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Science advances and estimation of wetland emissions

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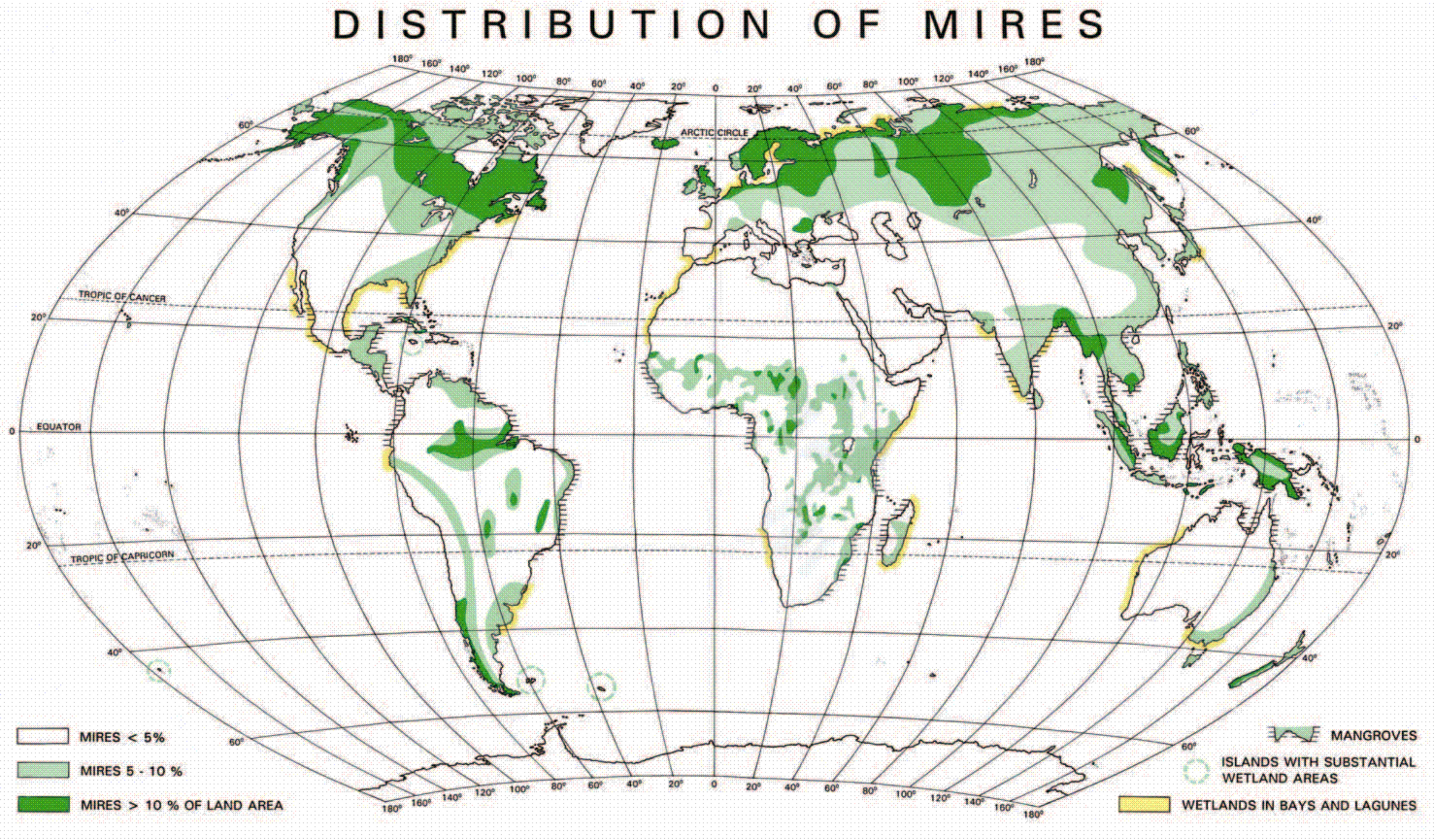
Contents

Objectives

- Summarize knowledge of GHG dynamics in pristine and degraded peatlands
- Improved quantification of anthropogenic GHG emissions and removals in peatlands
- Methodological and conceptual issues in peatland restoration

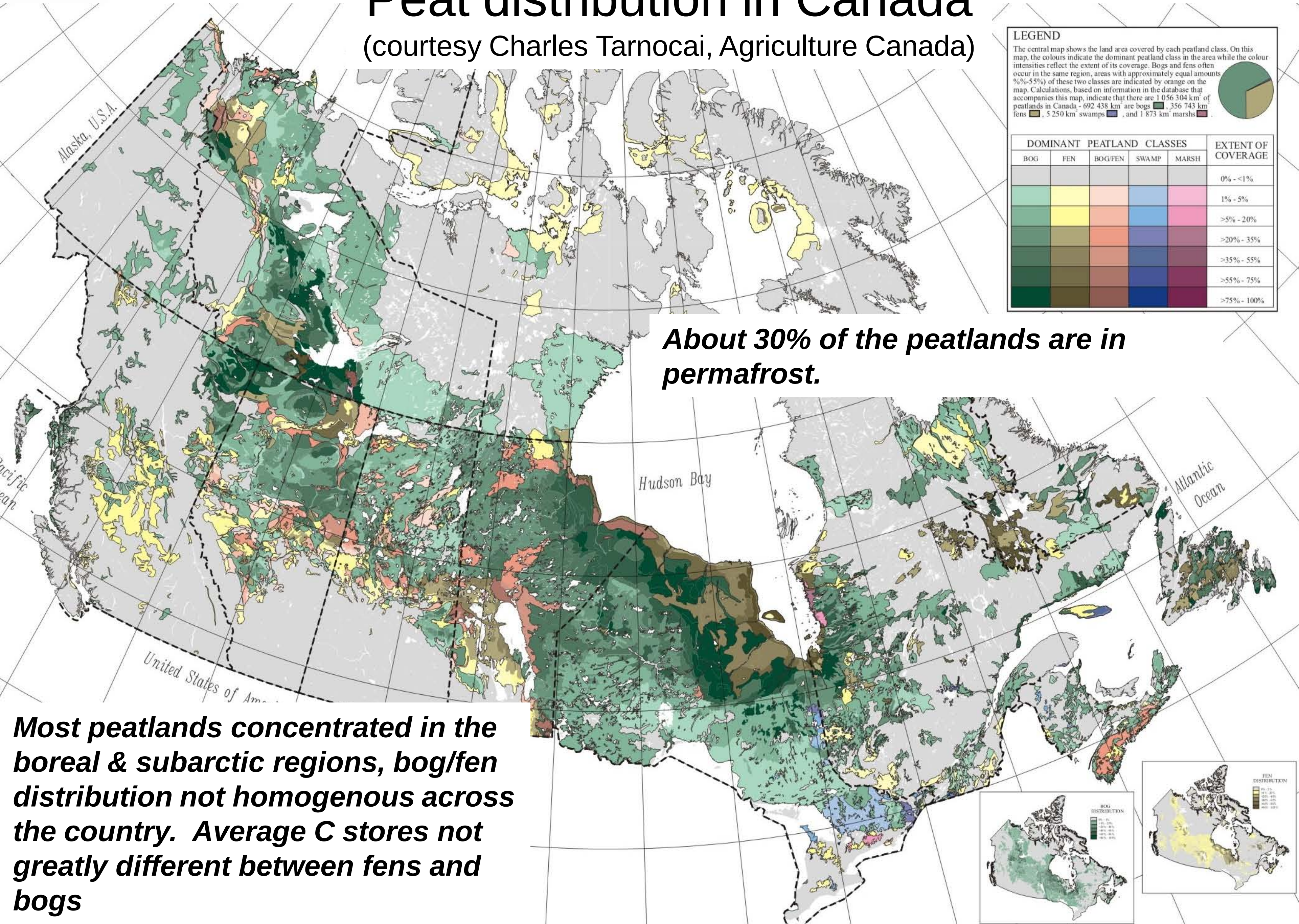
Peatlands are the main wetlands reservoir for soil C. World-wide they contain about 450 Gt C, most in the northern peatlands & about 60 Gt in tropical regions (this number very uncertain).



After Strack et al. 2008. Peatlands and Climate Change. International Peat Society, Vapaudenkatu, Jyvaskyla, Finland.

Peat distribution in Canada

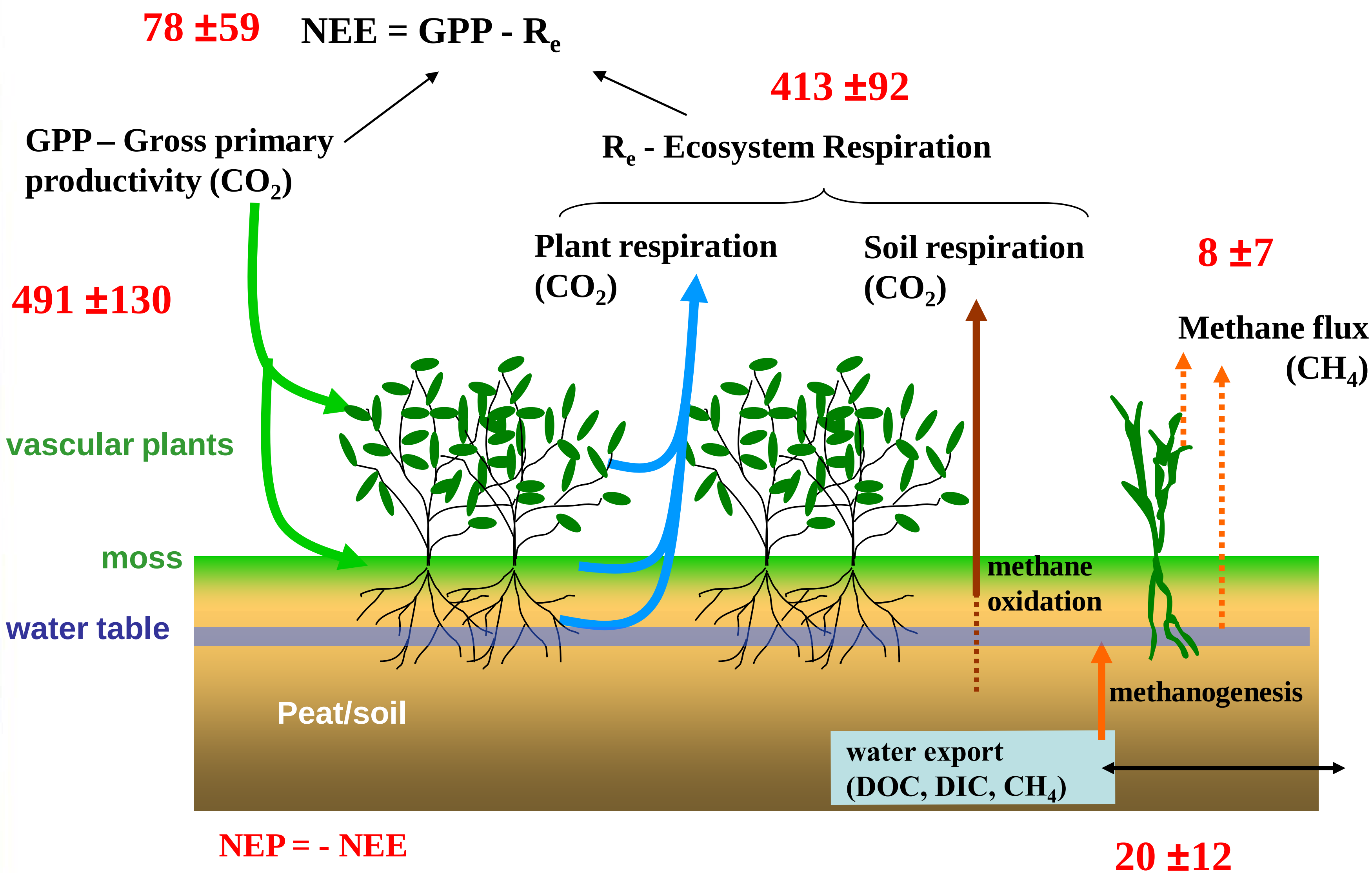
(courtesy Charles Tarnocai, Agriculture Canada)



About 30% of the peatlands are in permafrost.

Most peatlands concentrated in the boreal & subarctic regions, bog/fen distribution not homogenous across the country. Average C stores not greatly different between fens and bogs

C Dynamics in Peatlands: average fluxes (g C m^{-2} yr^{-2})

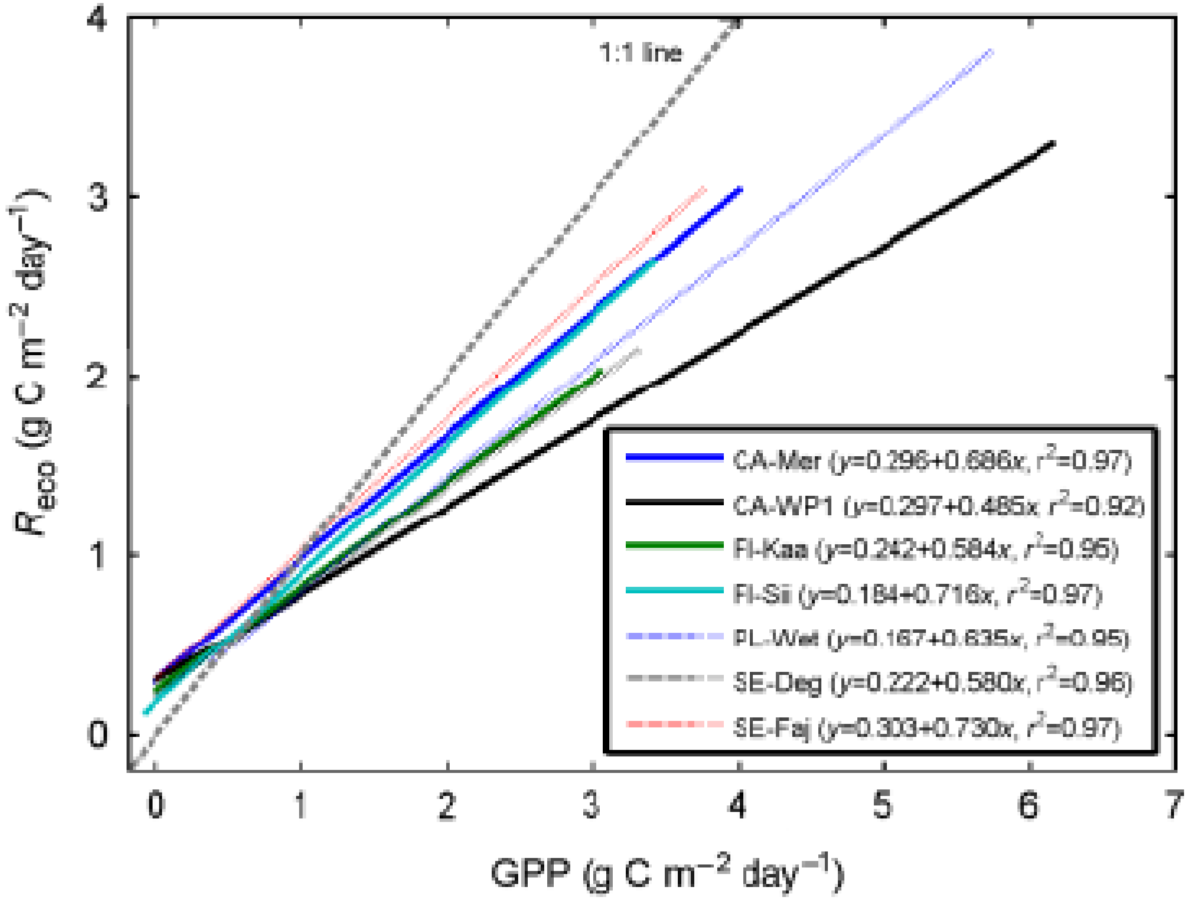


Recent compilation of scientific studies : NEE sensitivity to climate factors

Linear relationship between GPP and R_e : physiological link, same drivers (eg length of growing season)

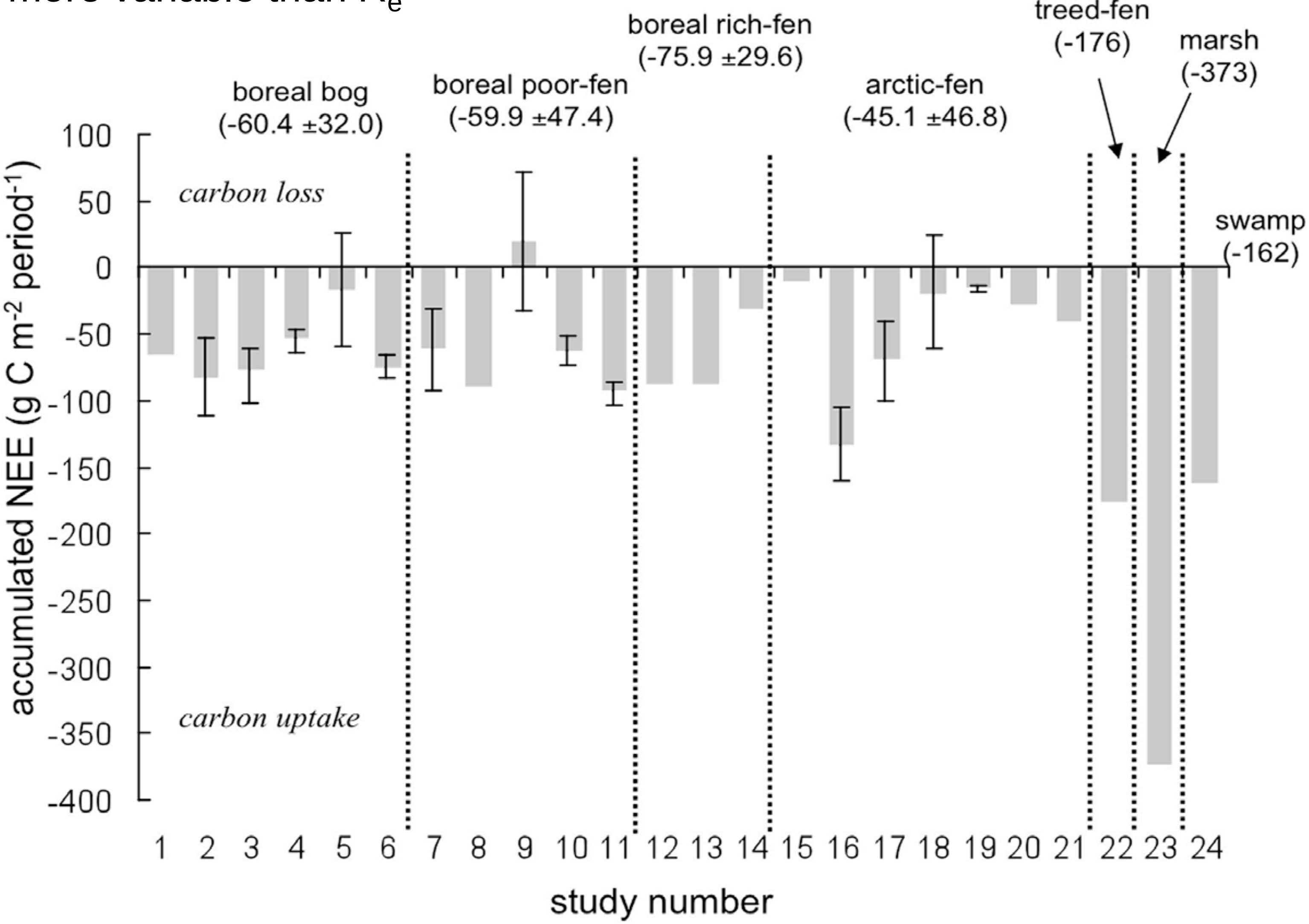
Slopes < 1 : net CO2 uptake

Different slopes reflect varying vegetation and soil chemistry



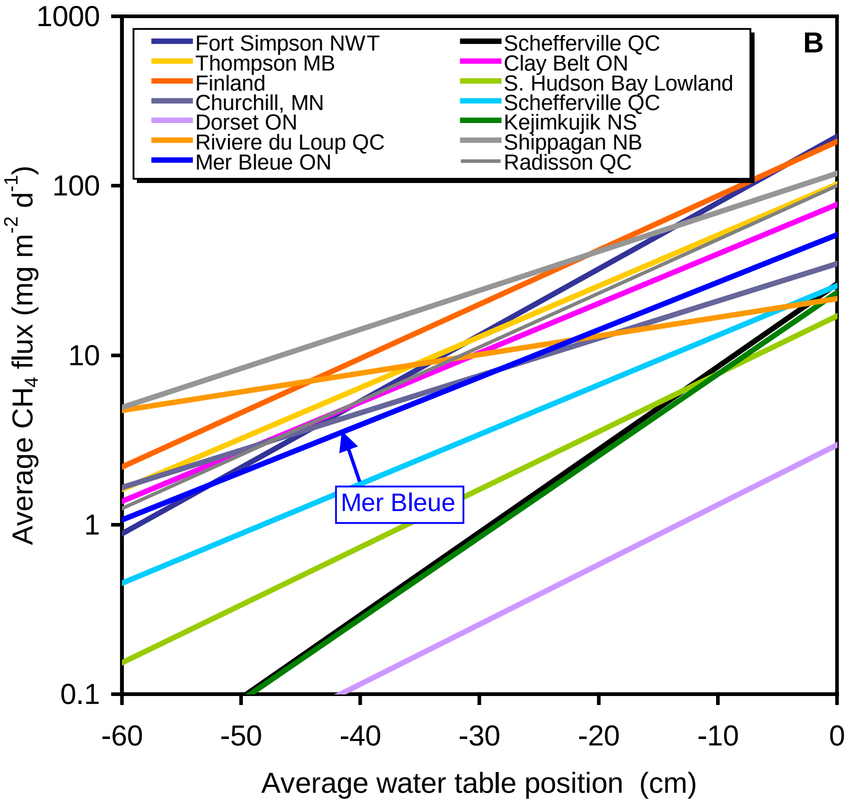
After: Lund et al. 2010

- Overall: peatland type not a good predictor of NEE;
- LAI and pH affect both GPP and NEE
- GPP more variable than R_e



After Lafleur, 2009

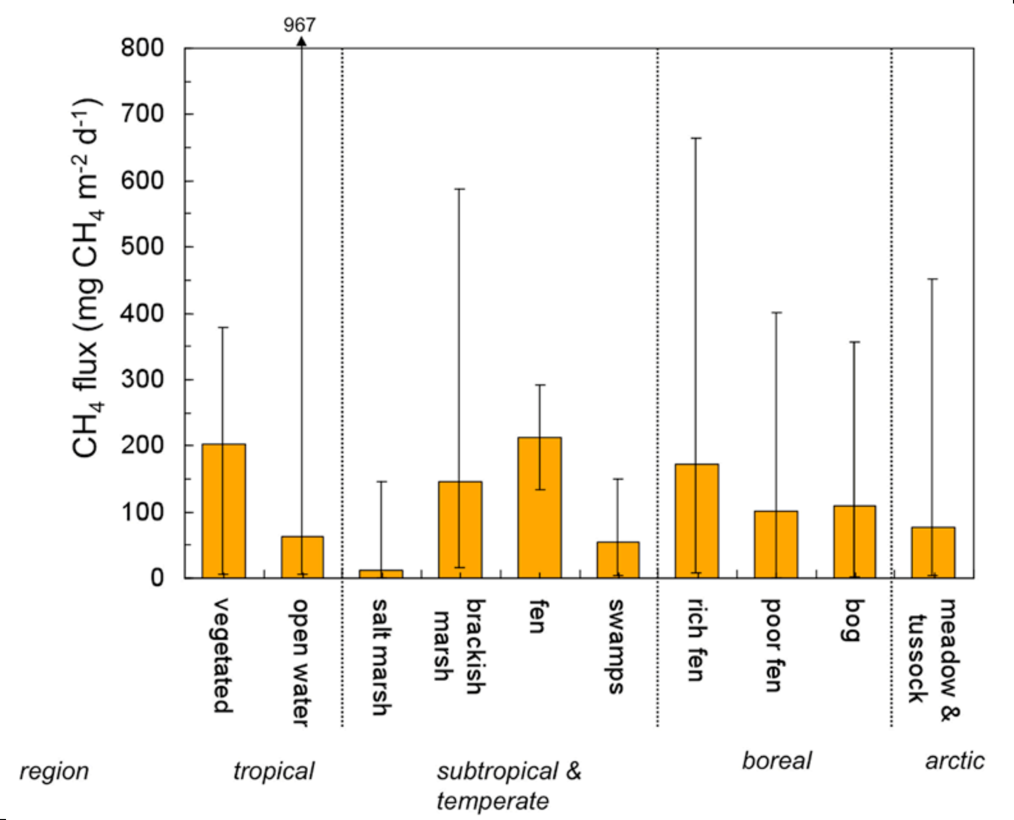
Controls on CH4 emissions



WTD a key factor in CH_4 emissions (depth of oxic and anoxic parts of the peat)

Different intercepts : mean or base rate of CH_4 emission controlled by other factors (vegetation, mean climate, etc.)

after Moore TR, unpub.



CH4 emissions highly variable

Winter emissions contributing about 10% of the annual emissions

Spatial ‘hotspots’

Lafleur, 2009

Role of DOC in Peatland C budget

DOC losses from peatlands range from <5 to 40 g C m^{-2} yr^{-1}

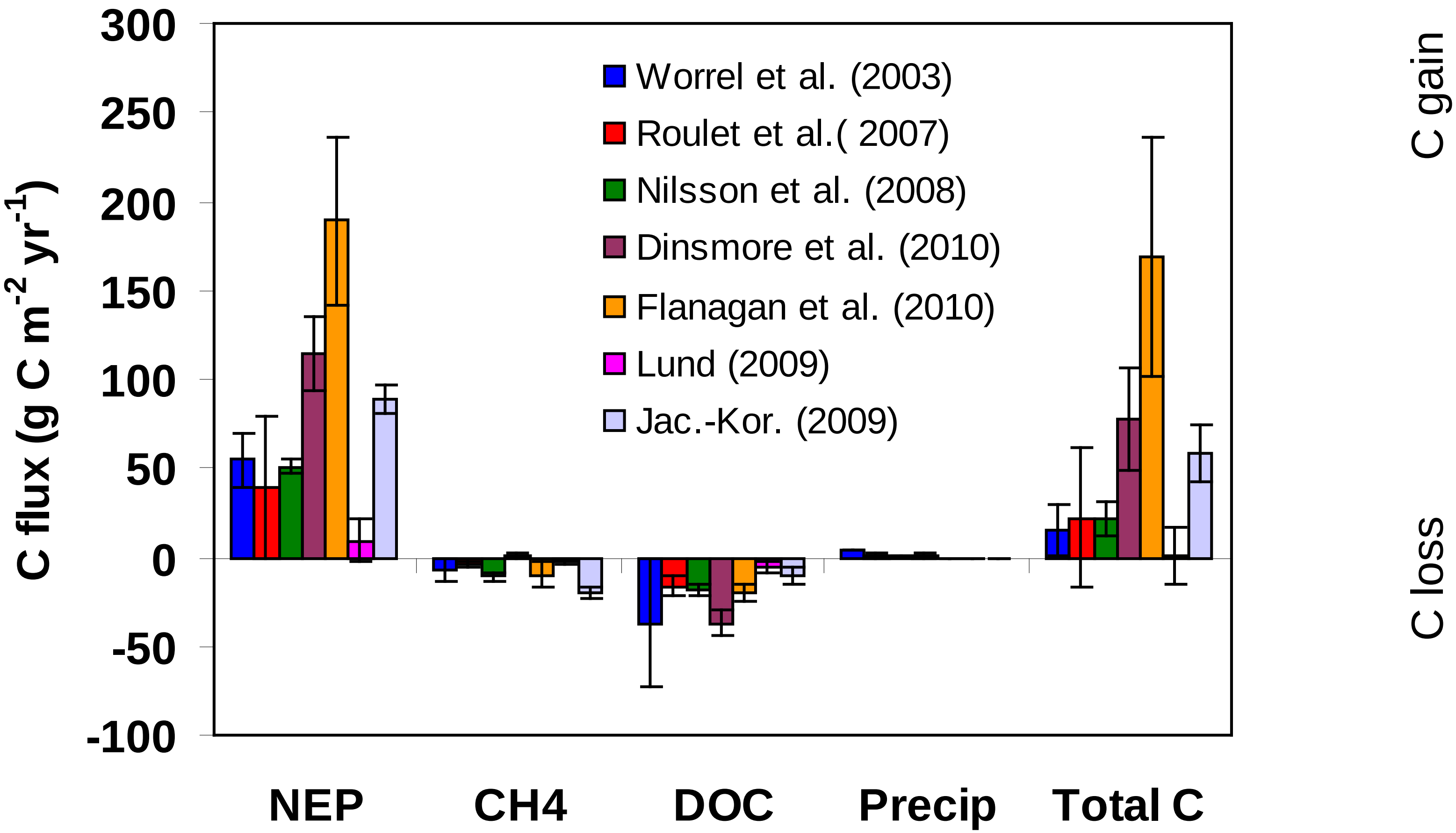
DOC as a percent of NEP range averages from 5% to 70%; in individual years it can be >100%

DOC export is controlled by 1) production in the peat profile and 2) discharge (Q):

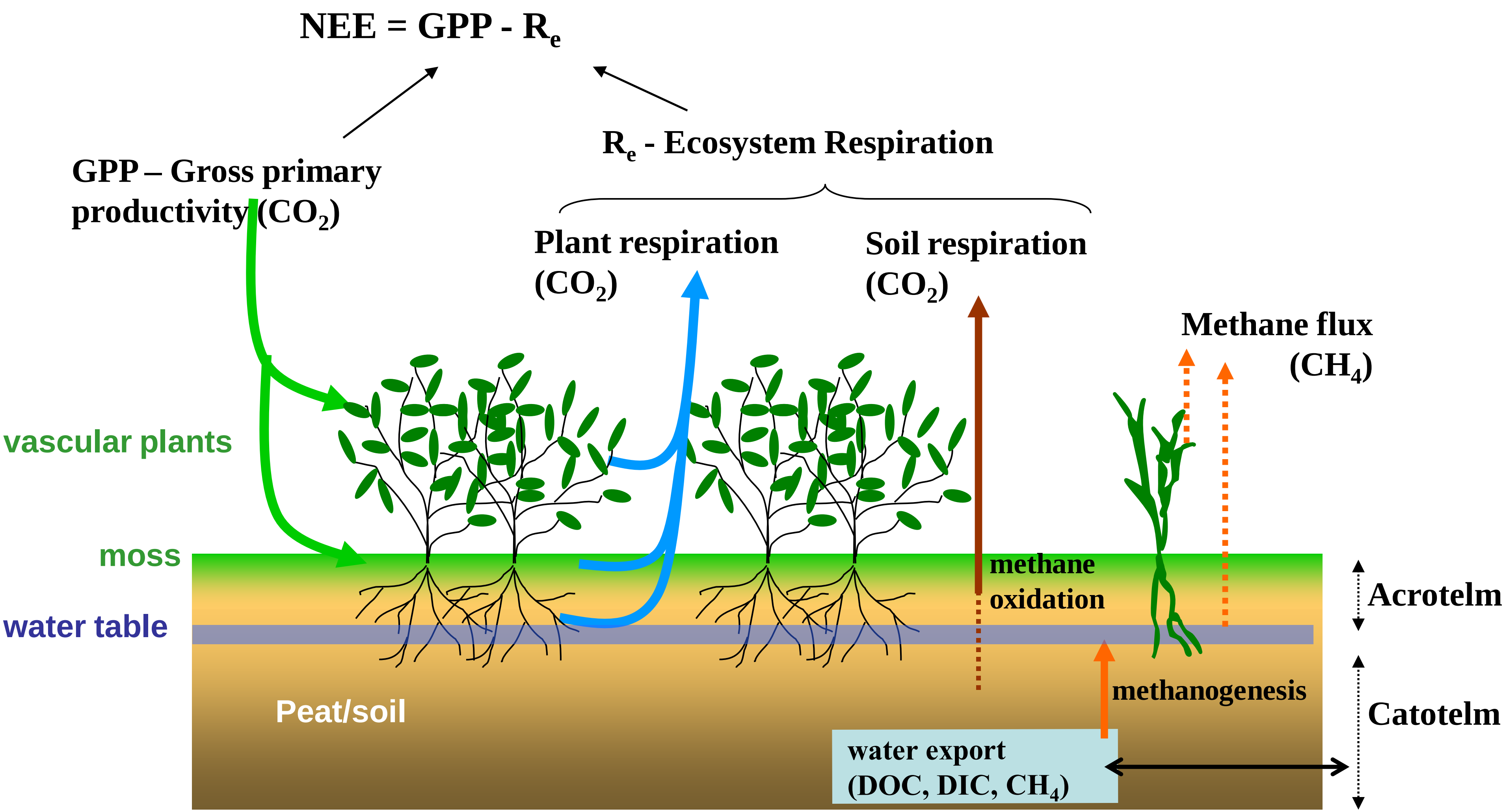
- variations in flux at a given peatland are largely determined by Q
- differences among peatlands in similar hydrologic settings are production related

Compilation of annual measured C budgets for peatland sites

$$\Delta C = CO_2\text{-}C + CH_4\text{-}C + DOC + C_{ppt}$$



Peatlands Drainage



NEP = - NEE

Strack and Waddington, 2007

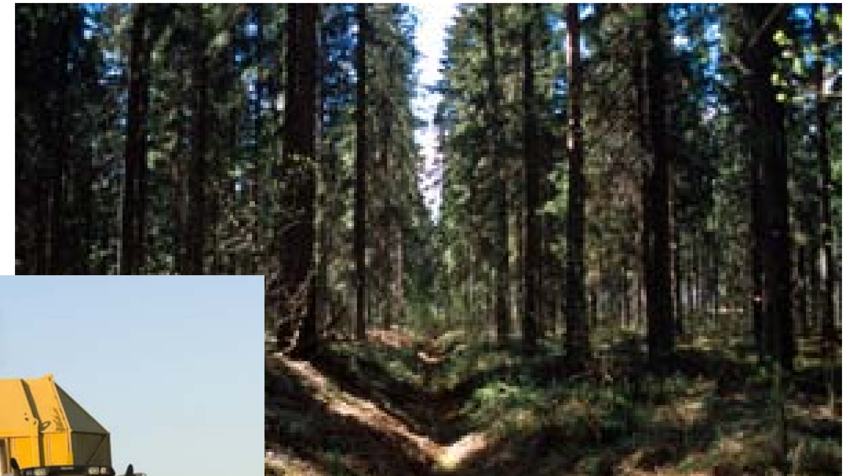
Intensity of post-drainage utilization varies

Intensive forestry

Pasture

Cropping

Peat extraction



Degraded peatlands

Non-functional acrotelm:

Loss of peat hydraulic properties

Price and Whitehead, 2004

Erratic water table regime : drying and rewetting episodes

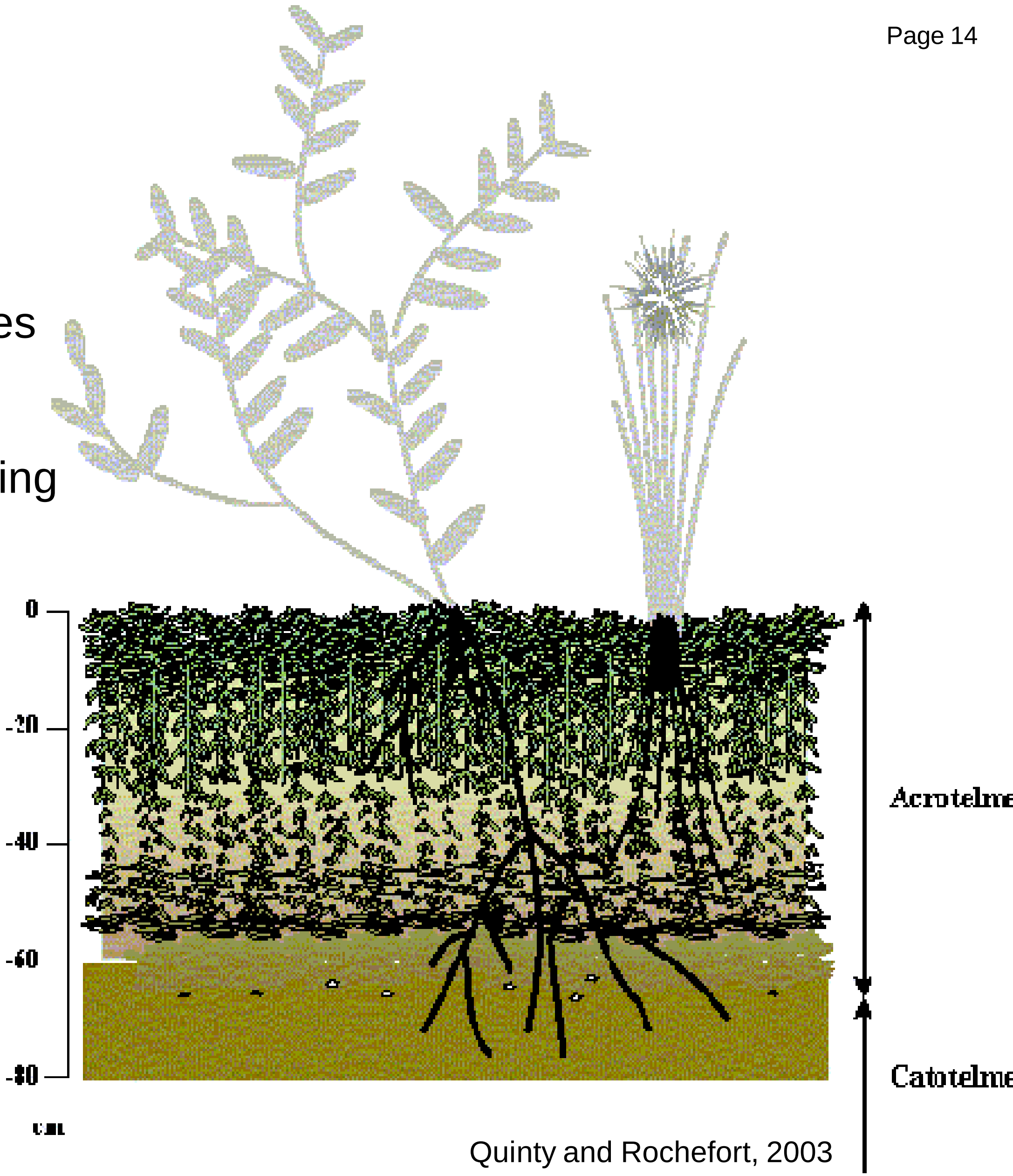
McNeil and Waddington, 2003

Persistent source of CO2 fluxes to atmosphere (100% - 400% of pristine)

Waddington et al., 2002

Little re-colonization by Sphagnum mosses

Waddington et al., 2008



Quinty and Rochefort, 2003

Steps in Peatland Restoration

‘Natural’ recolonization of degraded peatlands is slow, and vegetation establishment dominated by vascular vegetation (herbs and shrubs), with poor moss colonization

Poulin et al., 2005

Rewetting reduces R_e but does not stabilize WT fluctuations if functional moss layer is missing

Waddington and Day, 2007

Restoring C sink function involves water table regulation by living moss layer (acrotelm)

Post-mining restoration techniques have been developed and field tested: functional acrotelm and C sequestration function re-established within ~ one decade.

Lucchese et al., 2010

Contrasting GHG dynamics of Peatlands in different States

Functions / *States*

Functions	Pristine	Degraded	Re-wetted	Restored
Vegetation & peat	Intact moss cover and peat structure	No moss; peat compaction & subsidence	Little or no moss	Re-established moss layer
Hydrology	WTD fluctuation regulated by moss	WTD highly fluctuating – climate sensitive	WTD highly fluctuating – if not regulated	WTD and acrotelm fluctuations regulated
C exchange	GEP > R_e & more variable	R_e dominates; GEP $\rightarrow$0	R_e smaller; CH_4 loss larger	GEP>R_e; CH_4 possibly larger
NEP	Long-term C sink	C source to atmosphere	C source to atmosphere	net C sink

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Restoration objectives should be determined

Rehabilitation
To re-establish the productivity and some, but not necessarily all, of the plant and animal species thought to be originally present at a site.* Ex: re-establish C sink through perennial, vascular vegetation

Restoration
Re-establishing the presumed structure, productivity and species diversity that was originally present at a site that has been degraded, damaged or destroyed. In time, the ecological processes and functions of the restored habitat will closely match those of the original habitat. Ex: re-establish C sink and hydrological regulation by moss layer

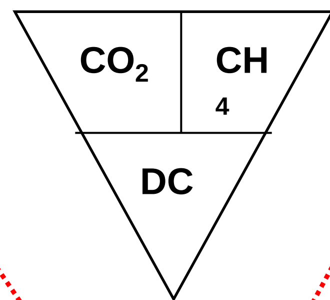
Nelleman and Corcoran 2010; FAO 2005.

Restoration of C sequestration function must take into account vegetation, hydrology and climate

feedback

CLIMATE

Growing season
- temperature
- light
- moisture balance



PEATLAND TYPE and STATE
- vegetation : moss, perennial herbaceous
- LAI
- peat condition
- biogeochemistry

HYDROLOGY
- flow (in & out)
- WTD mean and variation

Monitoring peatland restoration involves:

- Understanding the state of peatlands: vegetation, hydrology, climate (slide 18)
- Determining restoration or rehabilitation objectives (slide 17)
- Monitoring key elements of C budget: NEE, DOC, CH4 (slide 11)

Key methodological and conceptual issues

- Vegetation influence on restoration/rehabilitation pathway
- Spatial variability in CH4 emissions
- Reconcile climate cooling of long-term C sequestration and annual climate forcing (GHG balance)

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