim van Egmond/Visuals Unlimited, Inc.

Modeling goal: describe system – state, functions, dynamics, feedbacks

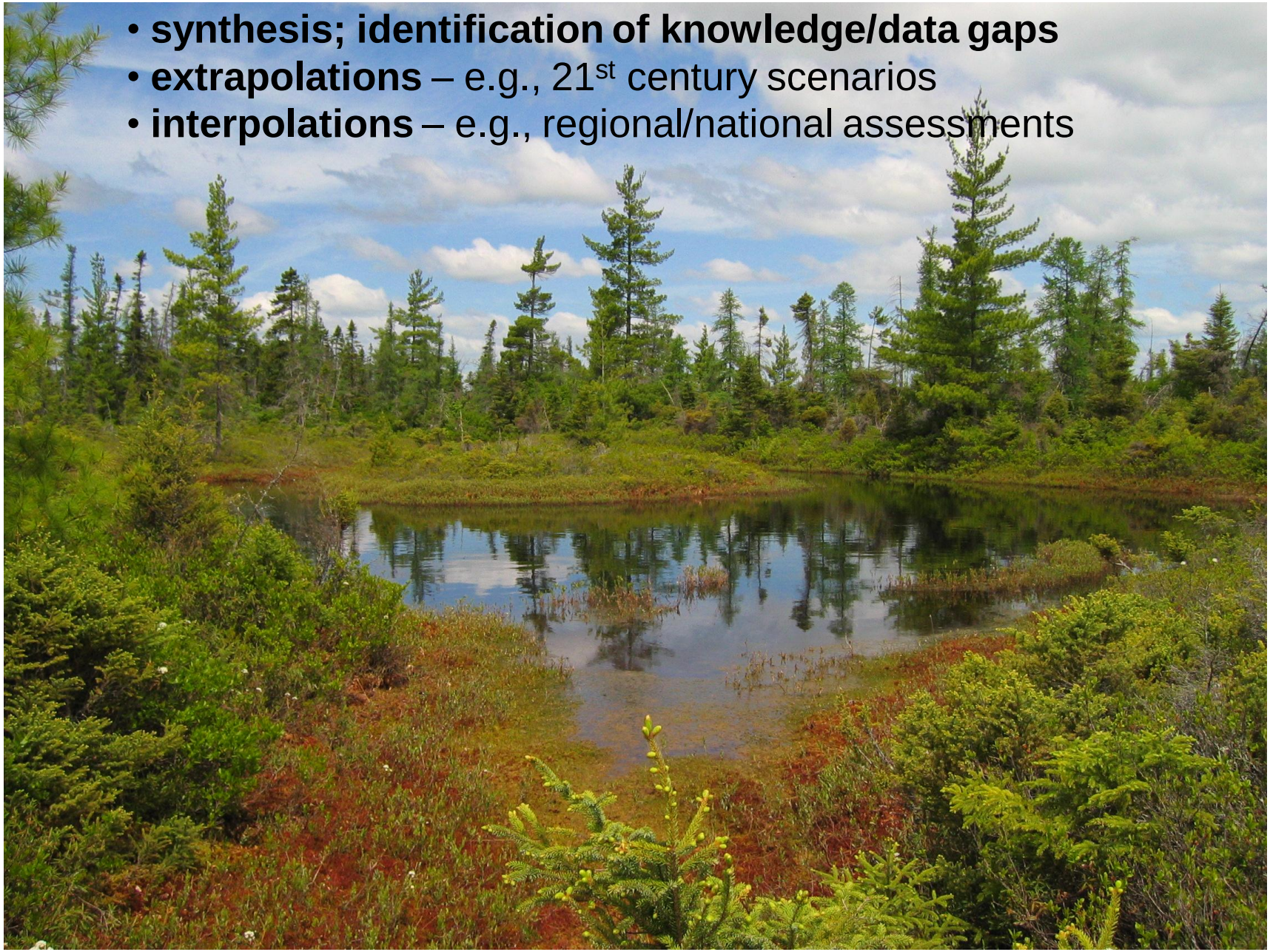


Photo credit: A. Baird

Modeling goal: describe system – state, functions, dynamics, feedbacks

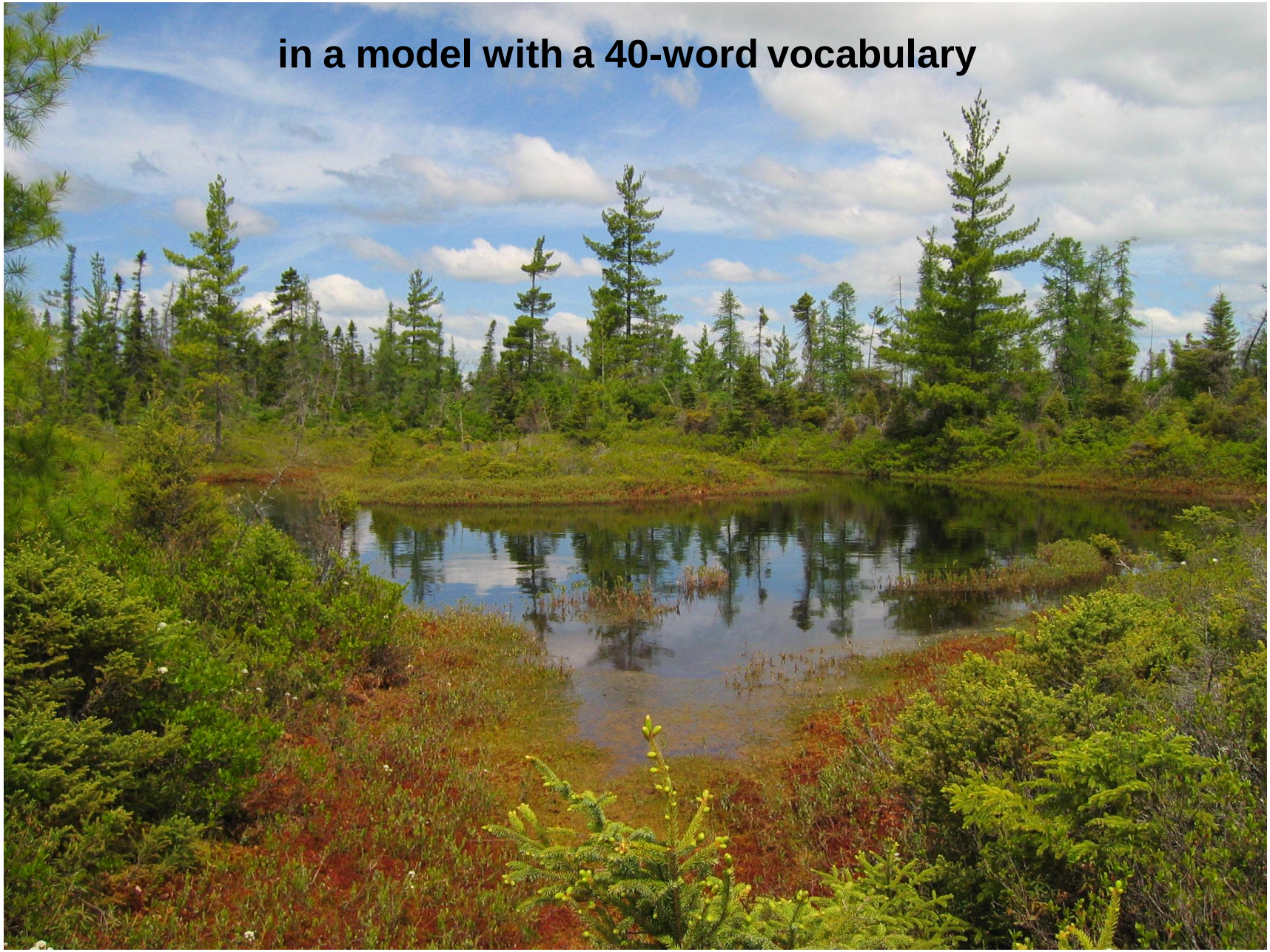
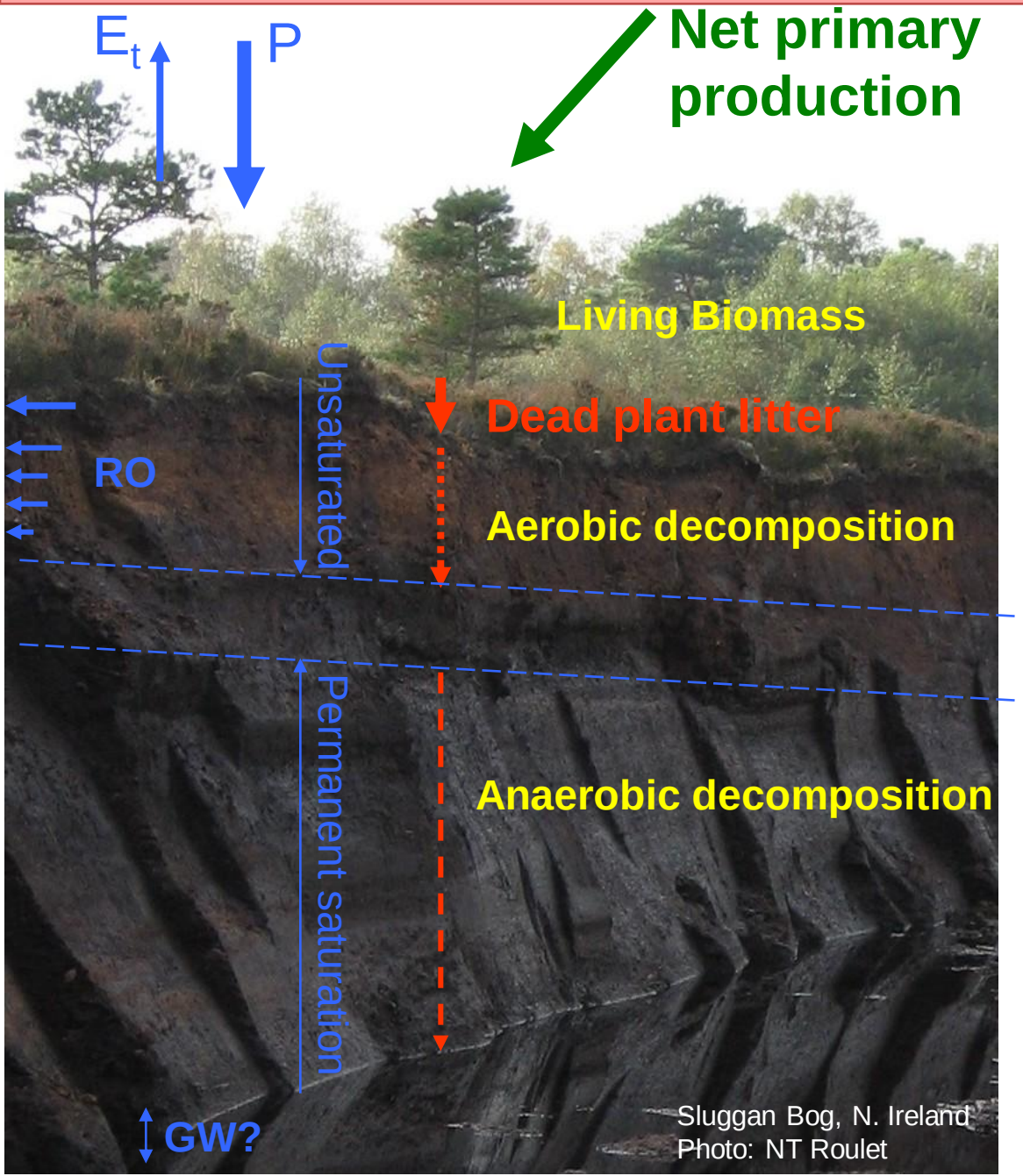
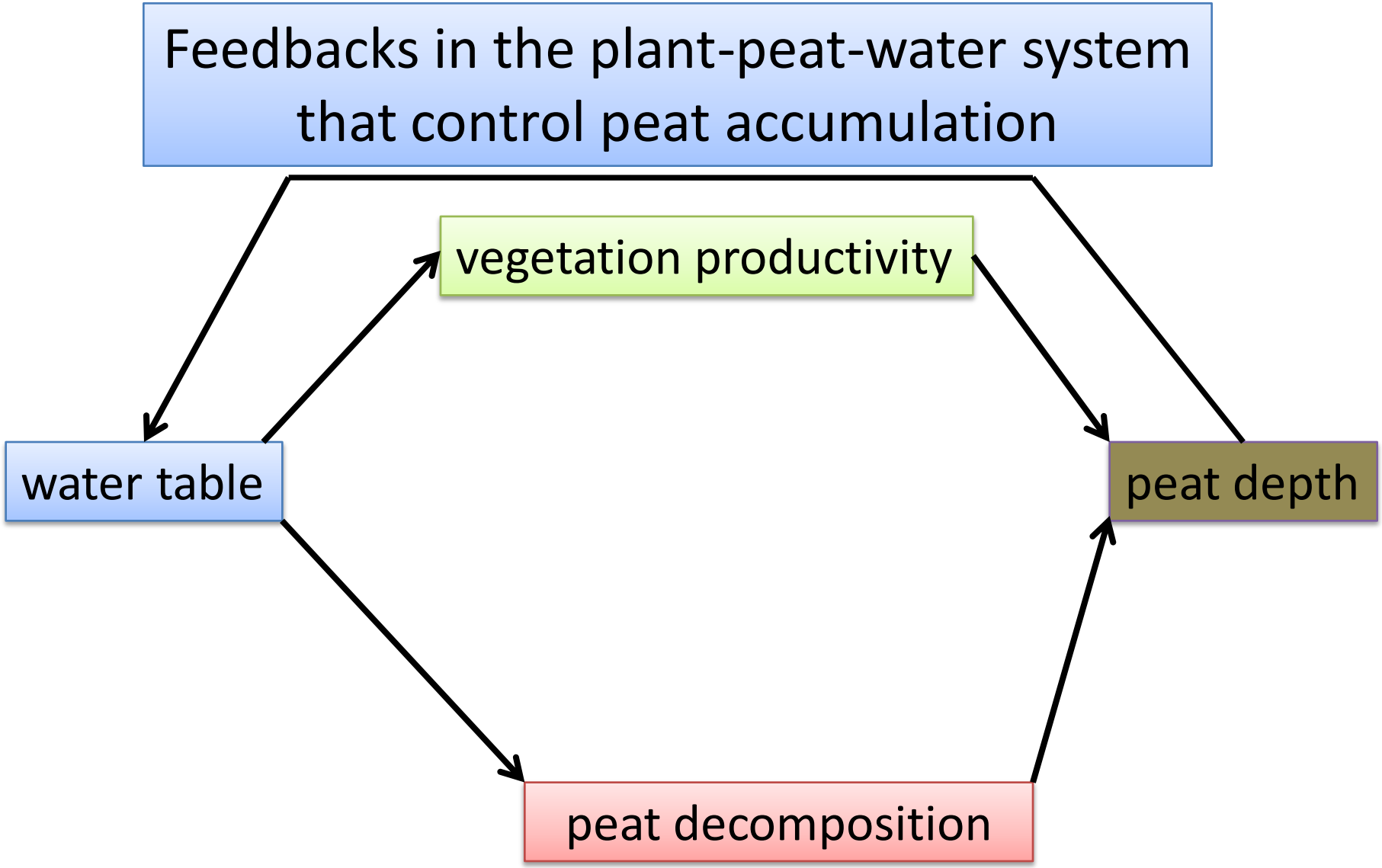
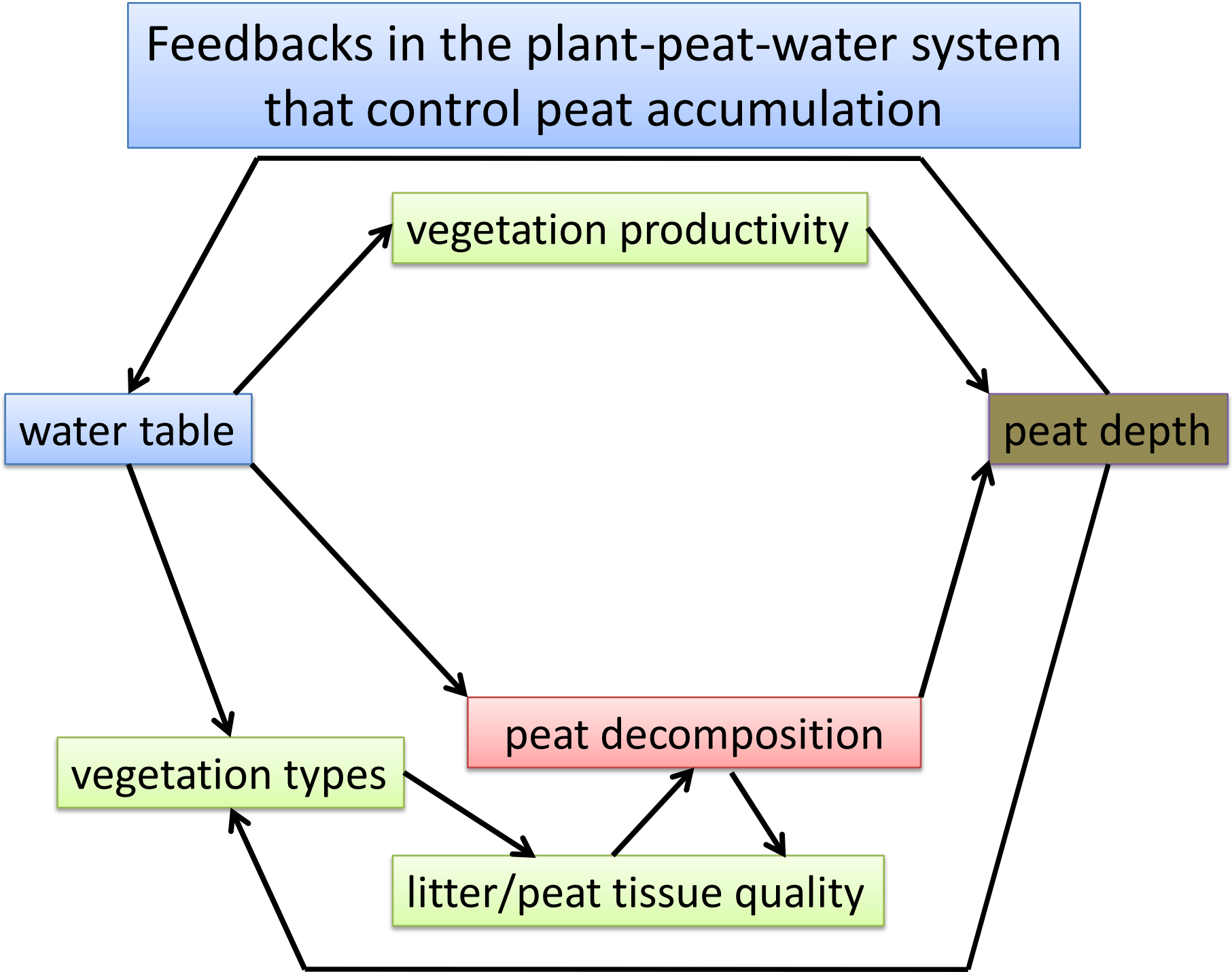


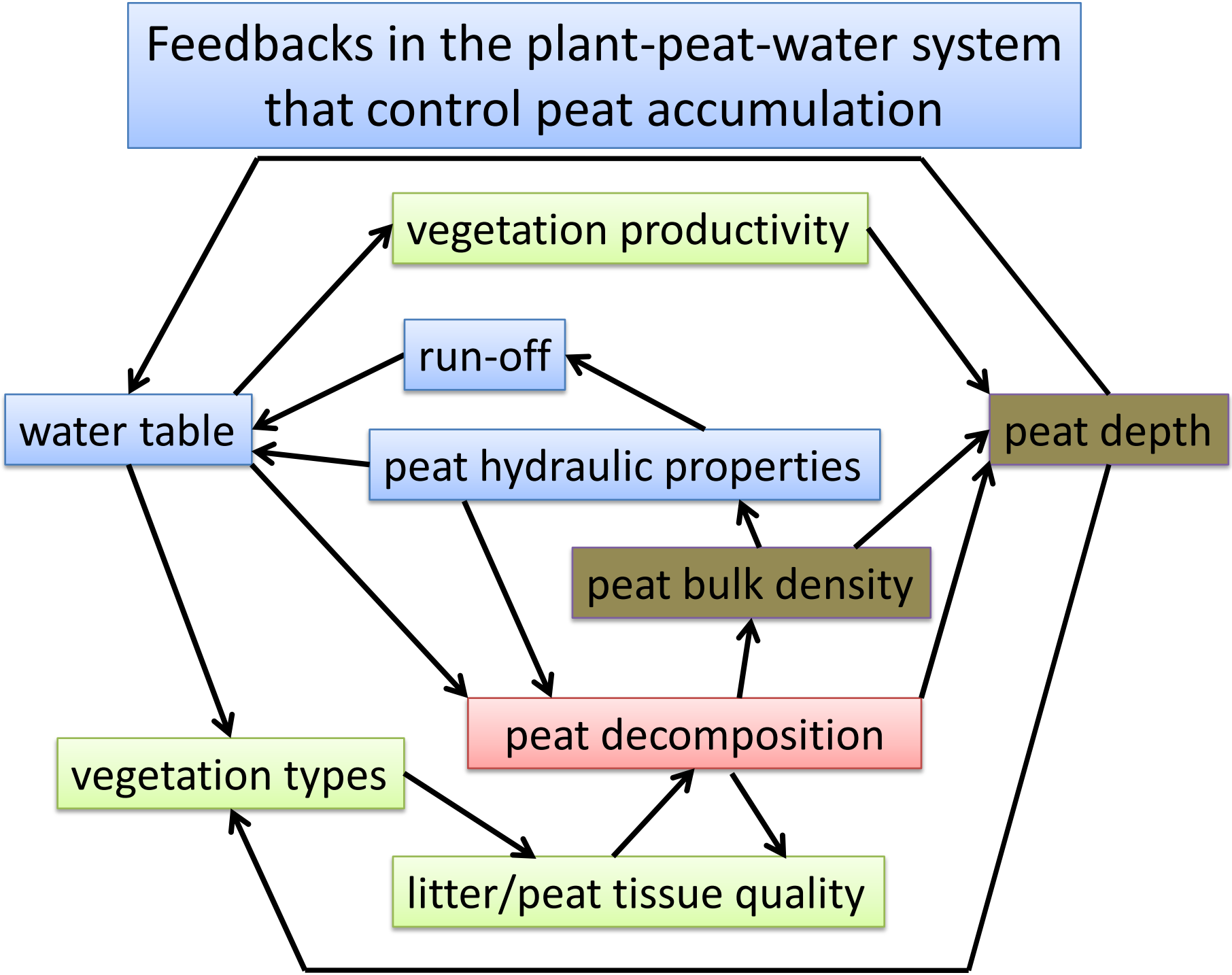
Photo credit: A. Baird

The Peatland Carbon – Hydrological System

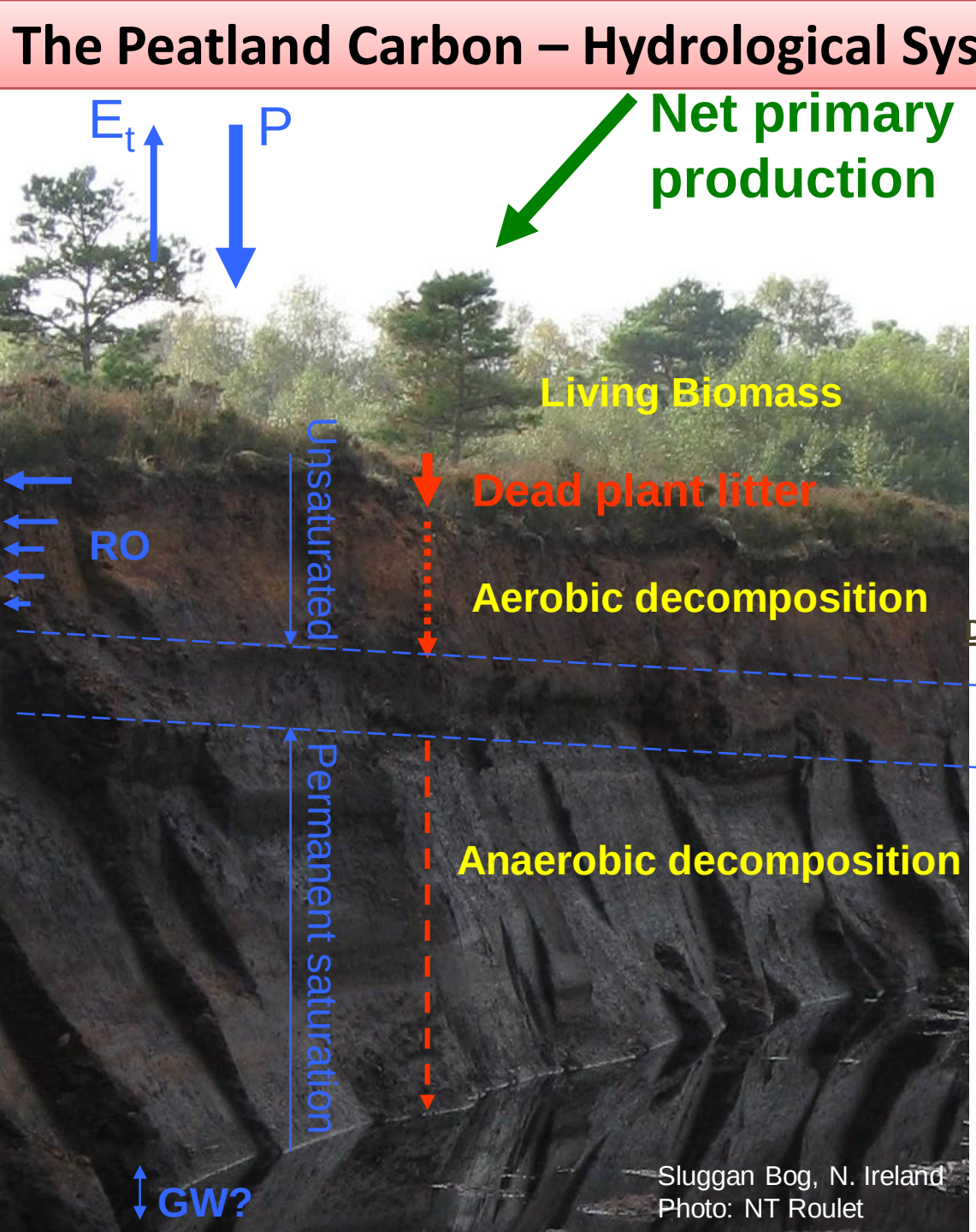


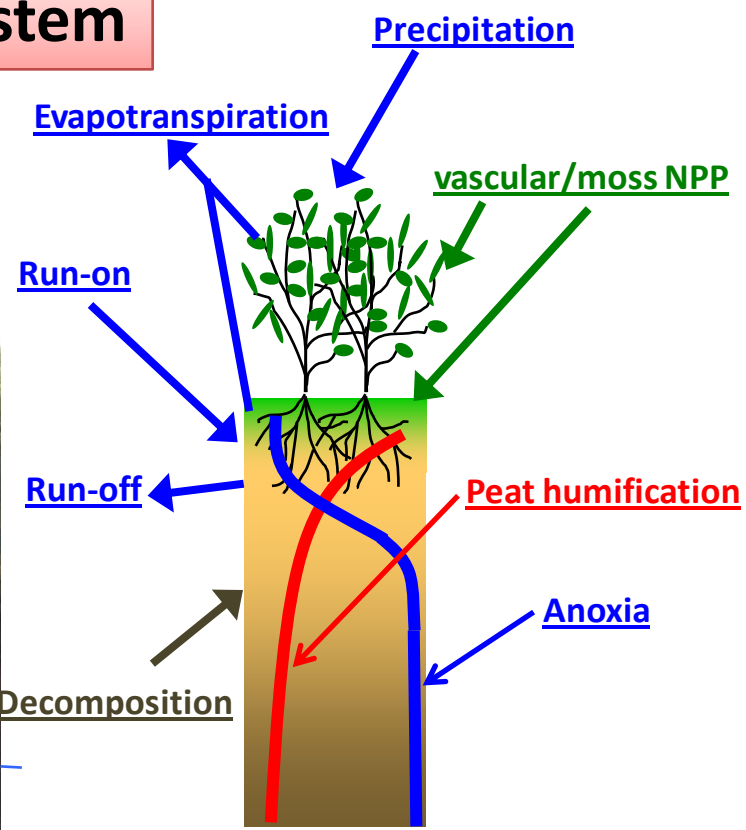

Feedbacks in the plant-peat-water system that control peat accumulation
vegetation productivity
water table
peat depth
peat decomposition

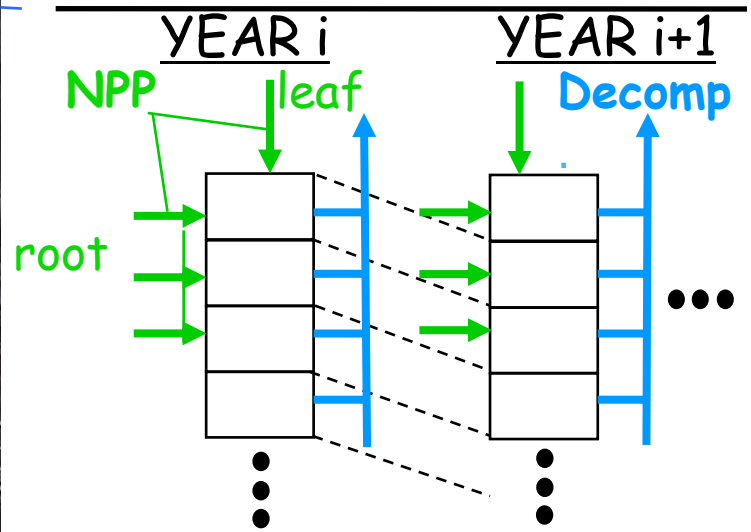

Feedbacks in the plant-peat-water system that control peat accumulation
vegetation productivity
water table
peat depth
peat decomposition
vegetation types
litter/peat tissue quality


Feedbacks in the plant-peat-water system that control peat accumulation
vegetation productivity
run-off
water table
peat hydraulic properties
peat depth
peat bulk density
peat decomposition
vegetation types
litter/peat tissue quality

The Peatland Carbon – Hydrological System

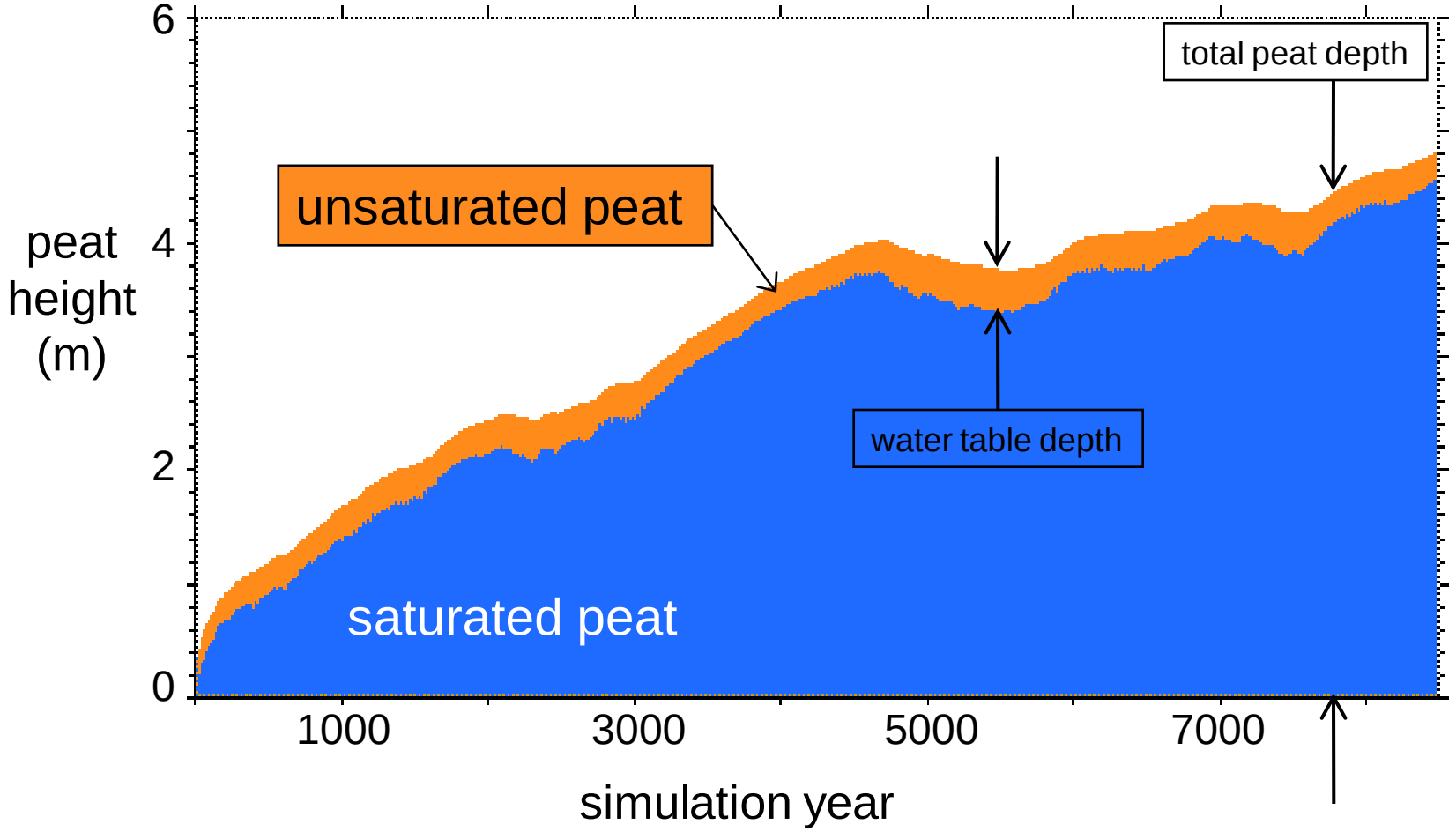






HPM 8500-year simulation of hypothetical sub-boreal peatland annual peat accumulation and water table depth

(also simulating net C balance, plant community composition)



HPM – Holocene Peat(land) Model

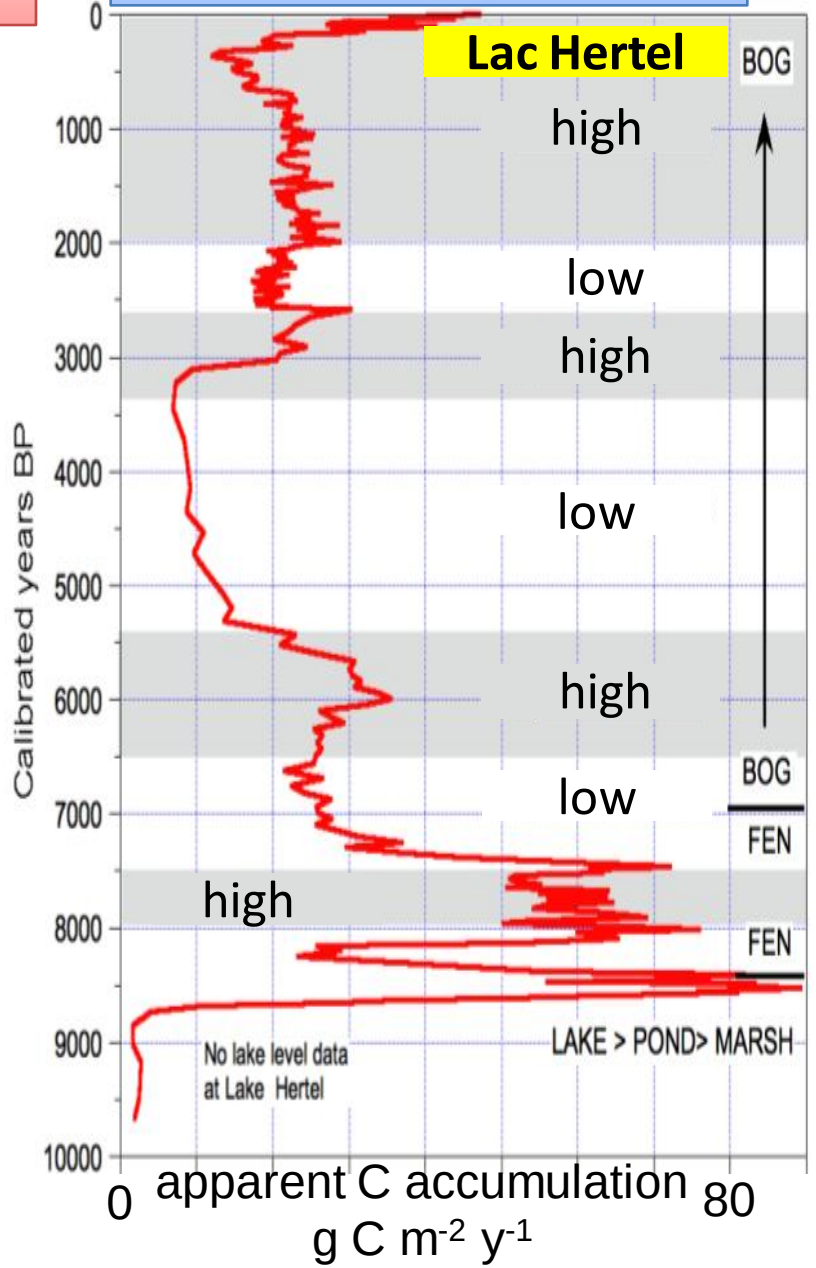
Frolking et al. 2010. *Earth System Dynamics*, 1, 1–21, 2010

Mer Bleue Bog, Ontario, Canada

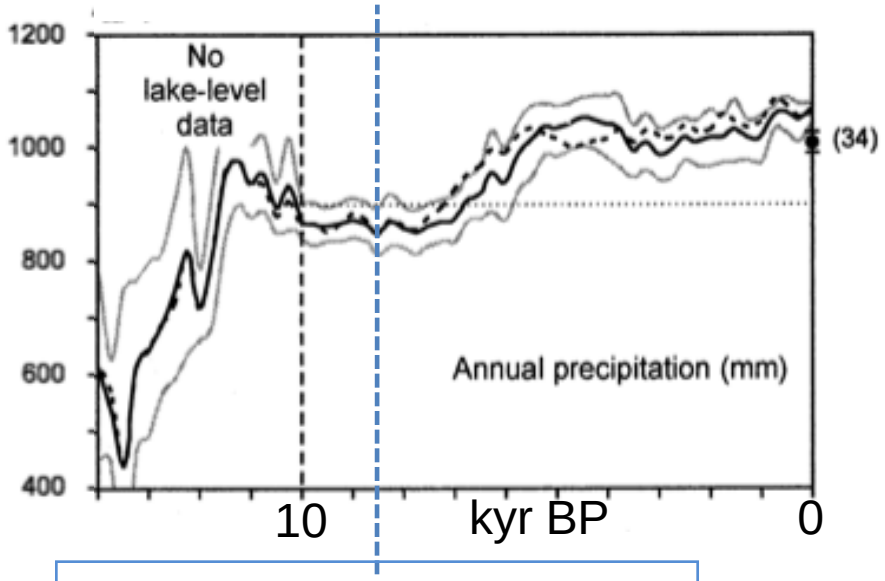
peat accumulation through the Holocene

Photo: Elyn Humphries

PJH Richard core data
Mer Bleue core – MB930



Precipitation history - reconstructed from pollen & lake-level data



simulations start at 8500 BP

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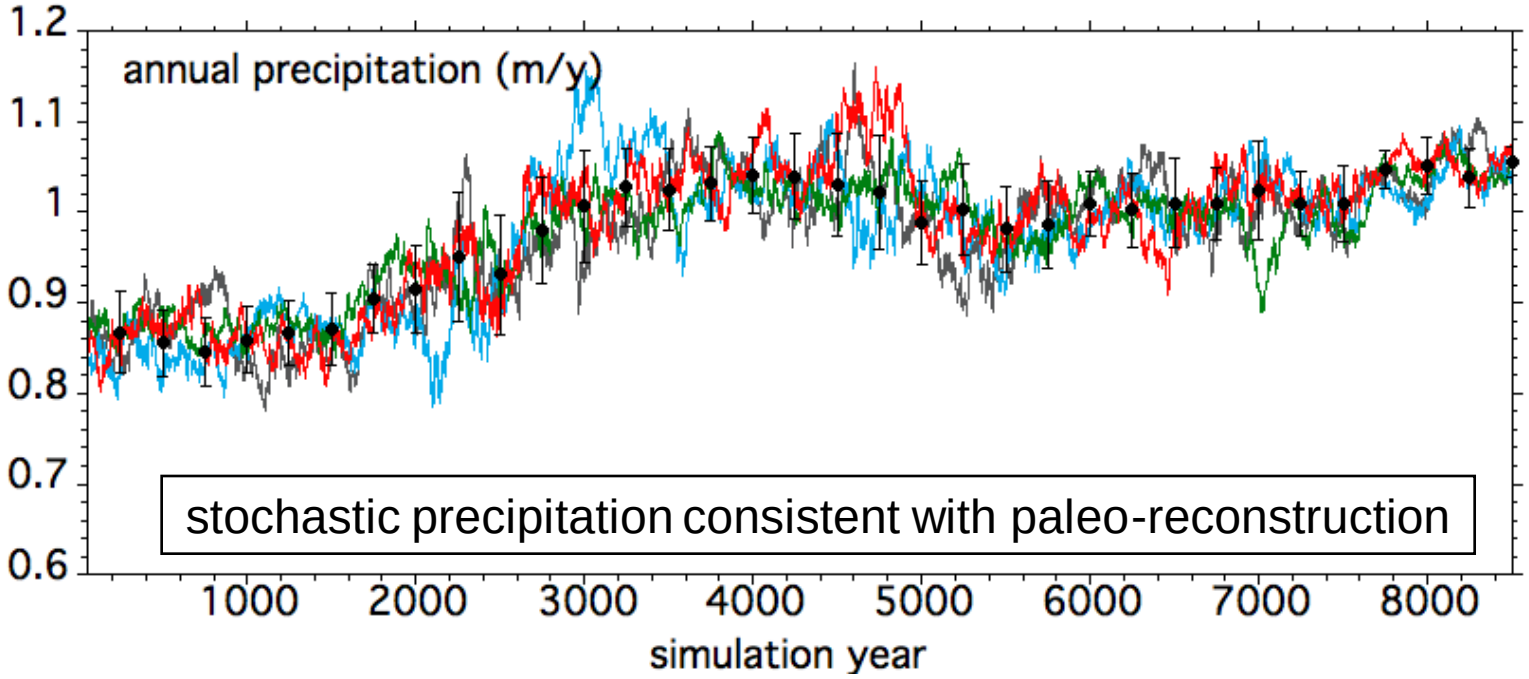
Palaeogeography, Palaeoclimatology, Palaeoecology 193 (2003) 51–72

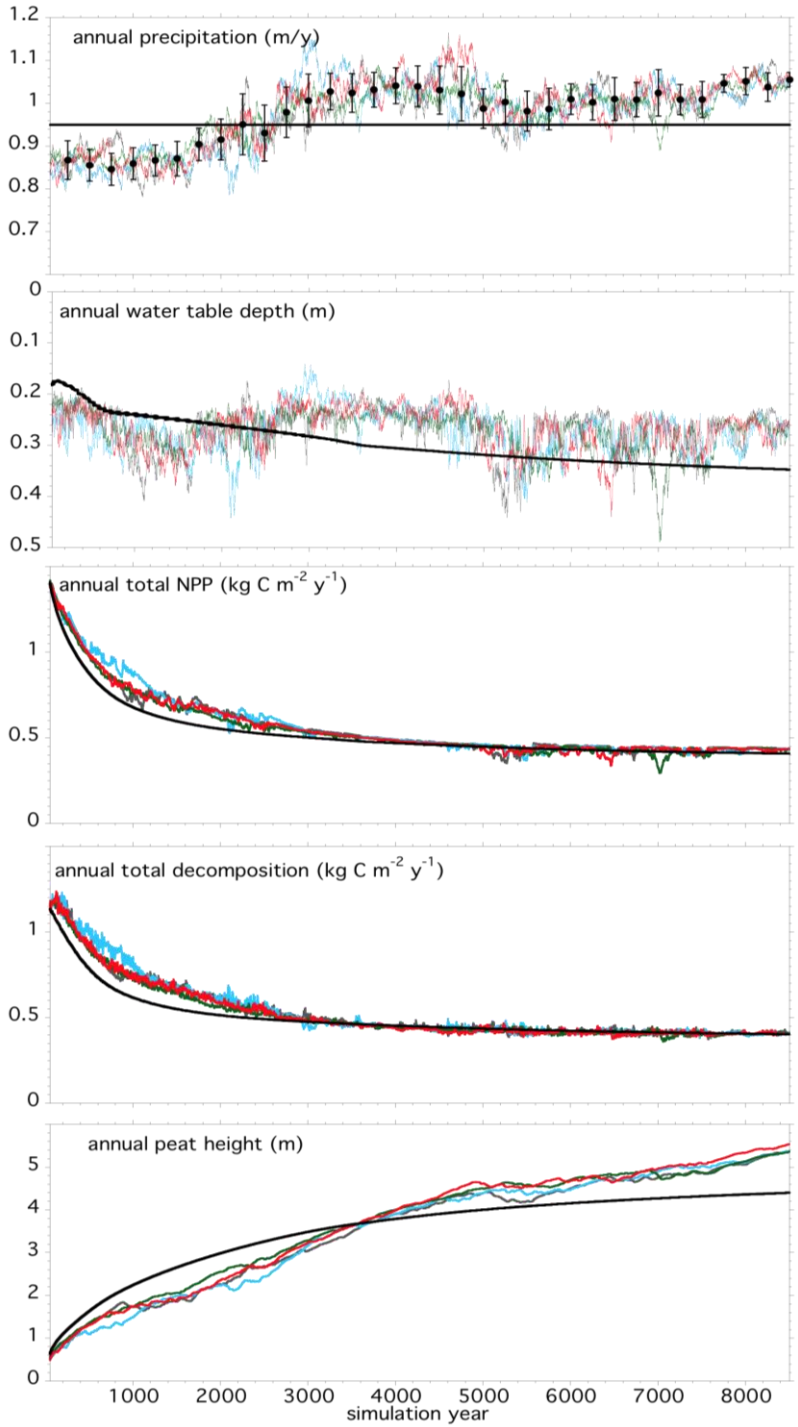
www.elsevier.com/locate/palaeo

Postglacial climate in the St. Lawrence lowlands, southern Québec: pollen and lake-level evidence

Serge D. Muller [a,b,c,*], Pierre J.H. Richard [a,b], Joël Guiot [d], Jacques-Louis de Beaulieu [c], David Fortin [a]



stochastic precipitation consistent with paleo-reconstruction



annual precipitation (m/y)

model driver (input)

simulation output

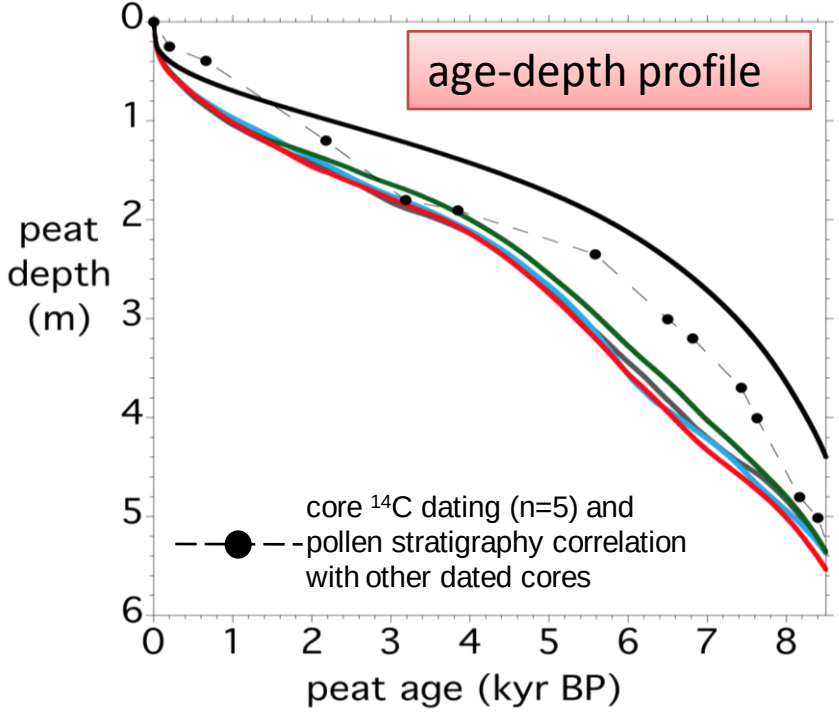
annual water table depth (m)

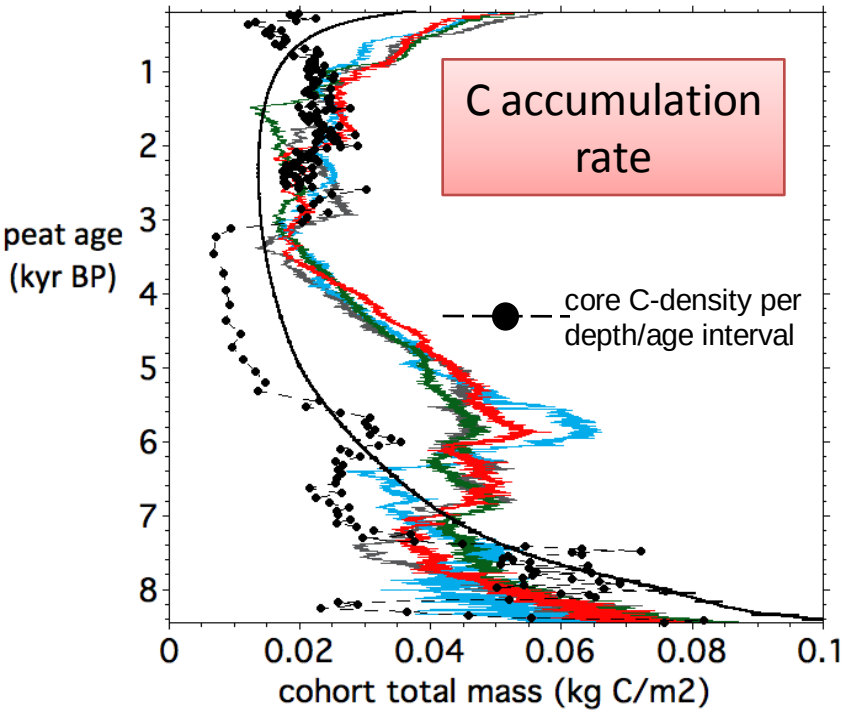
annual total NPP (kg C m^2/y)
net of 12 PFTs calculated separately

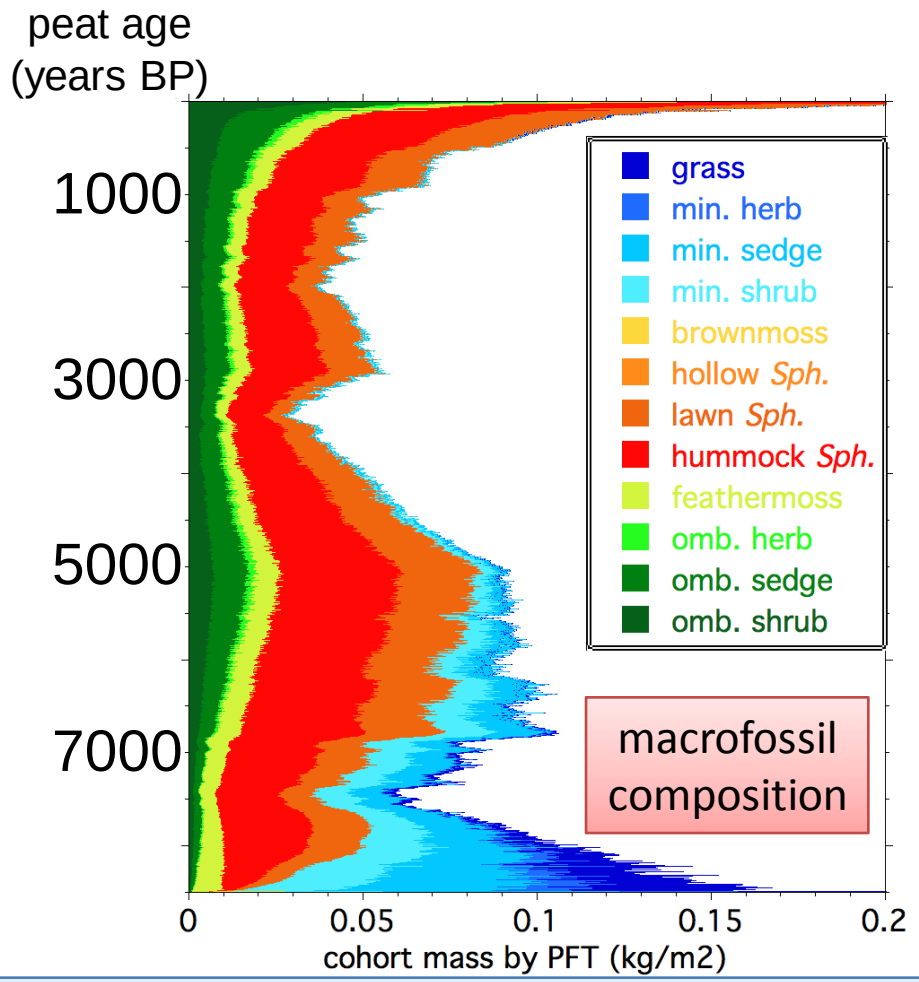
annual total decomp. (kg C m^2/y)
net of 12 PFTs calculated separately

annual total peat height (m)

Mer Bleue core and simulated 'core'







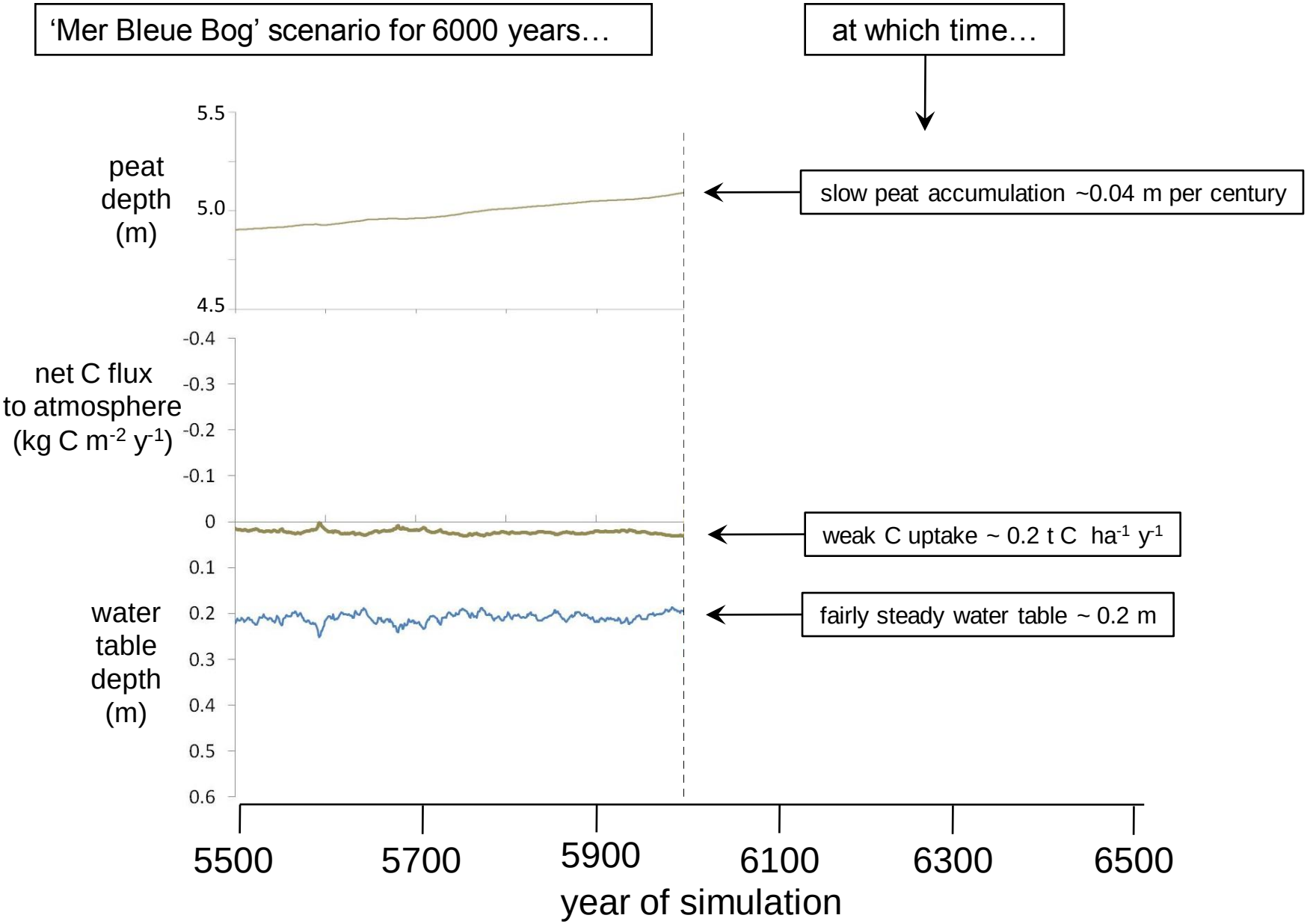
vascular PFTs: 65% of total NPP; 35% of final peat.

ombrotrophic PFTs: 65% of total NPP; 80% of final peat.

- 6.5% of total NPP over 8500 years remains as peat.

Modeling peatland carbon dynamics

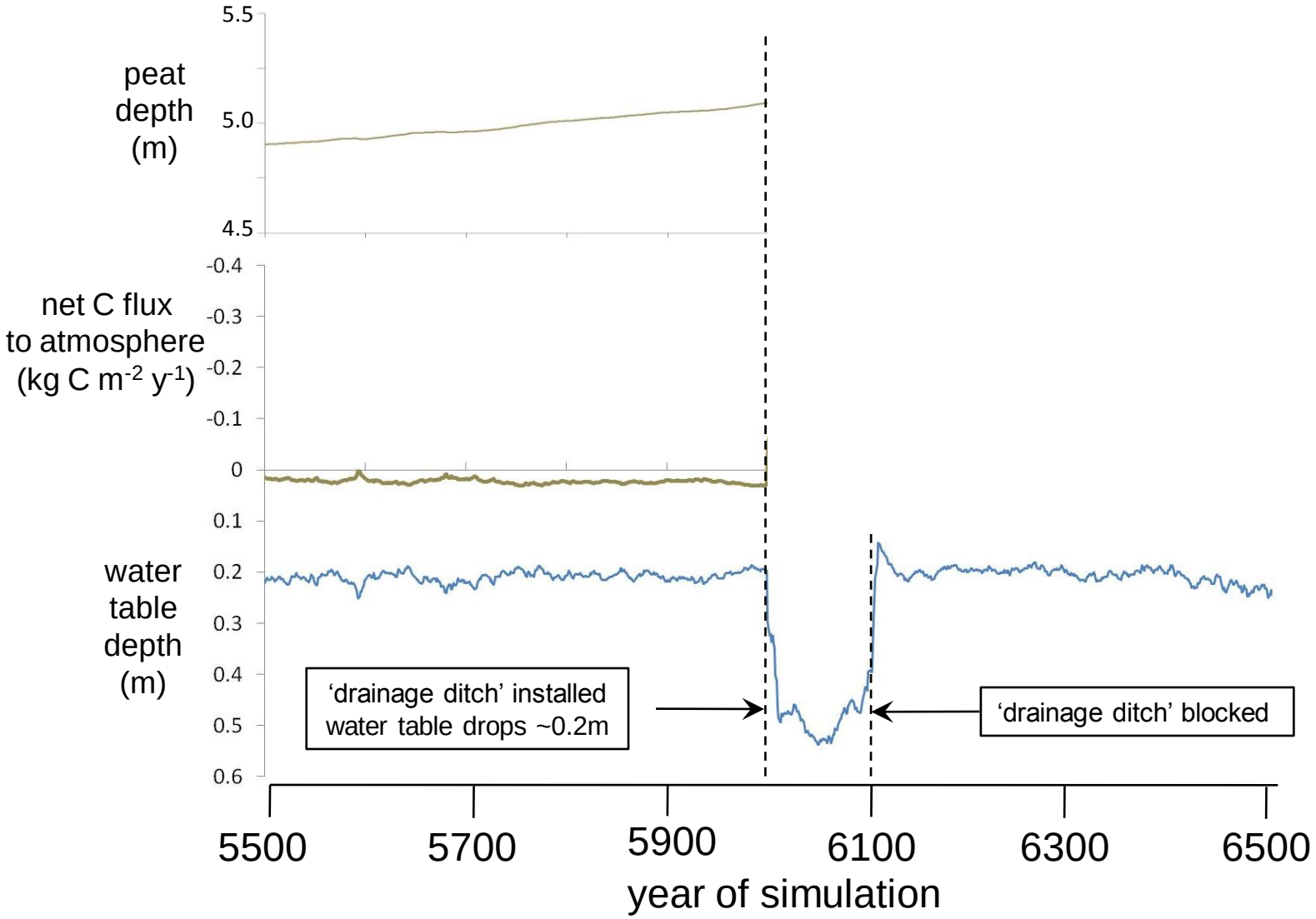
Characterizing anthropogenic disturbances



Modeling peatland carbon dynamics

Characterizing anthropogenic disturbances

'Mer Bleue Bog' scenario, ditch installed in year 6000, maintained, then blocked in year 6100.



Modeling peatland carbon dynamics

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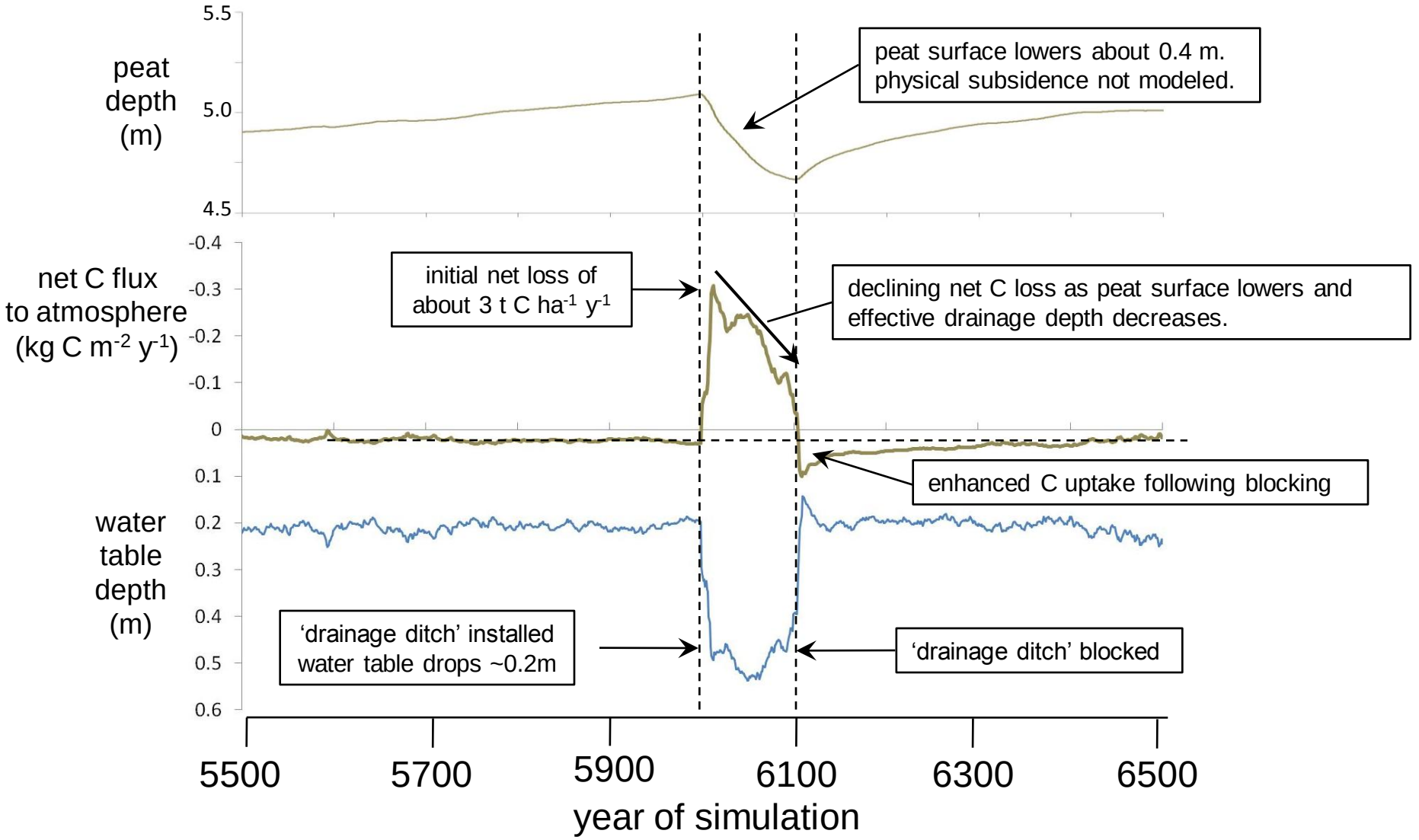

Modeling tropical peatland carbon dynamics – challenges

- much less studied than temperate and boreal peatlands.
- no models developed to simulate tropical peatland C dynamics?
- a number of challenges to developing and applying effective & useful models.

1 – Characterizing tropical peatland vegetation…
e.g., northern peatland studies focus on mosses more than trees

2 – Characterizing tropical peatland hydrology…
e.g., are C/H_2O internal feedbacks of northern peatlands relevant?

3 – Parameterizing tropical peatland decomposition…
e.g., how to handle coarse woody debris in peat profile?

4 – Characterizing anthropogenic disturbances…
e.g., drainage, fire, restoration

5 – Mapping tropical peatlands...
e.g., vegetation community, peat depth, bulk density, hydrological setting

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3 – Parameterizing tropical peatland decomposition…

4 – Characterizing anthropogenic disturbances…

5 – Mapping tropical peatlands...

Thank you!

Essentially, all models are wrong, but some are useful.

-George Box

Essentially, all models are wrong, but some are useful.

-George Box

-or-

Remember that all models are wrong;
the practical question is how wrong do they have to be to not be useful.

- George Box & Norman Draper