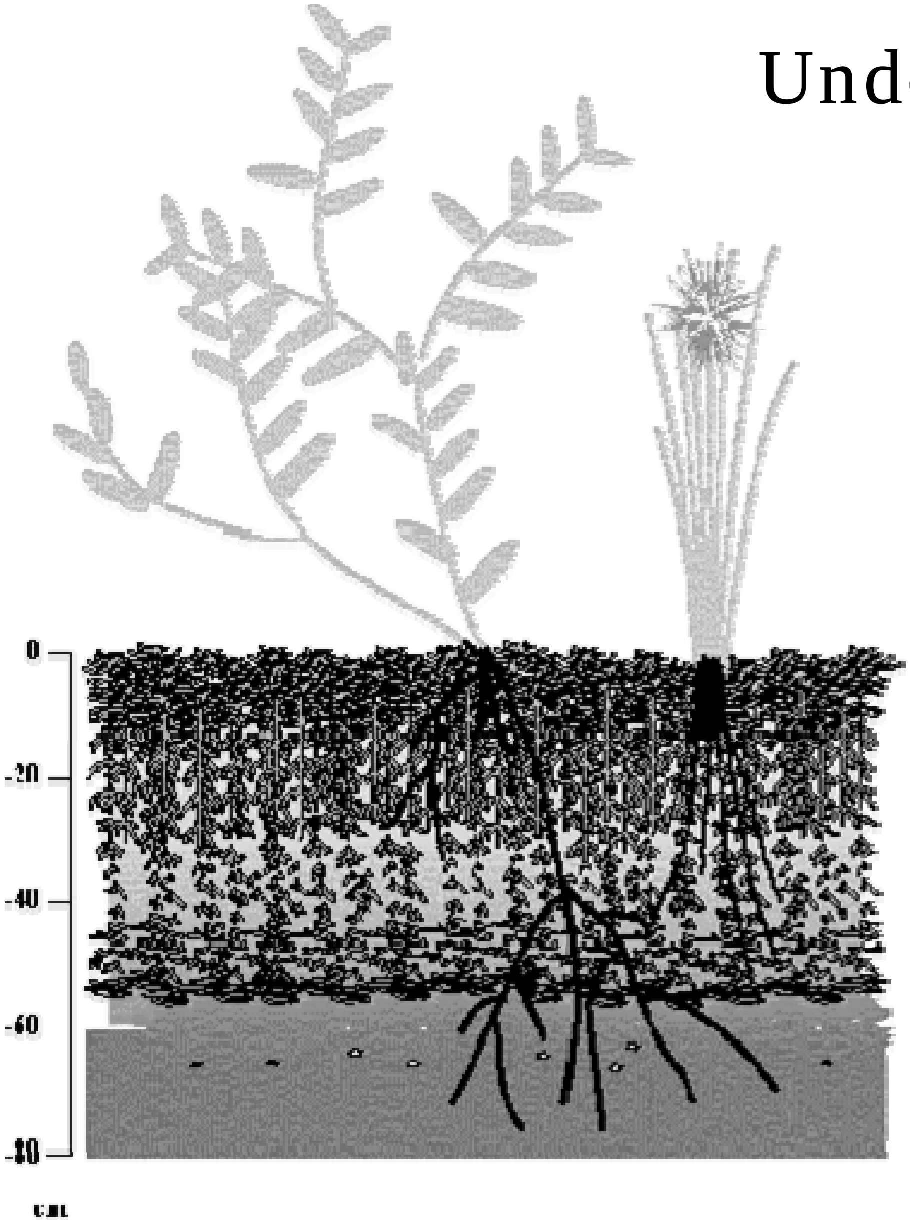
Understanding Anthropogenic Impact on Peatlands GHGs



Drawing from Quinty and Rochefort, 2003

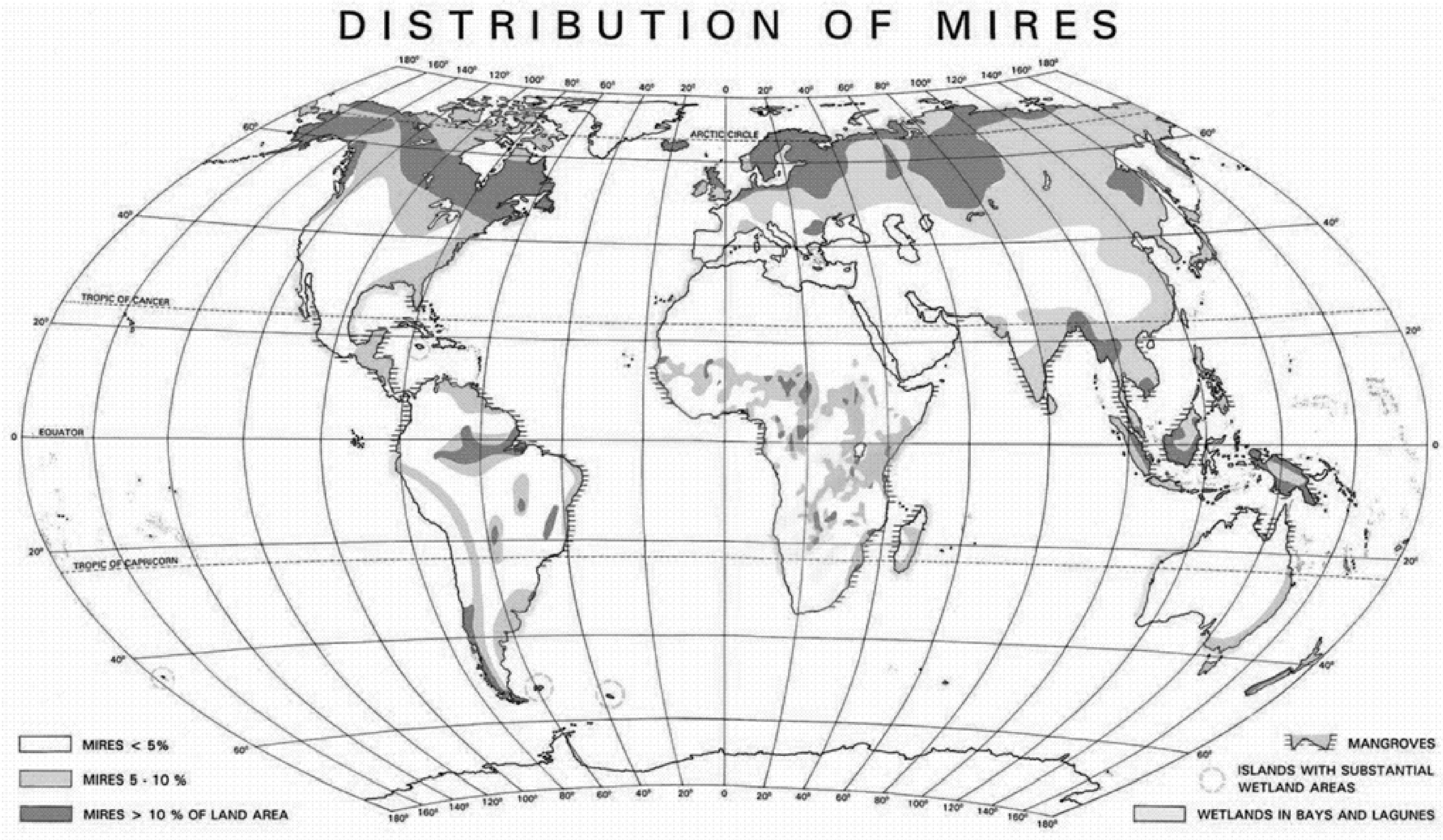
Dominique Blain, PhD

IPCC TFI Side Event
Maritim Hotel, Bonn
8 June 2011

A Proposed Approach

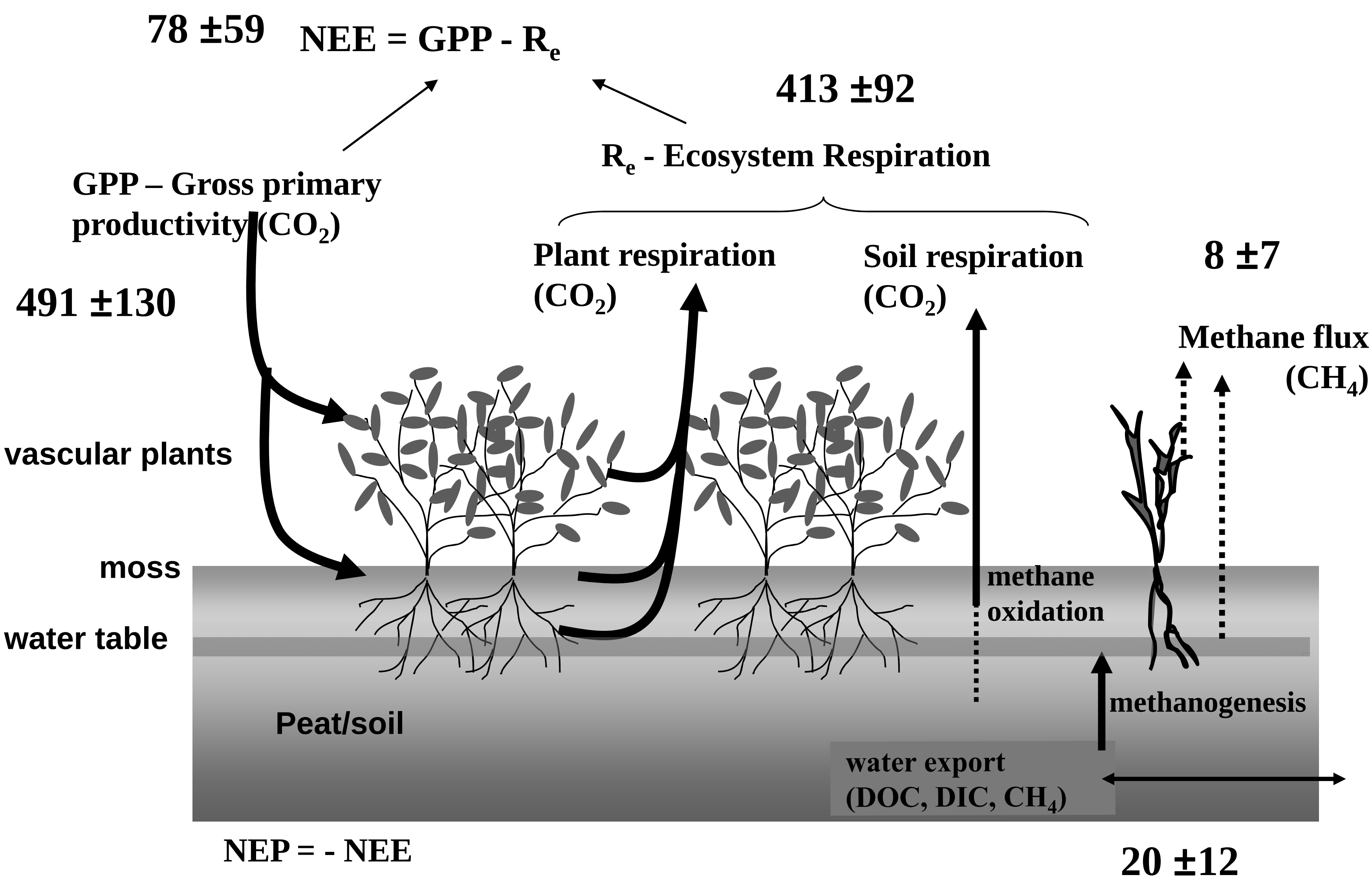
- Measuring GHG fluxes
- Understanding drivers of GHG dynamics
- Understanding GHG dynamics in degraded, rewetted and restored peatlands
- Putting it all together

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.

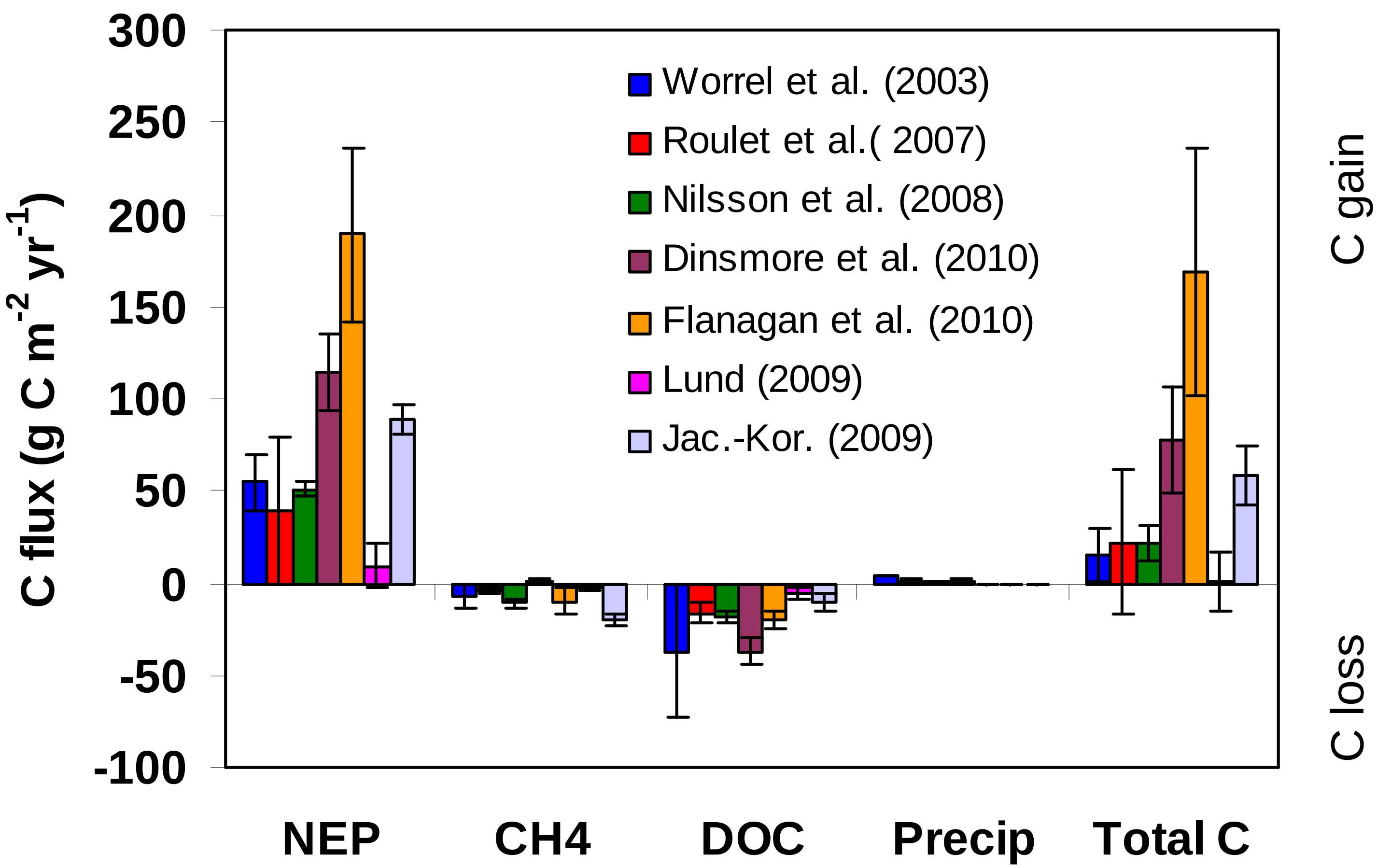
Measuring GHG fluxes in northern peatlands (g C m^{-2} yr^{-2})



Blain & Lafleur, 2010

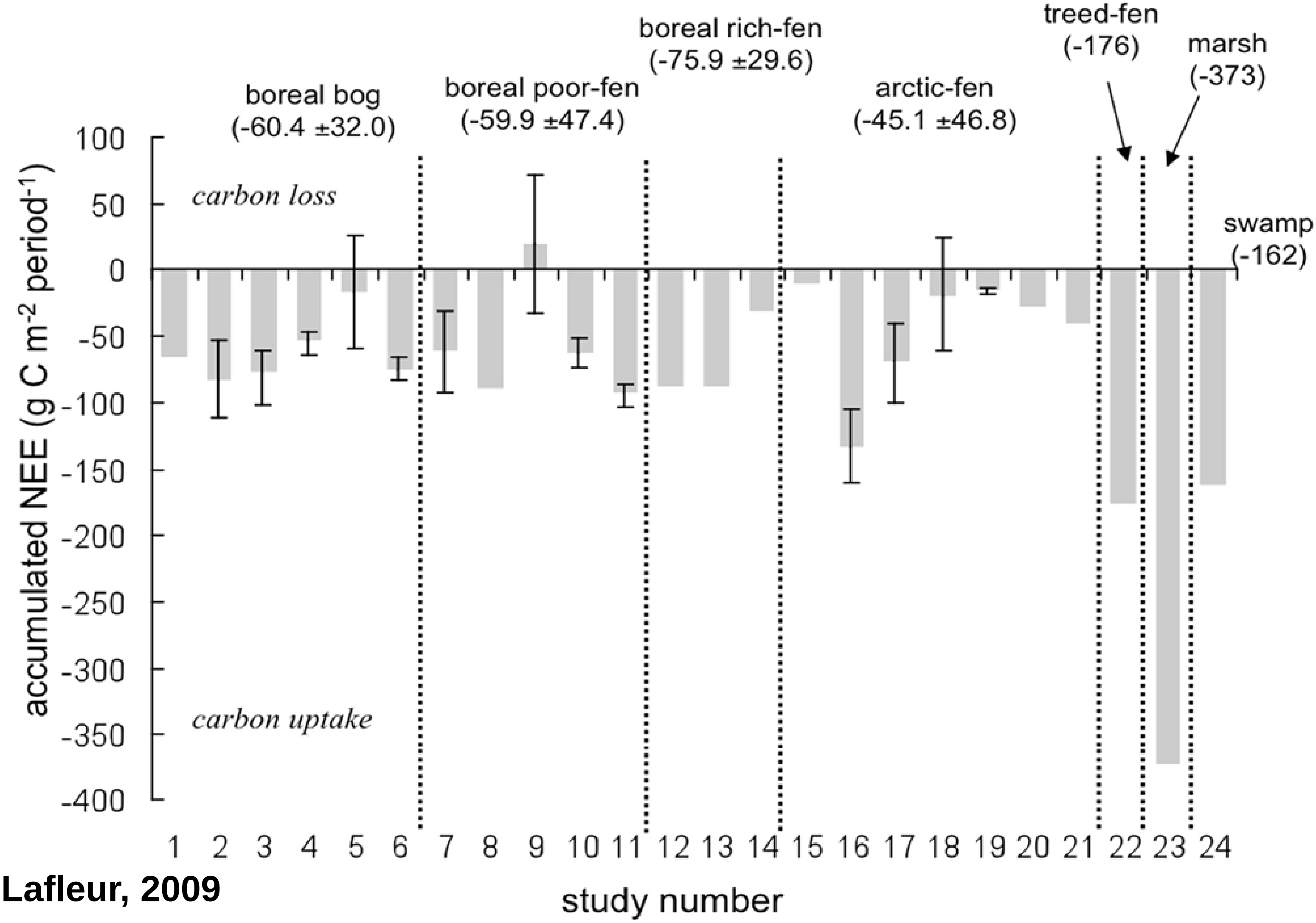
Compilation of annual measured C budgets for peatland sites

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



Understanding drivers of Net Ecosystem Exchange

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

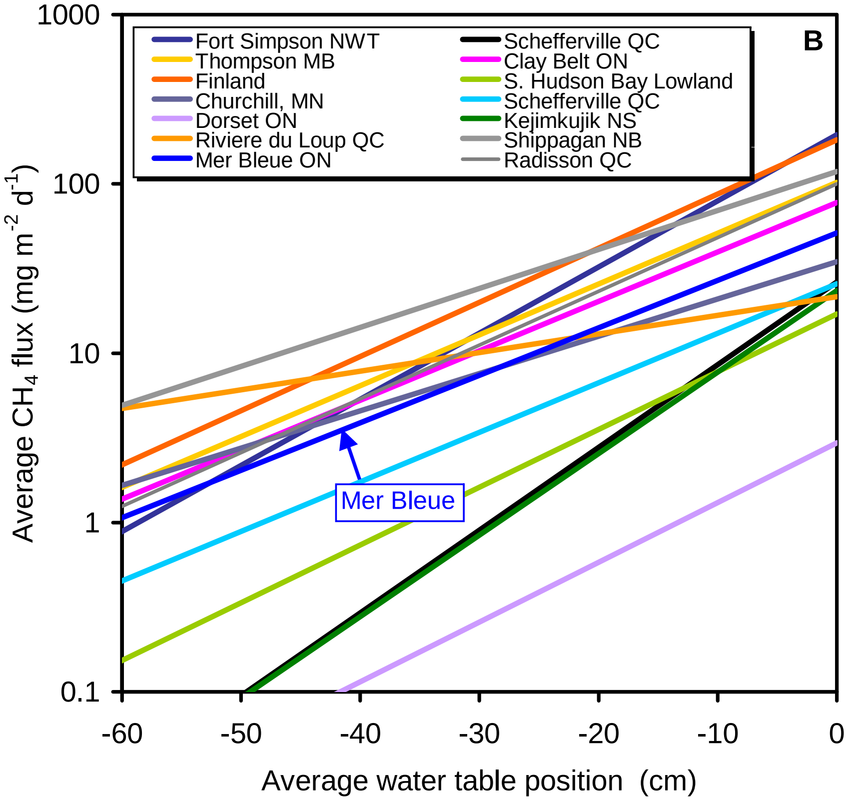


After Lafleur, 2009

Understanding Controls over CH4 emissions

- CH4 emissions highly variable
- Winter emissions contributing about 10% of the annual emissions
- Spatial 'hotspots'

Lafleur, 2009



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.

Carbon is also lost in dissolved form:

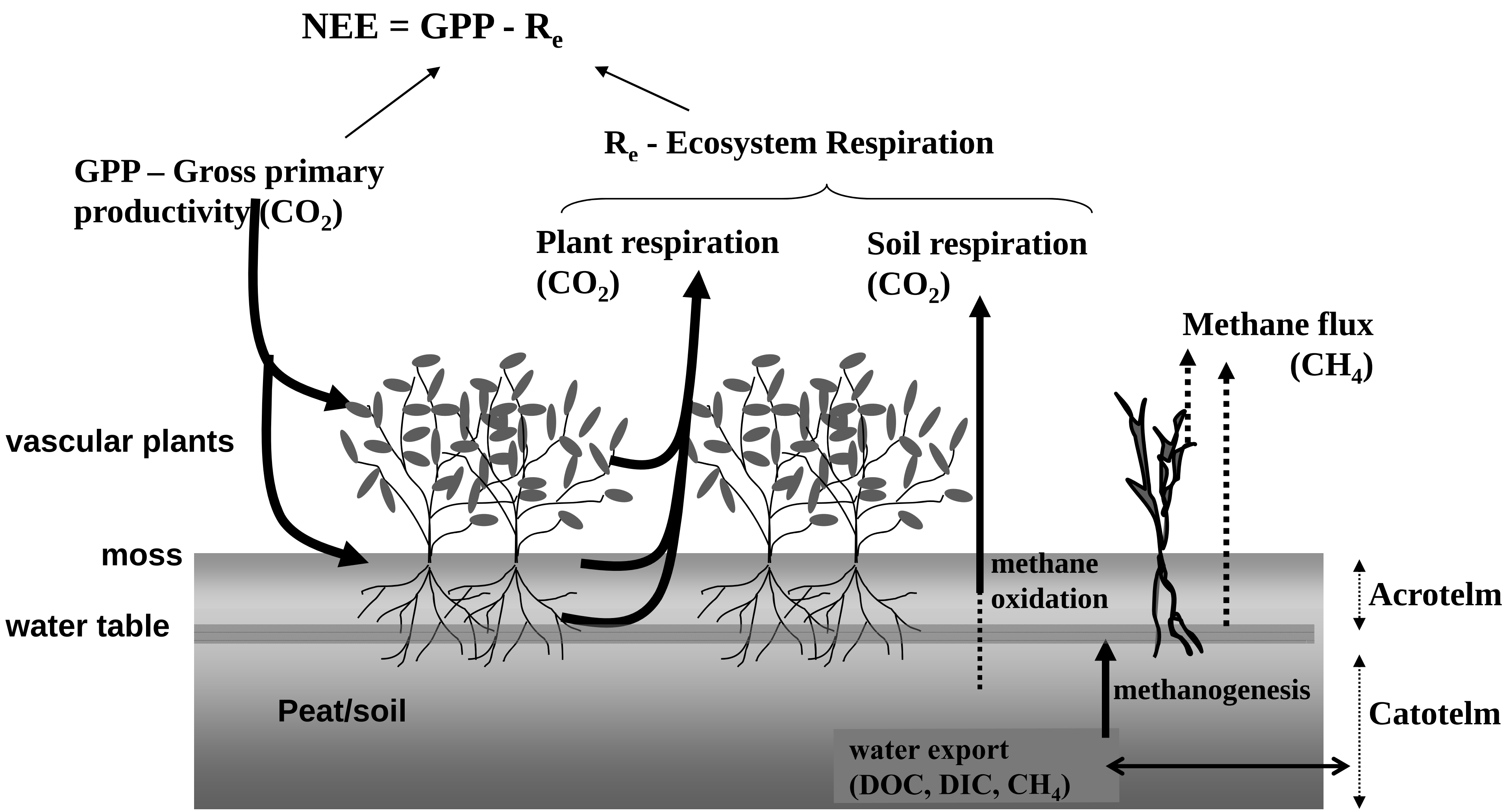
DOC losses from peatlands range from <5 to 40 g C m^{-2} yr^{-1}

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

Peatlands Drainage: what happens



NEP = - NEE

Strack and Waddington, 2007

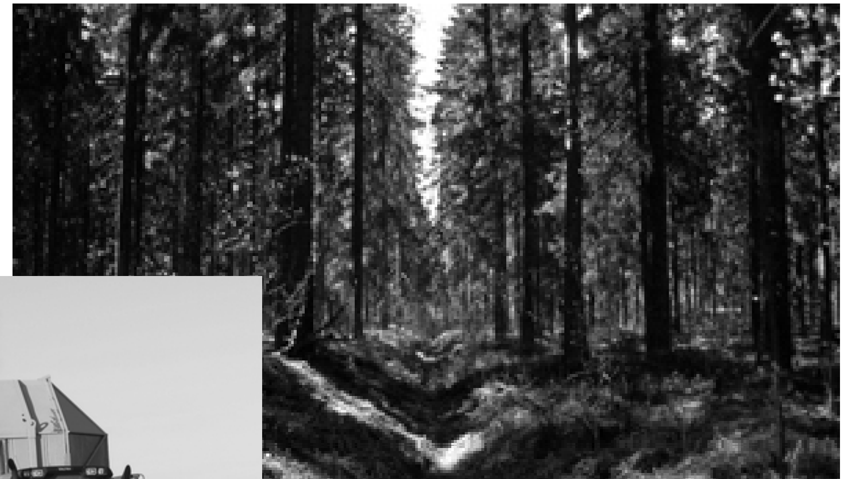
Intensity of post-drainage utilization varies

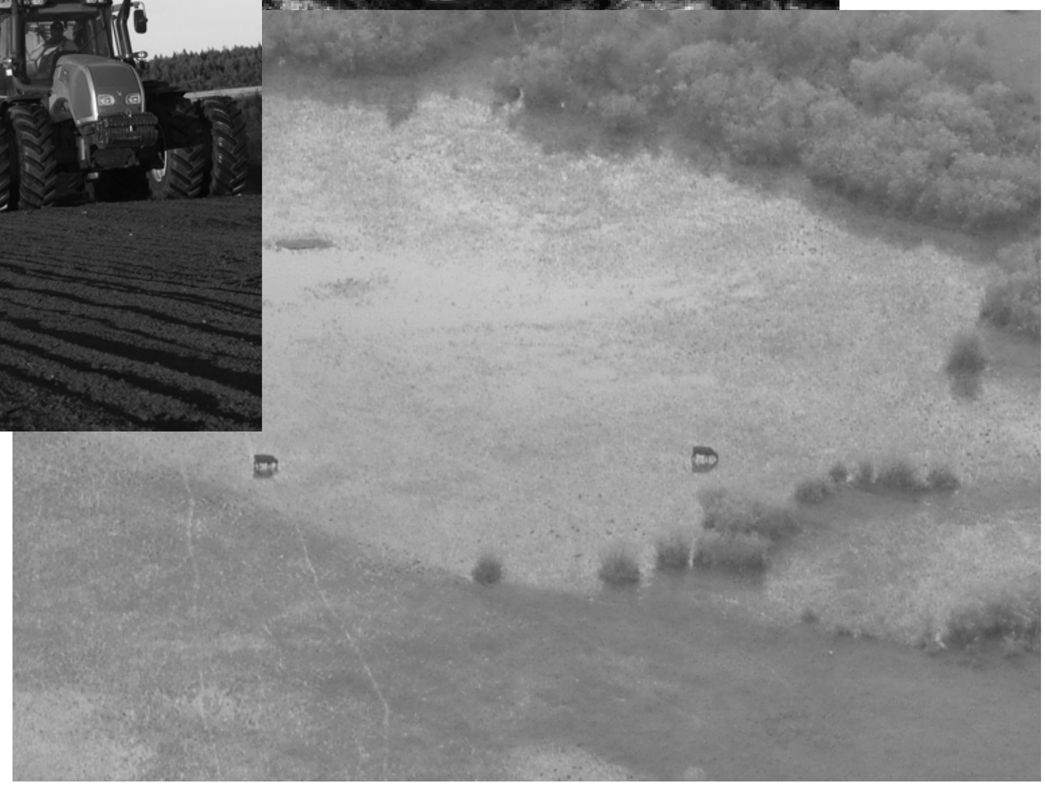
Intensive forestry

Pasture

Cropping

Peat extraction





Degraded peatlands: losses of functions

Non-functional acrotelm:
Loss of peat hydraulic properties

Price and Whitehead, 2004

Erratic water table regime : drying and rewetting episodes

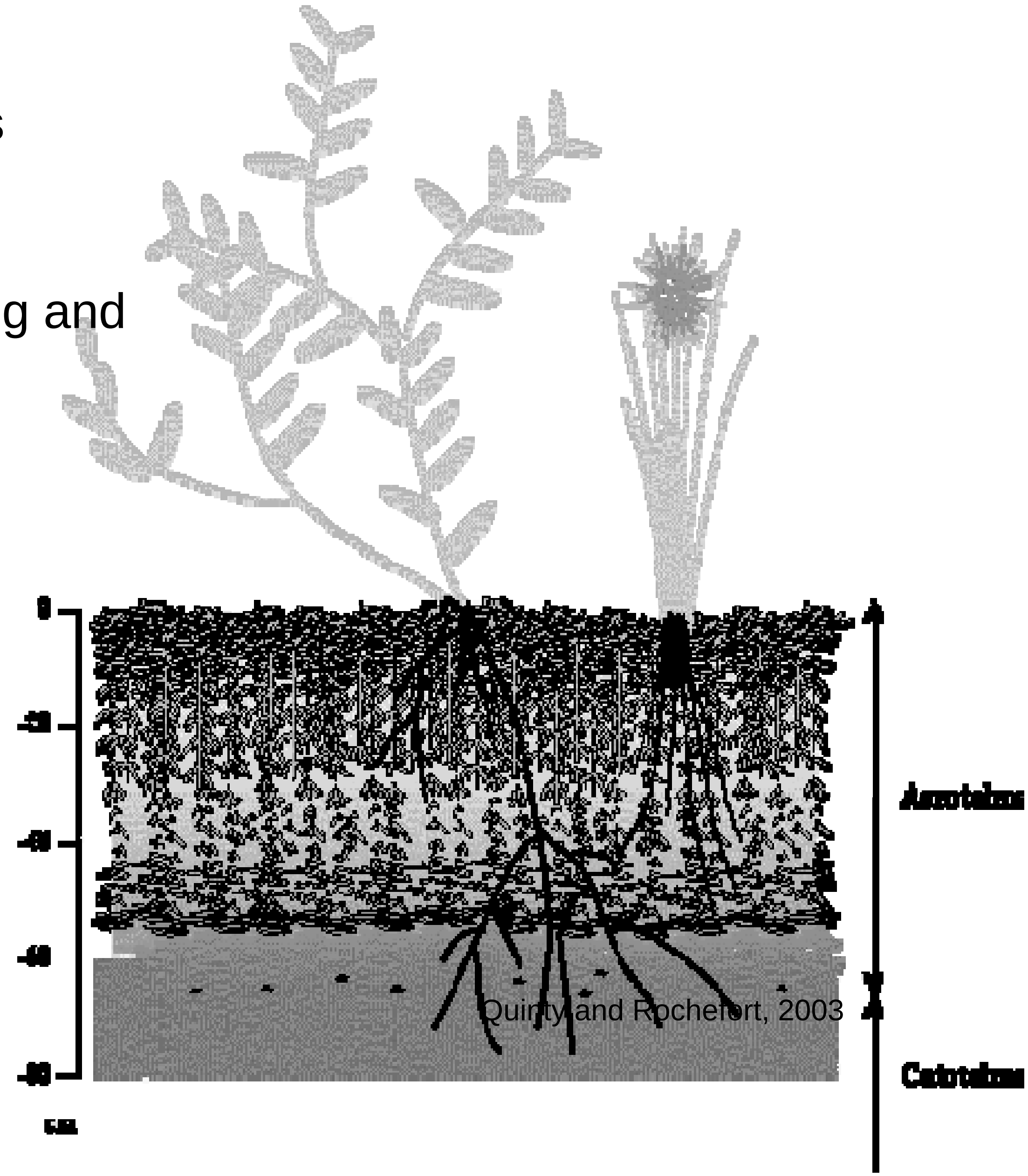
McNeil and Waddington, 2003

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

A peatland may not restore on its own

‘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

Waddington et al., 2008

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

Pristine peatlands : long-term C sequestration and climate cooling effect; R_e suppression in anoxic zone; hydraulic properties of moss layer key factor in WTD regulation; climate and vegetation controls on NEE and CH4

Degraded peatlands : drained, with moss layer affected to various degrees by subsidence, compaction, removal. High R_e sustained over decades.

Re-wetted peatlands : reduction in R_e, WT subject to high fluctuations if not regulated (climate sensitive), harsh environment for moss re-colonization

Restored peatlands : C sequestration function re-established through a functional acrotelm.

Contrasting GHG dynamics of Peatlands in different States

Functions	*States*: 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

Vegetation influences restoration pathway: what are the restoration objectives?

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.

Improved estimation of anthropogenic emissions and removals in peatlands involves:

Including key elements of C budget: NEE, CH4, DOC

Understanding the state of peatlands and how functions are affected

Determine restoration pathway

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