Wetlands, Carbon and Climate Change

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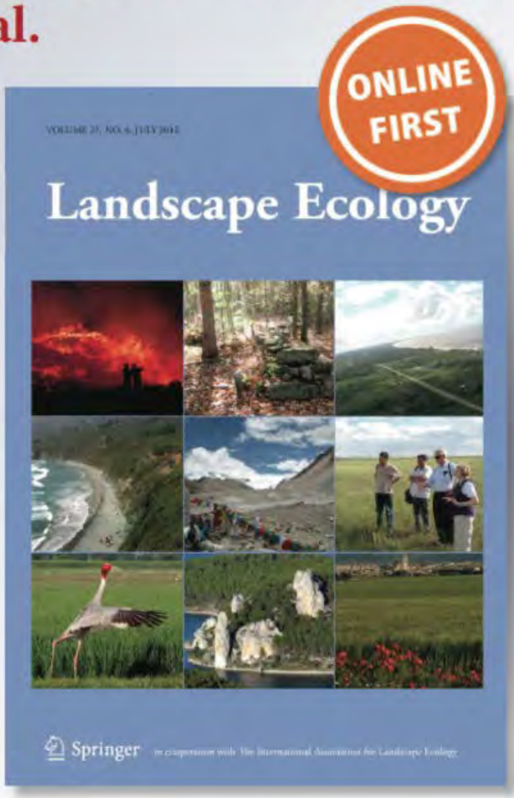
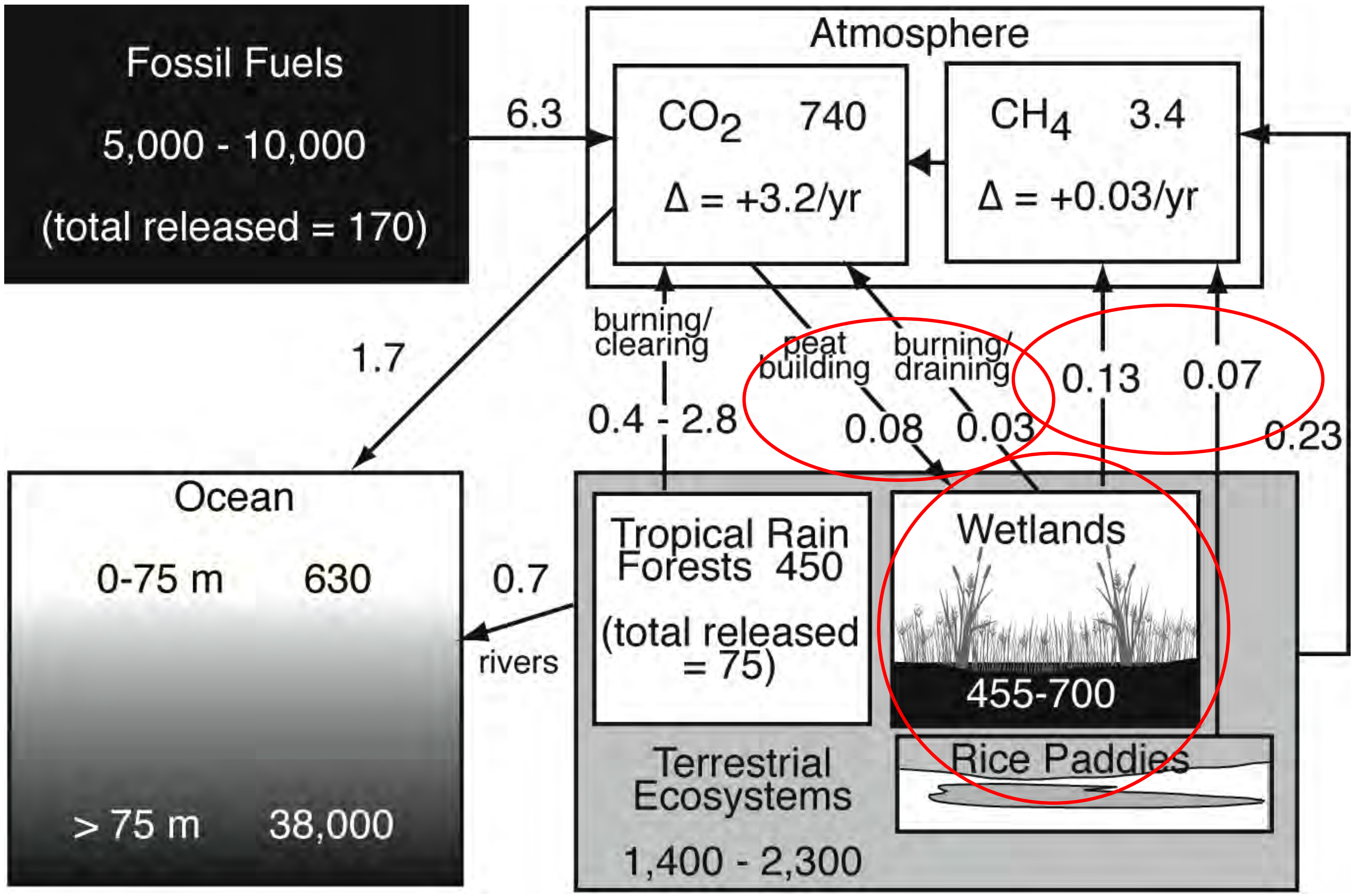


Springer

Old Global Carbon Budget with Wetlands Featured



Pools: Pg (=10^{15} g) Fluxes: Pg/yr

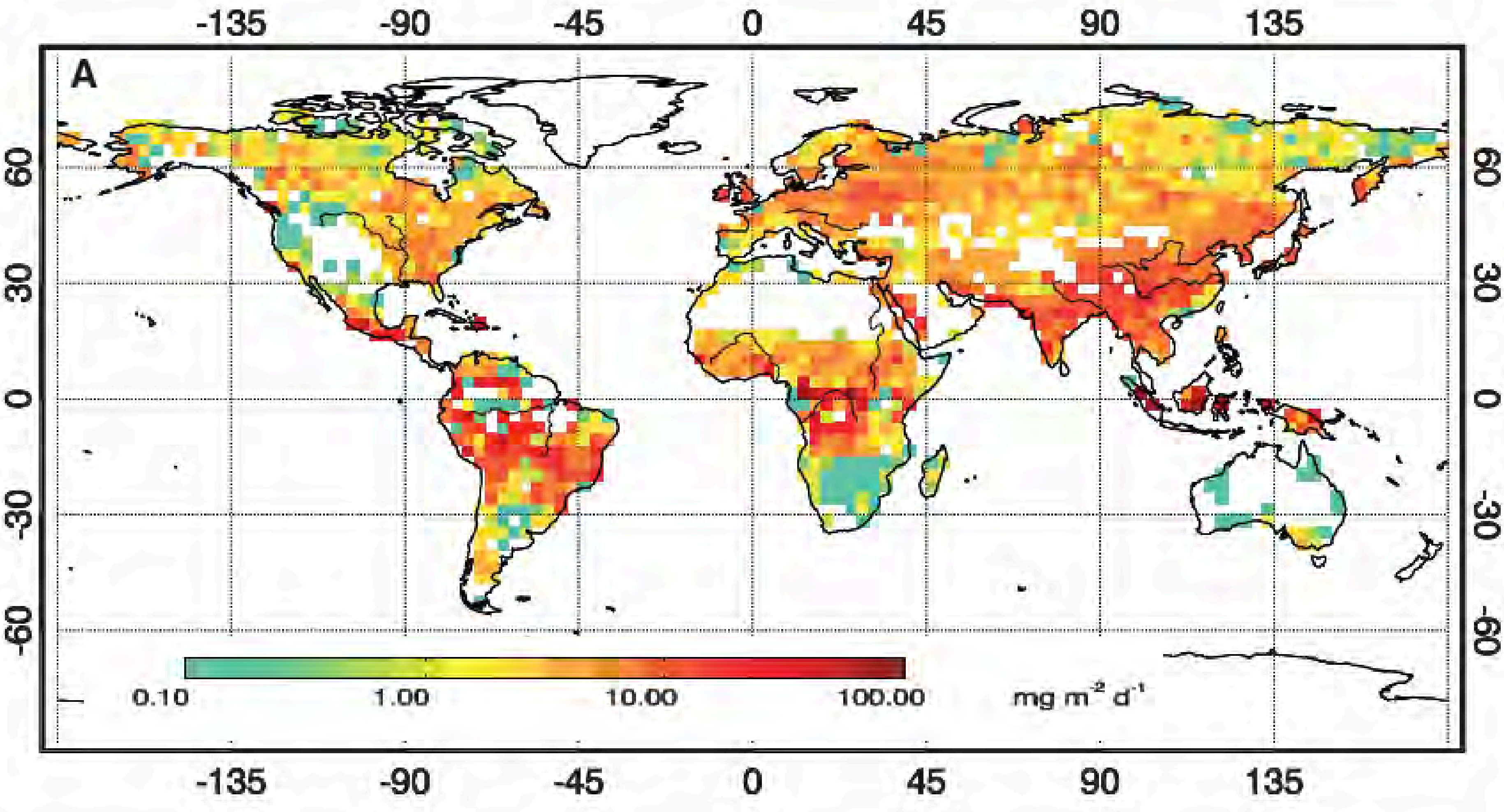
Source:Mitsch and Gosselink, 2007

Wetlands offer one of the best natural environments for sequestration and long-term storage of carbon….

…… and yet are also natural sources of greenhouse gases (GHG) to the atmosphere.

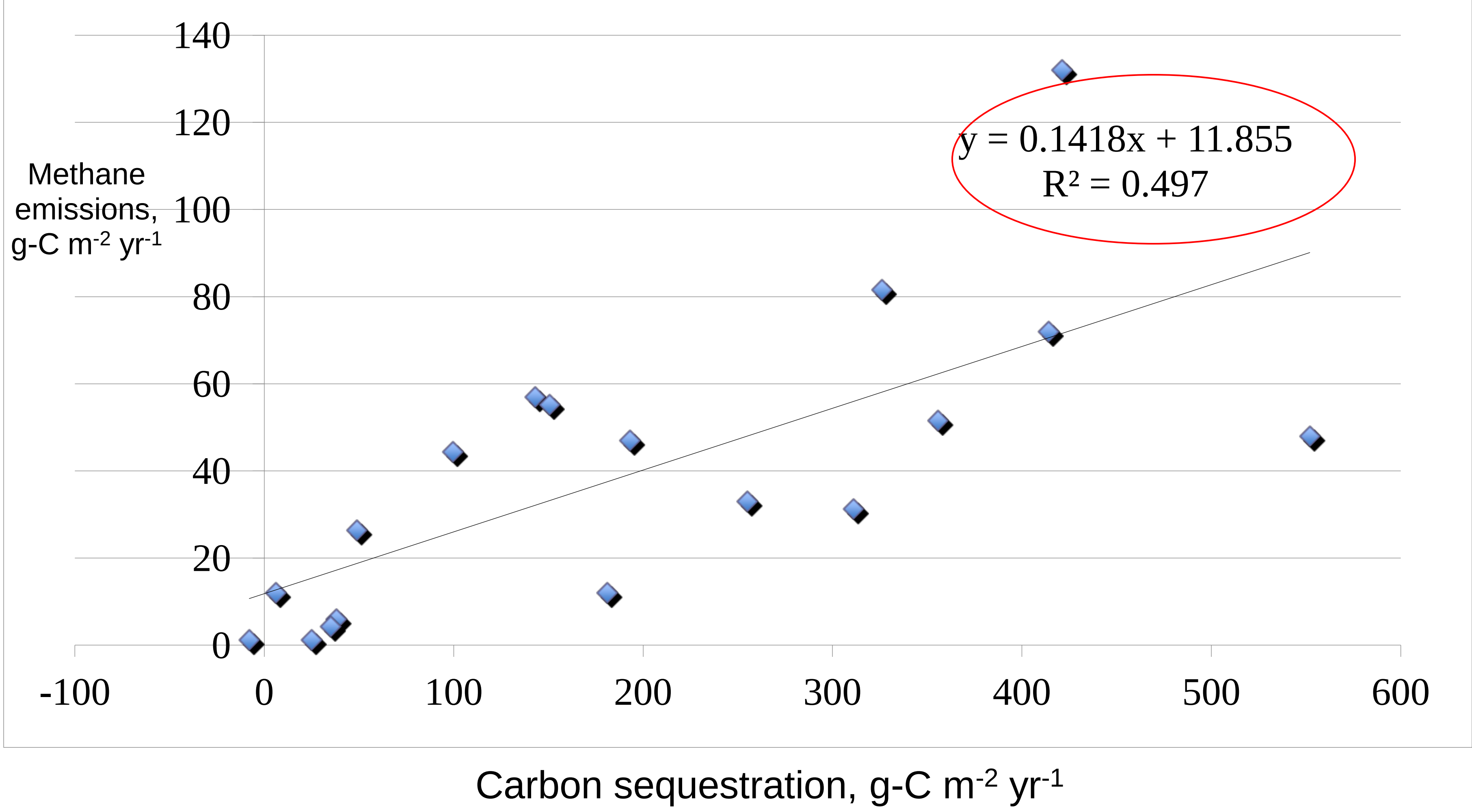
Both of these processes are due to the same anaerobic condition caused by shallow water and saturated soils that are features of wetlands.

Bloom et al./ *Science* (10 January 2010) suggested that wetlands and rice paddies contribute **227 Tg of CH_4** and that 52 to 58% of methane emissions come from the tropics. They furthermore conclude that an increase in methane seen from 2003 to 2007 was due primarily due to warming in Arctic and mid-latitudes over that time.



Bloom et al. 2010 Science 327: 322

Comparison of methane emissions and carbon sequestration in 18 wetlands around the world



- **On average, methane emitted from wetlands, as carbon, is 14% of the wetland's carbon sequestration.**

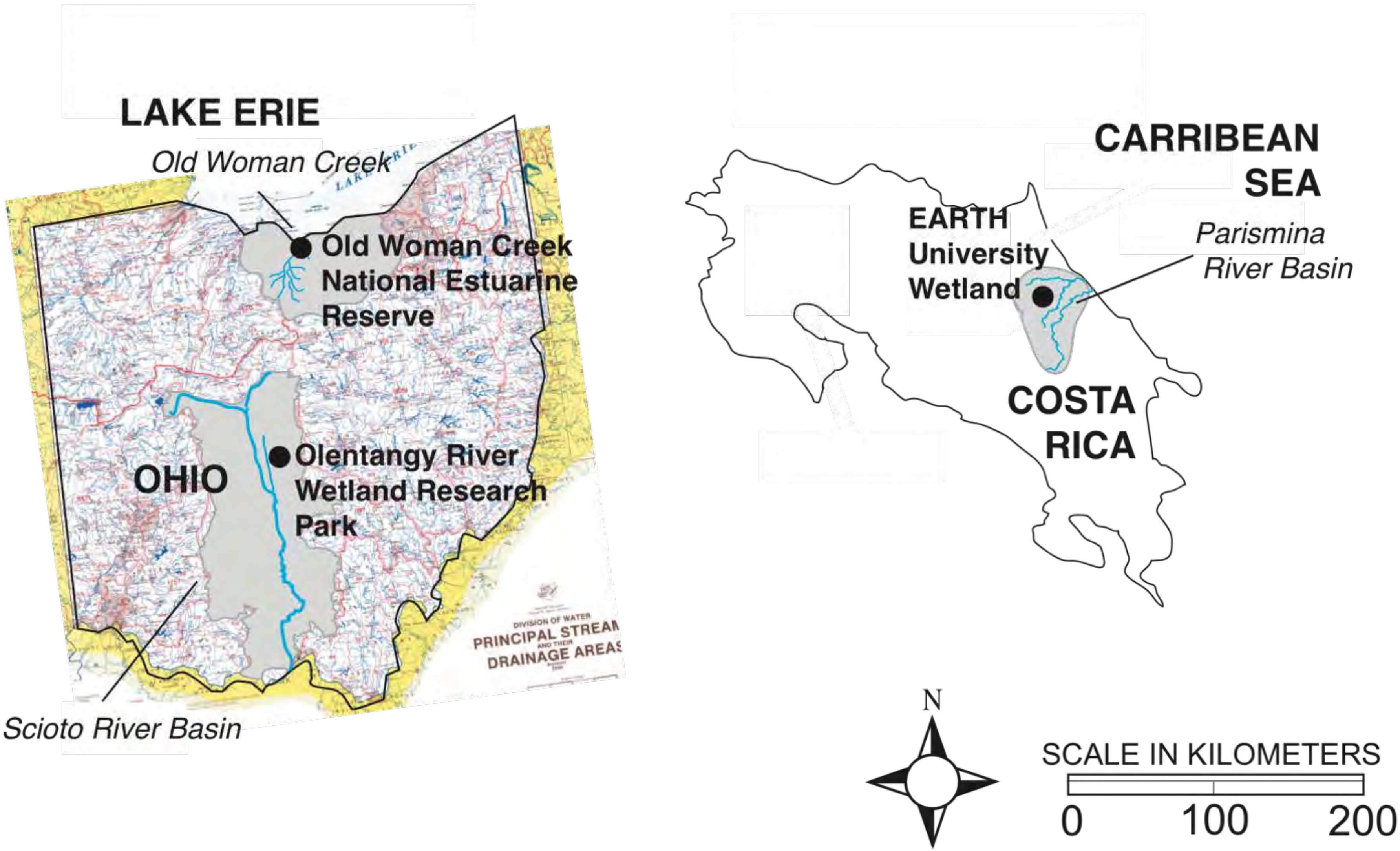
- **This 7.1:1 (sequestration/methane) carbon ratio is equivalent to 19:5 as CO_2 /CH_4**

- **The standard global warming potential (GWP_M) used by the International Panel on Climate Change (IPCC, 2007) and others to compare methane and carbon dioxide is now 25:1**

- **It could be concluded from this simple comparison that the world's wetlands are net sources of radiative forcing on climate.**

Our Initial Investigation

Comparison of carbon sequestration and methane emissions at three temperate and one tropical wetlands

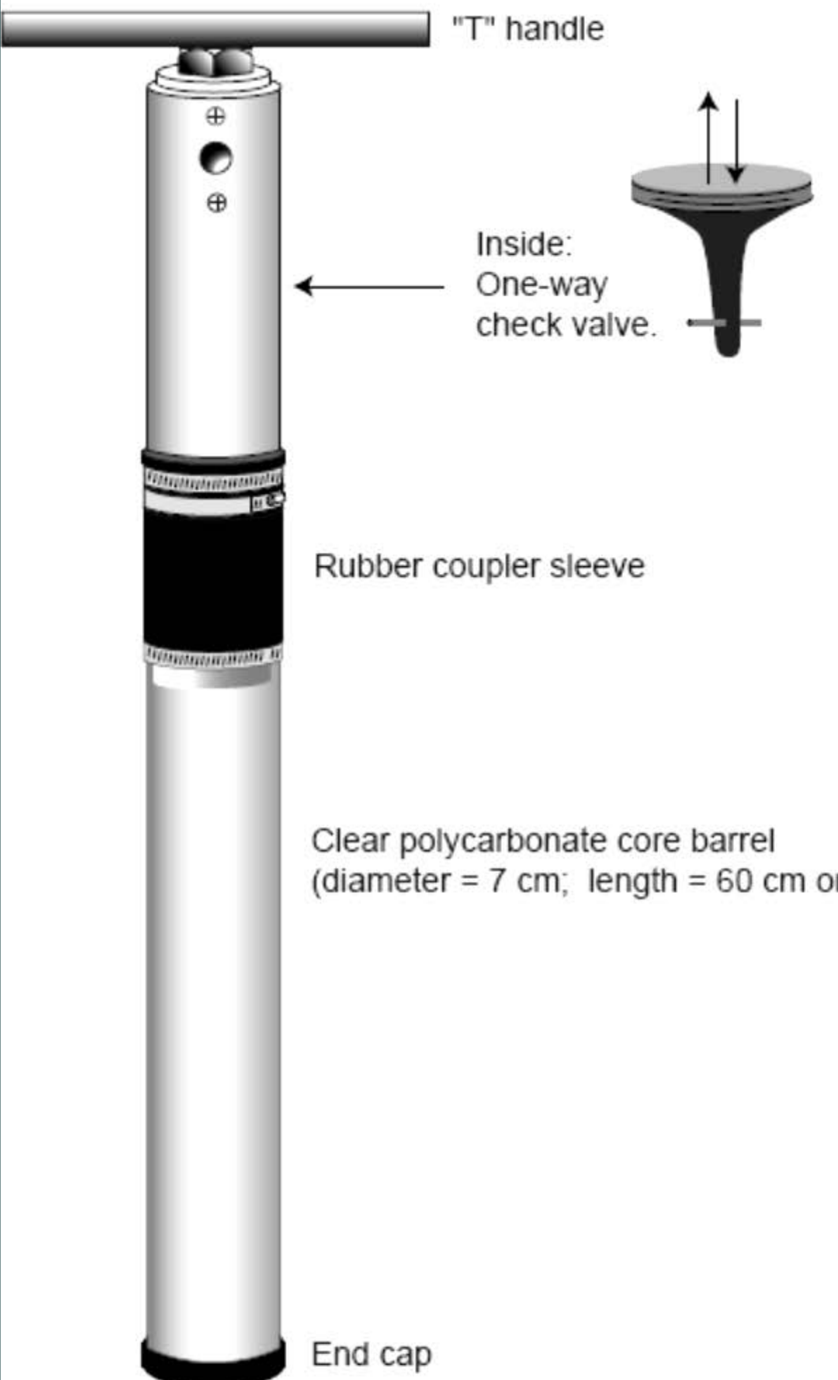


LAKE ERIE
Old Woman Creek
Old Woman Creek National Estuarine Reserve
Olentangy River Wetland Research Park
OHIO
Scioto River Basin
DIVISION OF WATER
PRINCIPAL STREAM AND THEIR DRAINAGE AREAS
CARRIBEAN SEA
EARTH University Wetland
Parismina River Basin
COSTA RICA
N
SCALE IN KILOMETERS
0
100
200

Old Woman Creek Wetland, northern Ohio, USA

Experimental wetlands, Olentangy River Wetland Research Park, central Ohio, USA

Raphia taedigera (swamp palm) La Reserva wetland, EARTH University, northeastern Costa Rica



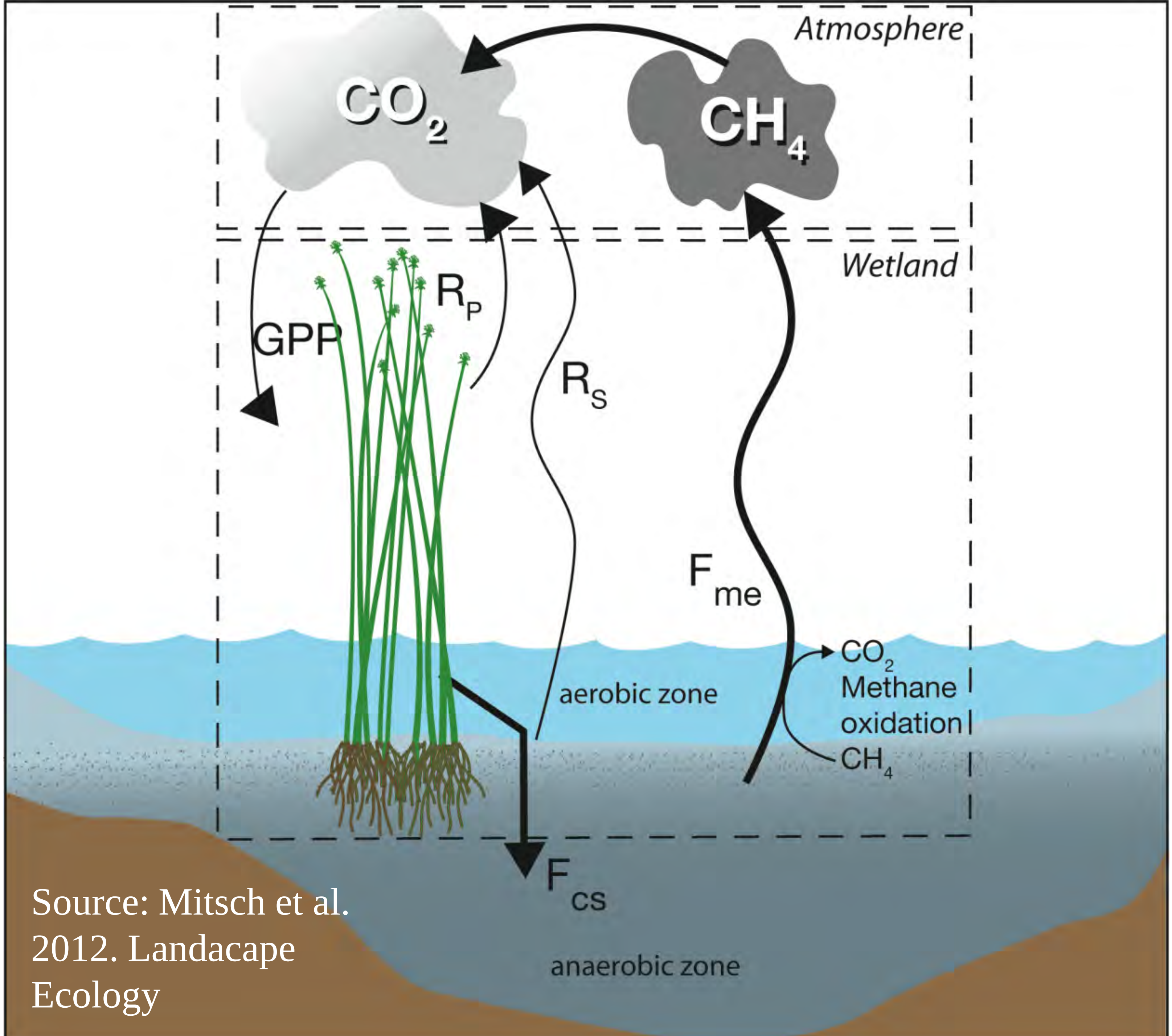
"T" handle
Inside:
One-way
check valve.
Rubber coupler sleeve
Clear polycarbonate core barrel
(diameter = 7 cm; length = 60 cm o
End cap

Comparison of carbon sequestration and methane emissions (as C) in ORWRP studies

Wetland	Carbon sequestration, g-C m^{-2} yr^{-1}	Methane emission, g-C m^{-2} yr^{-1}	ratio
TROPICAL EARTH - Costa Rica	255	33	7.7:1
TEMPERATE Old Woman Creek - Ohio	143	57	2.5:1
TEMPERATE/CREATED Olentangy River Wetlands - Ohio	187	30	6.2:1

Comparison of carbon sequestration (as CO_2) and methane emissions (as CH_4)

Wetland	Carbon sequestration, g-CO_2 m^{-2} yr^{-1}	Methane emission, g-CH_4 m^{-2} yr^{-1}	CO_2/CH_4 ratio
TROPICAL EARTH - Costa Rica	935	44	21.2:1
TEMPERATE Old Woman Creek - Ohio	524	76	6.9:1
TEMPERATE/CREATED Olentangy River Wetlands - Ohio	686	40	17.1:1



Source: Mitsch et al. 2012. Landacape Ecology

Our carbon model

$dM_C/dt = F_{me} – k\ M_C$

$dC/dt = k\ M_{C-} - F_{cs}$

where

M_C = atmospheric methane, g-C m^{-2}

C = atmospheric carbon dioxide, g-C m^{-2}

F_{me} = methane emissions from the wetland, g-C m^{-2} yr^{-1}

F_{cs} = carbon sequestration by the wetland, g-C m^{-2} yr^{-1}

k = first-order decay of methane in the atmosphere, yr^{-1}

(based on 7-year half-life)

Our carbon model

We defined the carbon dioxide equivalent as:

$CO_{2\ equil.} = CO_2 + (GWP_M \times M_{CH4})$

where

CO_2 = atmospheric carbon dioxide, g-CO_2 m^{-2}

M_{CH4} = atmospheric methane, g-CH_4 m^{-2}

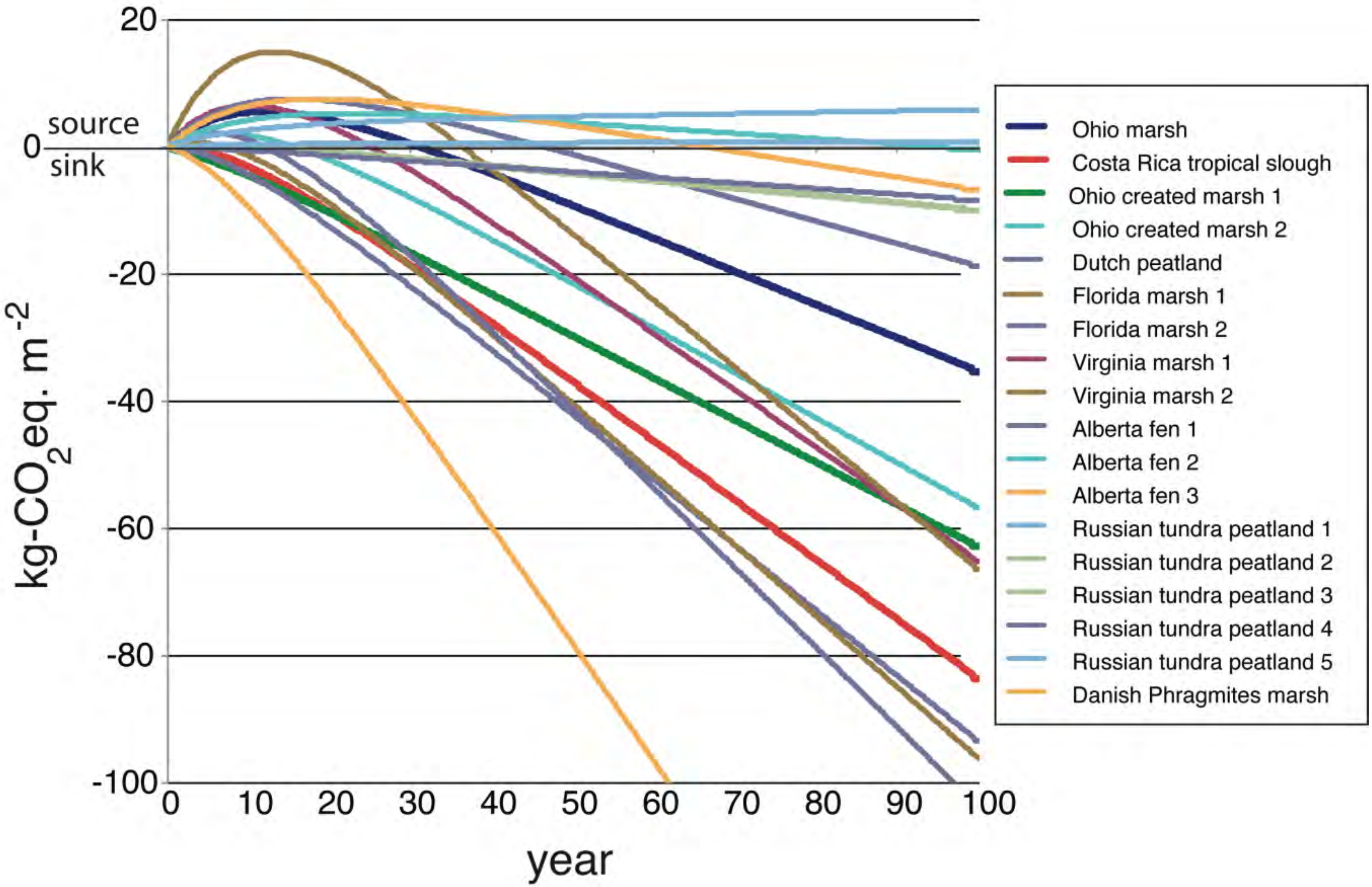
$GWP_M = 25$

Simulation of carbon sequestration/methane emission model

- 17 additional case studies were examined where methane emissions and carbon sequestration were estimated in the same wetland and data were published in peer-reviewed literature or were in press by our lab

- Of the 21 total wetlands used in this evaluation, only 4 had CO_2/CH_4 ratios > 25:1

Simulation results for 100 years



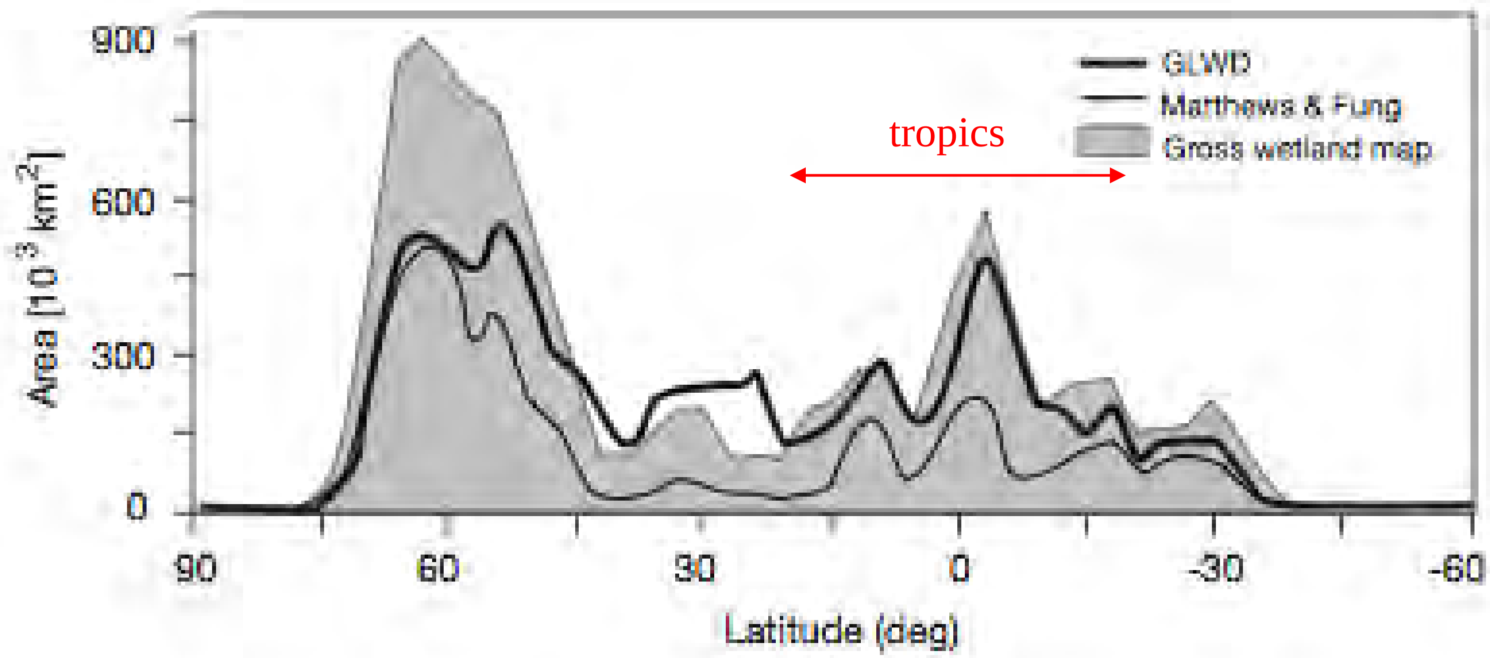
Net carbon retention after 100 simulated years for 21 wetlands

Wetland	Latitude, degrees N	Carbon-neutral years, yr	Carbon retention, g-C m^{-2} yr^{-1}
TROPICAL/SUBTROPICAL WETLANDS (n = 6)	10 - 30	0 - 255	194
TEMPERATE WETLANDS (n = 7)	37 - 55	0 - 36	278
BOREAL WETLANDS (n = 8)	54 - 67	0 – 95*	29

* two boreal wetlands could never be carbon neutral as they were sources of CO_2

Source: Mitsch et al. Landscape Ecology

Wetlands of the world, x 1000 km^2 by latitude



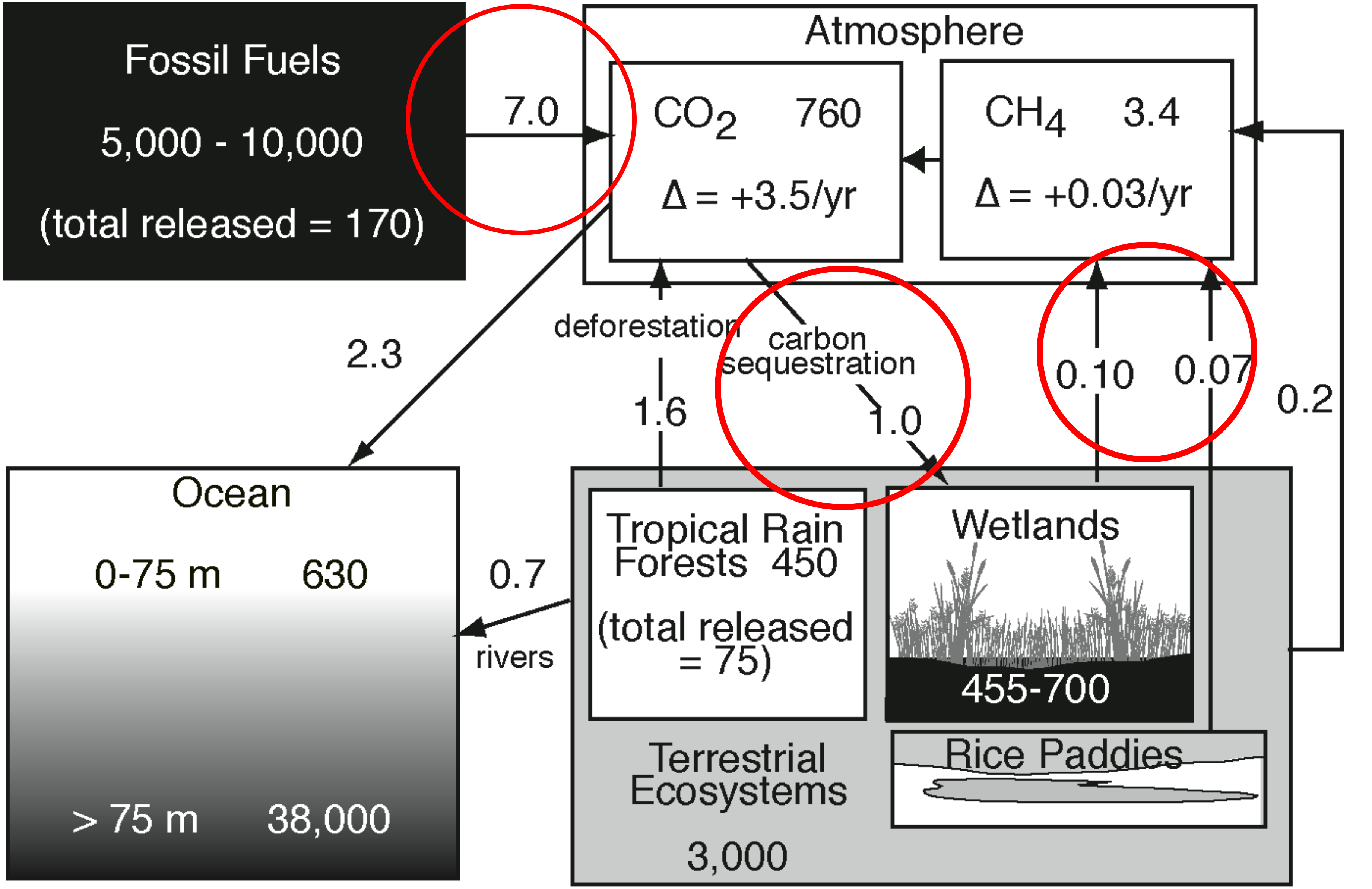
Source: Mitsch and Gosselink (2007)
from Lehner and Döll (2004)

Global carbon sequestration by wetlands

Wetland	Net carbon retention, g-C m^{-2} yr^{-1}	Estimated Area*, x 10^6 km^2	Carbon retention, Pg-C/yr
TROPICAL/SUBTROPICAL WETLANDS	194	2.9	0.56
TEMPERATE WETLANDS	278	0.6	0.16
BOREAL PEATLANDS	32	3.5	0.11
TOTAL		**7.0**	**0.83**

Source: Mitsch et al. Landscape Ecology

New Global Carbon Budget with Wetlands Featured



Pools: Pg (=10^{15} g) Fluxes: Pg/yr

Conclusions

- Most wetlands, if evaluated with the simple 25:1 methane : carbon dioxide ratio used by climate change policy makers, are net sources of radiative forcing and hence bad for climate.
- Most wetlands are net sinks of radiative forcing on climate well within 100 to 200 years when the decay of methane in the atmosphere is factored in.

Conclusions

- The world's wetlands, despite being only about 7% of the terrestrial landscape or <2% of the globe, could be net sinks for a significant portion (as much as 1 Pg/yr) of the carbon released by fossil fuel combustion.
- Wetlands can and should be created and restored to provide nutrient retention, carbon sequestration and other ecosystem services without great concern of creating net radiative sources on climate.

Thank you!

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