The short and long of wetland carbon emissions, uptake, & lateral transfer

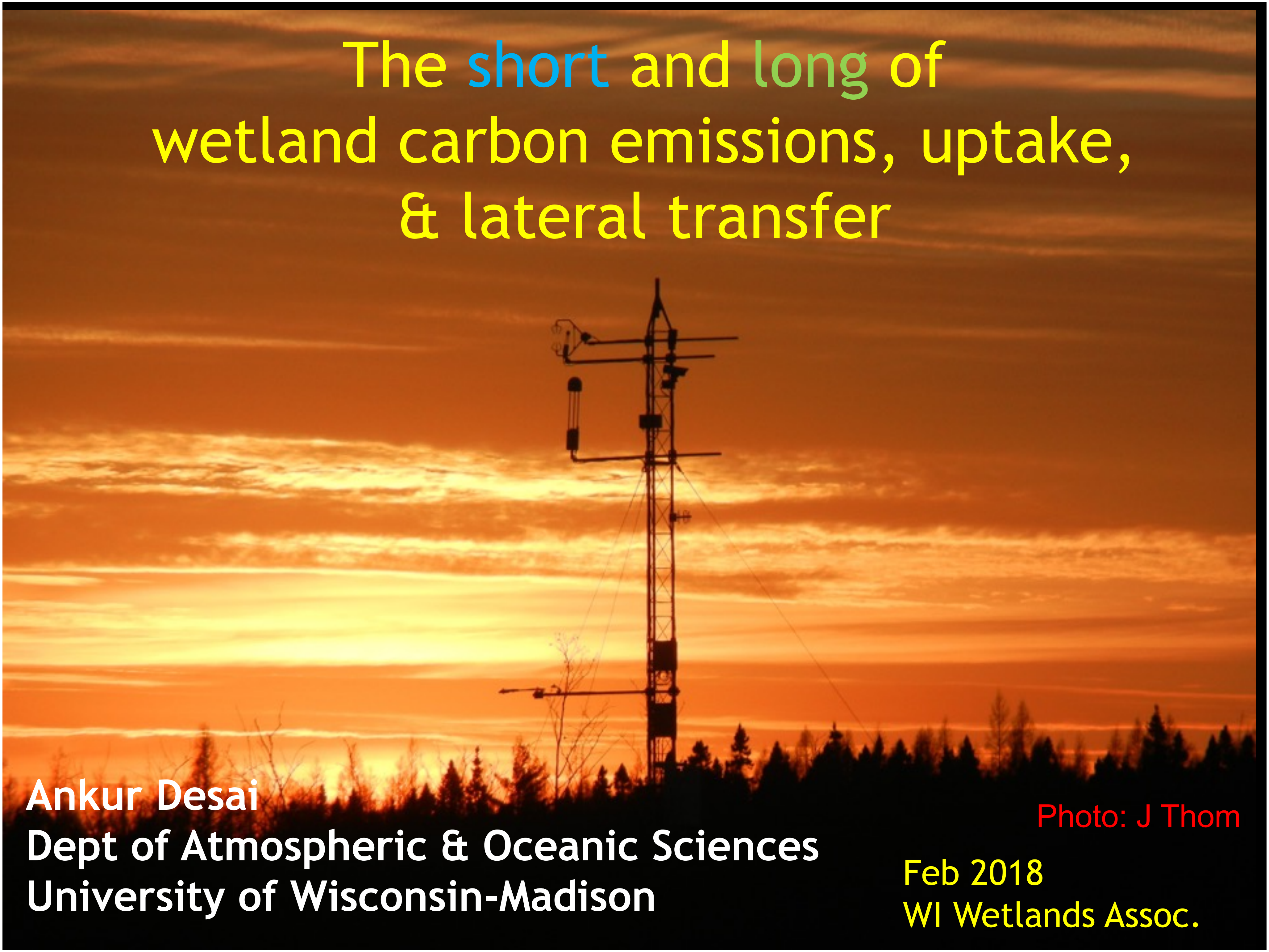

Photo: J Thom

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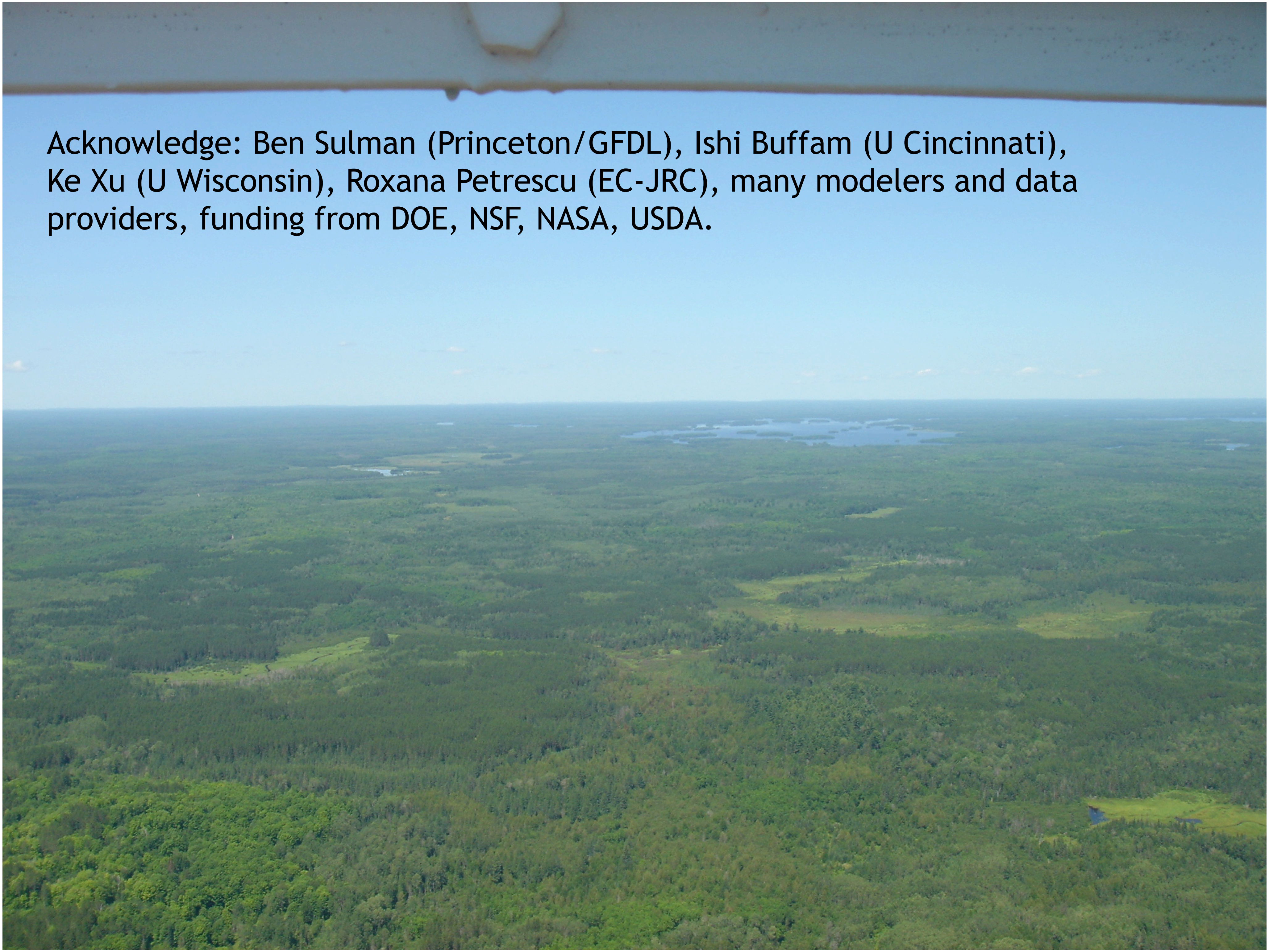
University of Wisconsin-Madison

Feb 2018
WI Wetlands Assoc.


Acknowledge: Ben Sulman (Princeton/GFDL), Ishi Buffam (U Cincinnati), Ke Xu (U Wisconsin), Roxana Petrescu (EC-JRC), many modelers and data providers, funding from DOE, NSF, NASA, USDA.

Wetlands provide many ecosystem goods and services

Millennium Ecosystem Assessment

Ecosystem Services Provided by or Derived from Wetlands

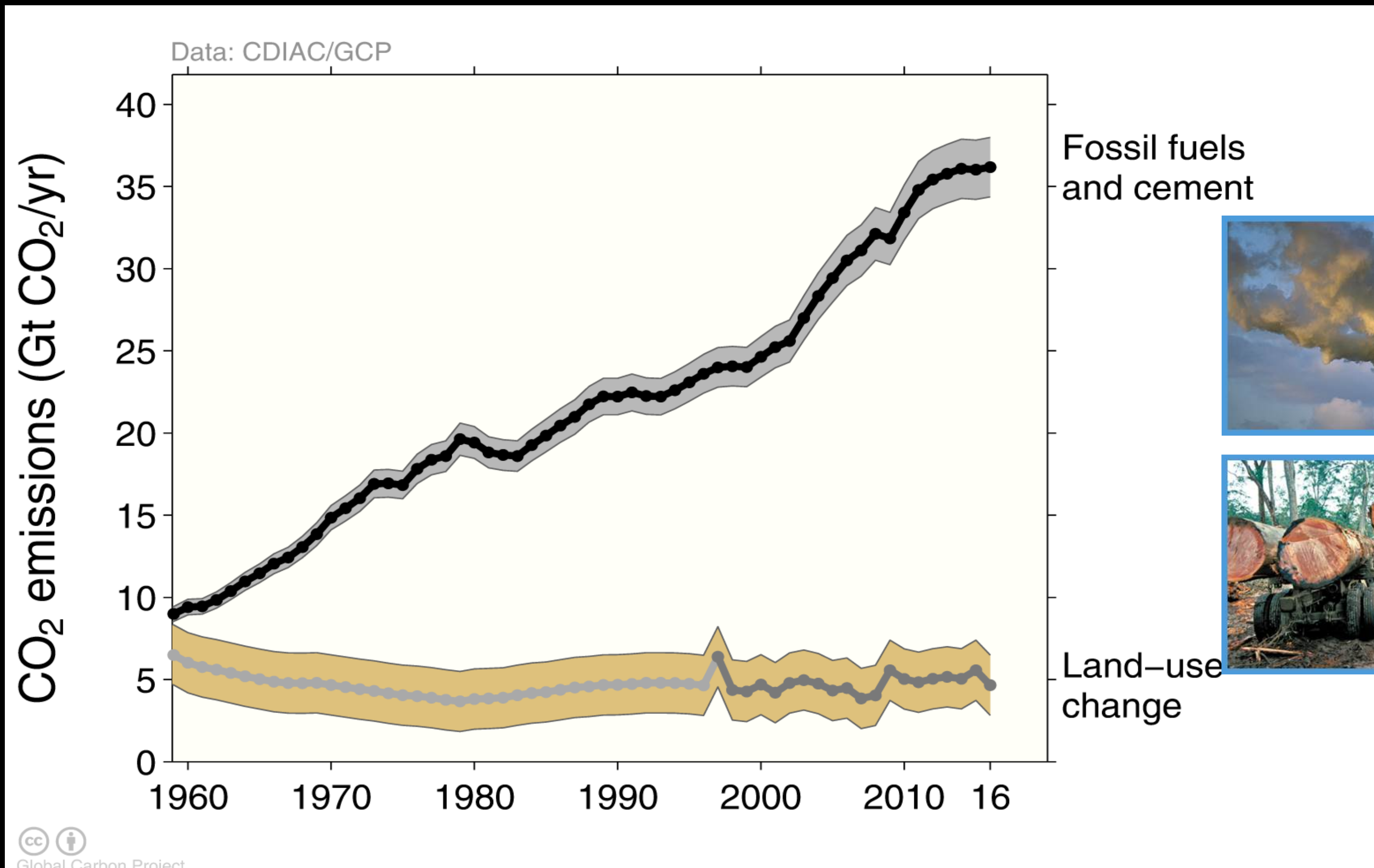
Services	Comments and Examples
Provisioning	
Food	production of fish, wild game, fruits, and grains
Fresh water[a]	storage and retention of water for domestic, industrial, and agricultural use
Fiber and fuel	production of logs, fuelwood, peat, fodder
Biochemical	extraction of medicines and other materials from biota
Genetic materials	genes for resistance to plant pathogens, ornamental species, and so on
Regulating	
Climate regulation	source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water regulation (hydrological flows)	groundwater recharge/discharge
Water purification and waste treatment	retention, recovery, and removal of excess nutrients and other pollutants
Erosion regulation	retention of soils and sediments
Natural hazard regulation	flood control, storm protection
Pollination	habitat for pollinators
Cultural	
Spiritual and inspirational	source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	opportunities for recreational activities
Aesthetic	many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	opportunities for formal and informal education and training
Supporting	
Soil formation	sediment retention and accumulation of organic matter
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients

[a] While fresh water was treated as a provisioning service within the MA, it is also regarded as a regulating service by various sectors.

Source: Ecosystems and human well-being: Wetlands and water – Millennium Ecosystem Assessment / p2

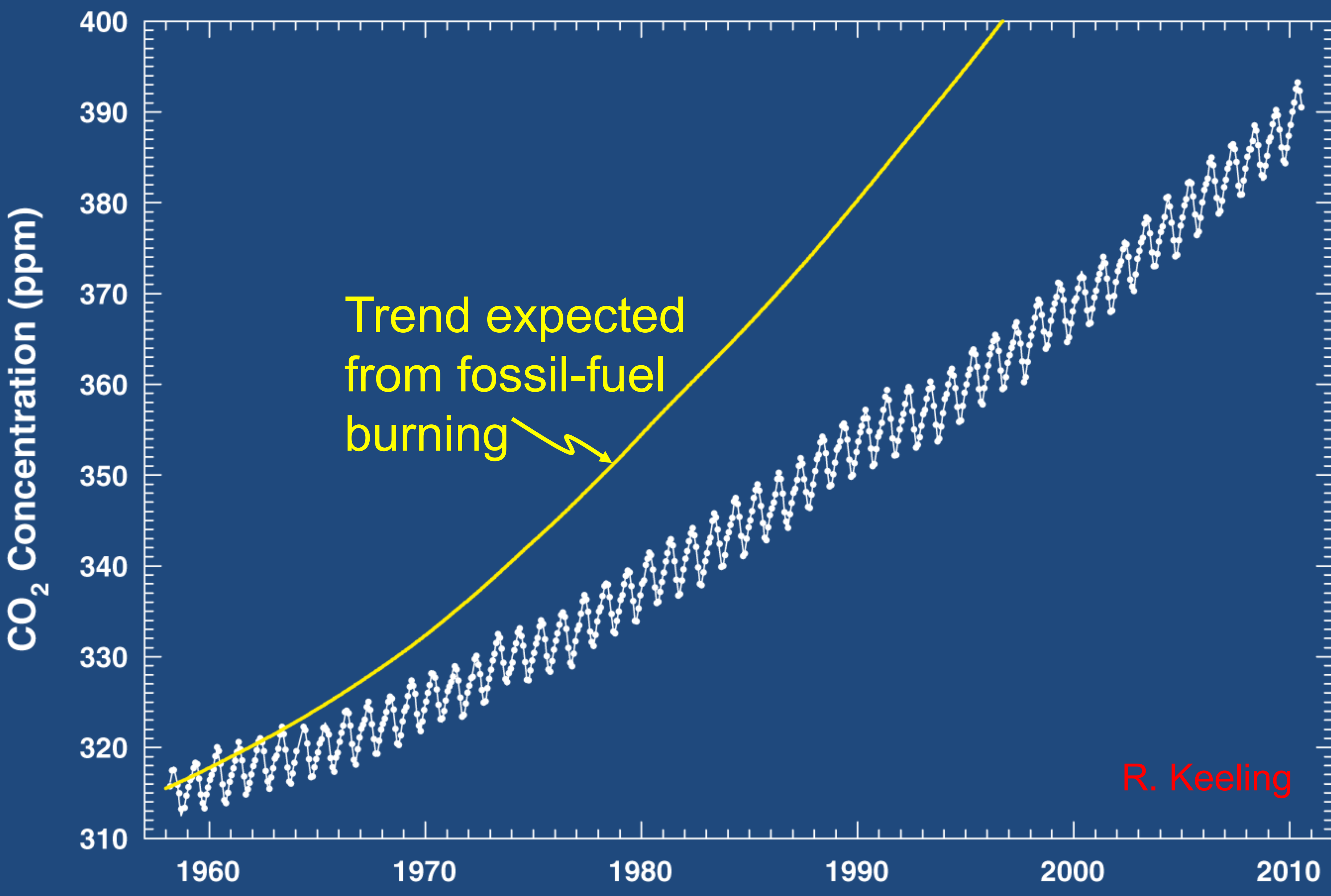
Total global emissions

Total global emissions: 40.8 ± 2.7 $GtCO_2$ in 2016, 52% over 1990
Percentage land-use change: 42% in 1960, 12% averaged 2007-2016



Land-use change estimates from two bookkeeping models, using fire-based variability from 1997
Source: CDIAC; Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Le Quéré et al 2017; Global Carbon Budget 2017

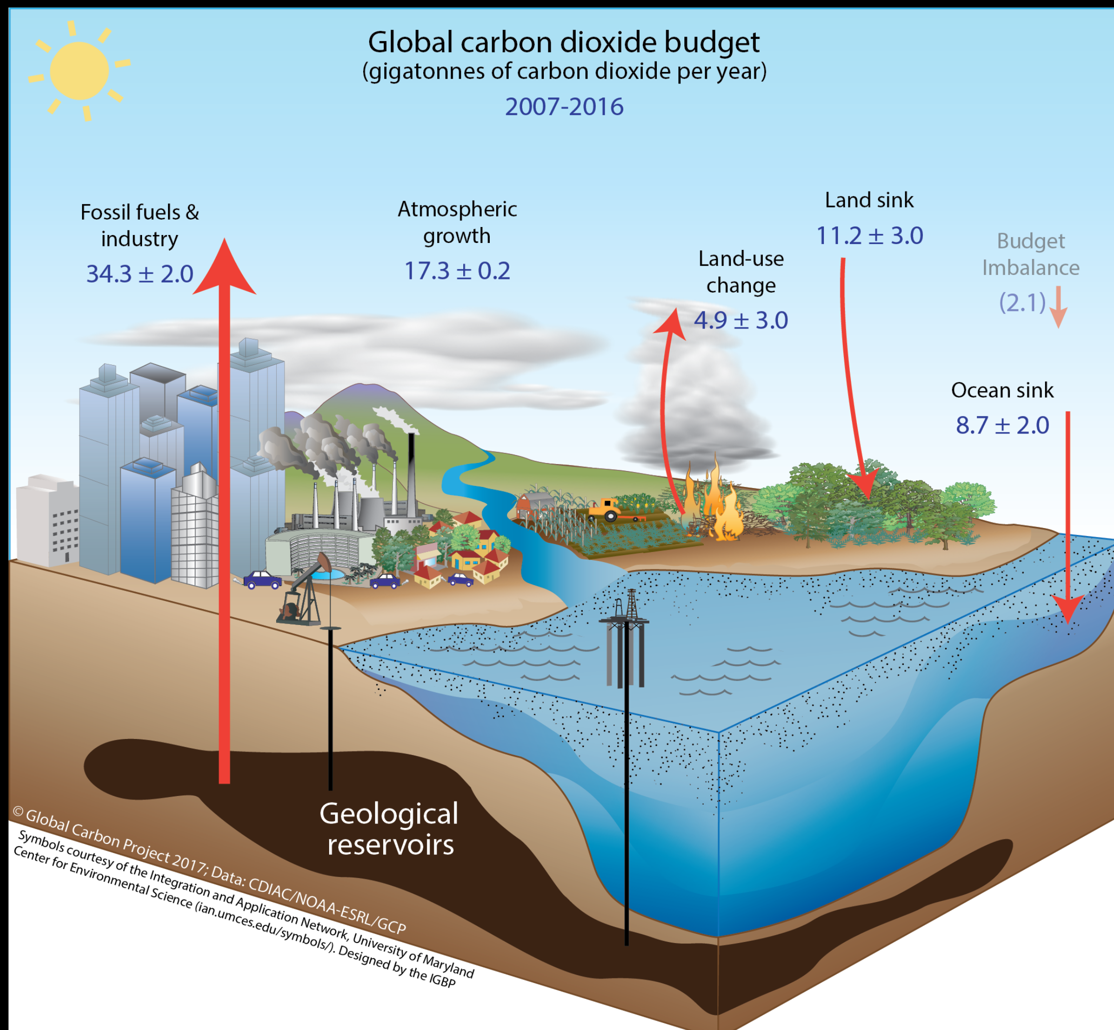
Atmospheric CO_2 records



GLOBAL CARBON PROJECT

Anthropogenic perturbation of the global carbon cycle

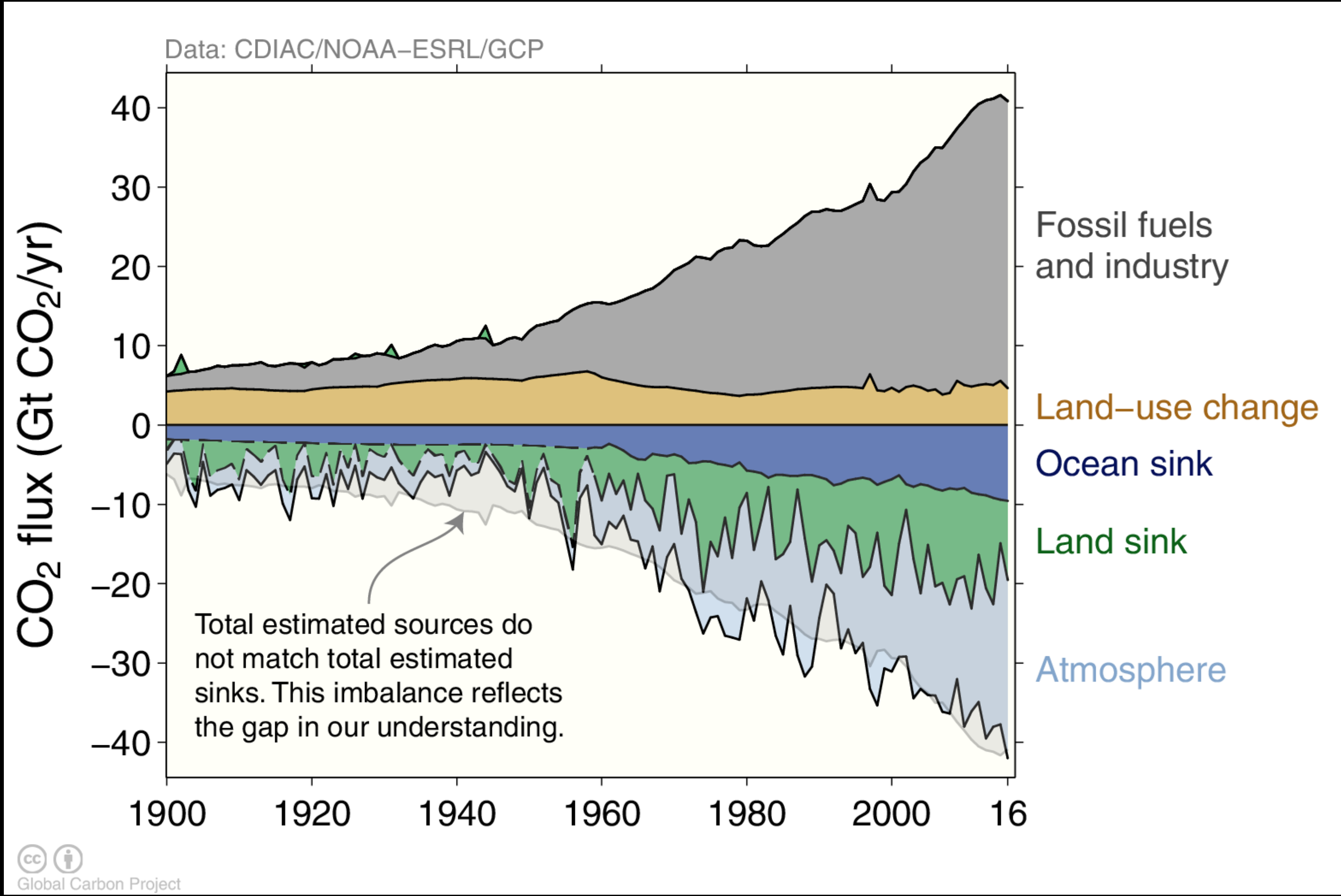
Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2007–2016 ($GtCO_2$/yr)



The budget imbalance is the difference between the estimated emissions and sinks.
Source: CDIAC; NOAA-ESRL; Le Quéré et al 2017; Global Carbon Budget 2017

Global carbon budget: sources vs sinks

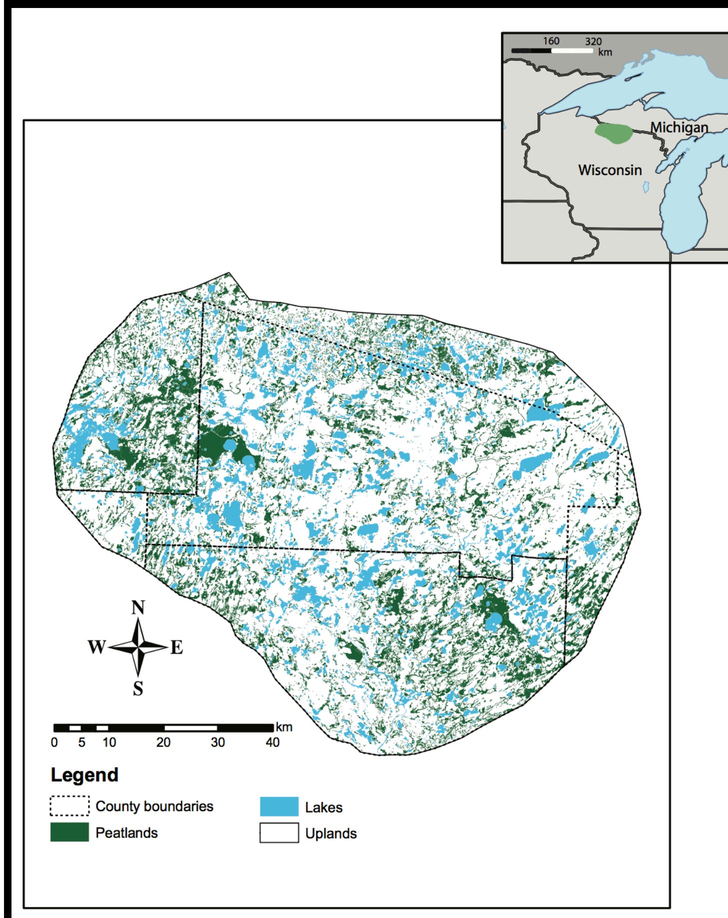
Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean
The "imbalance" between total emissions and total sinks reflects the gap in our understanding

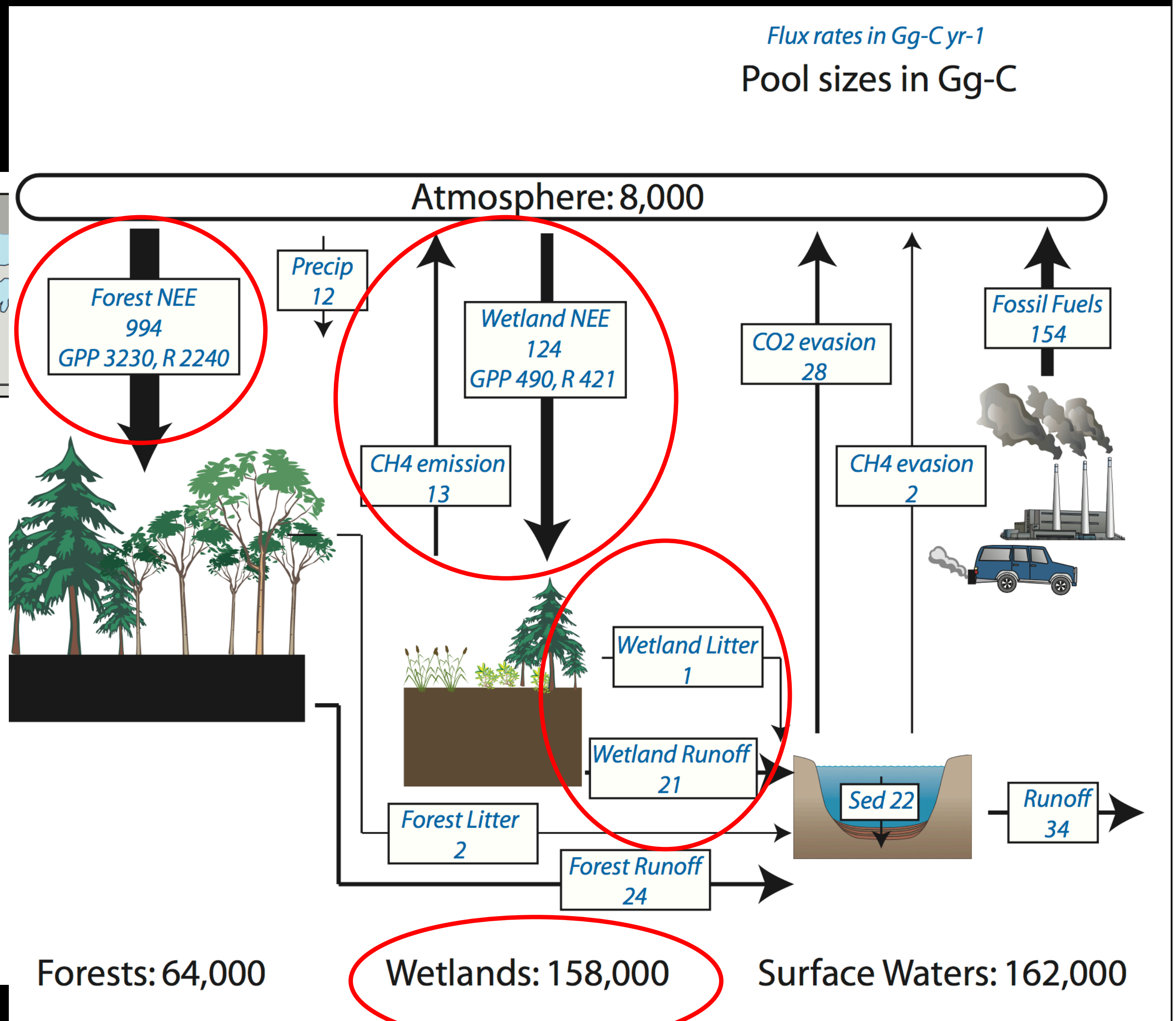


Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Joos et al 2013; Khatiwala et al. 2013; DeVries 2014; Le Quéré et al 2017; Global Carbon Budget 2017

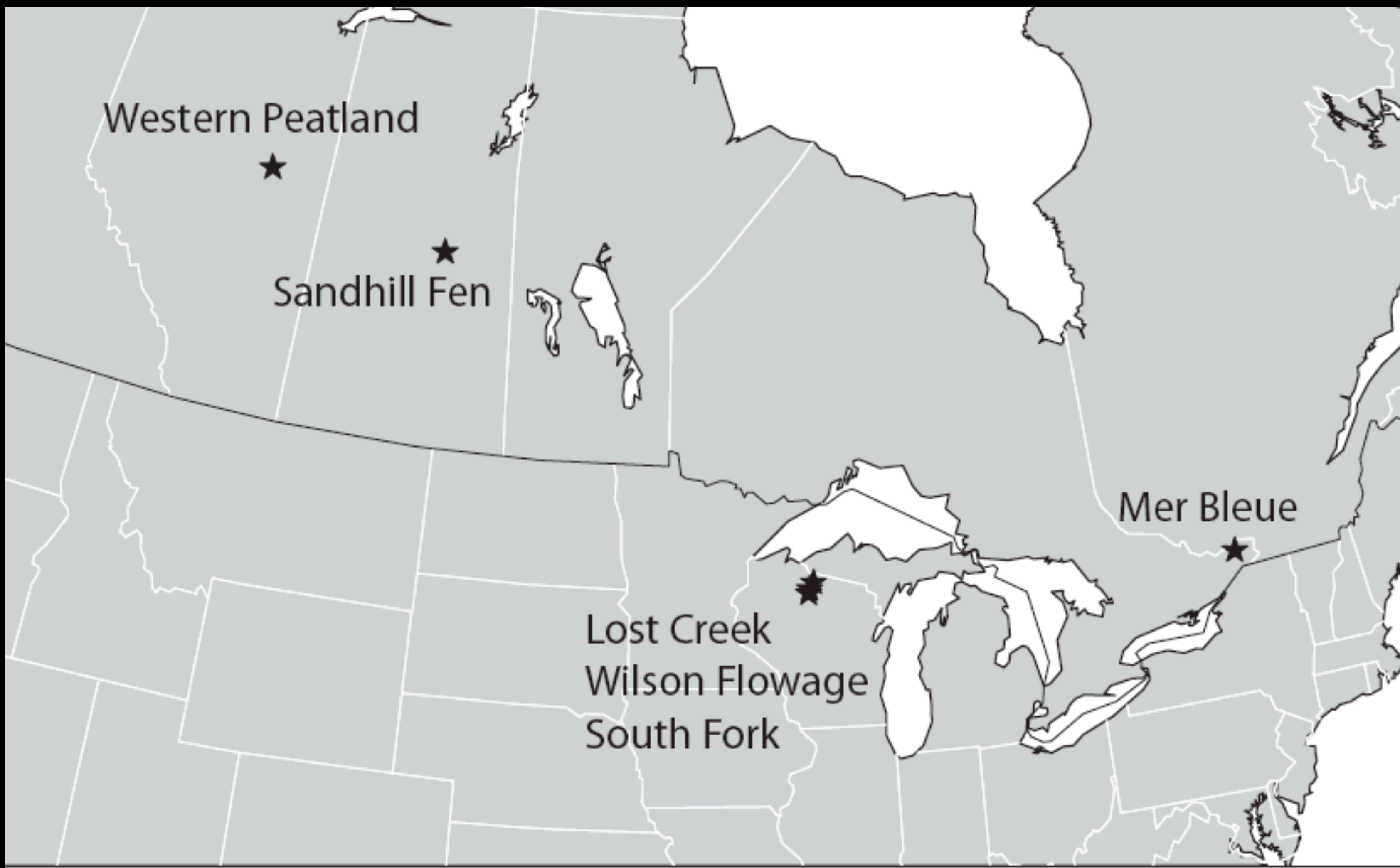
Wetlands are important part of Wisconsin's carbon cycle

Buffam et al, 2010

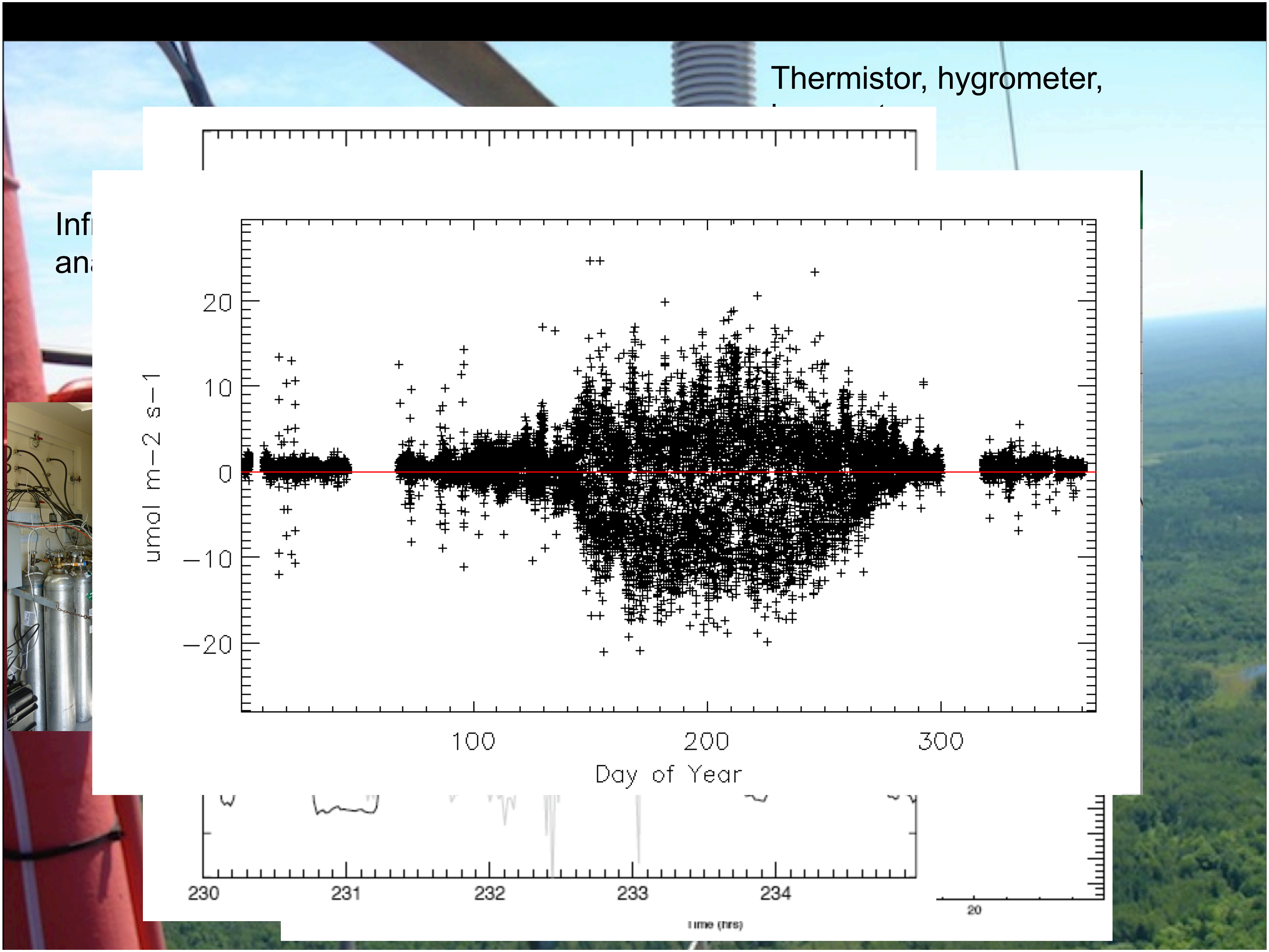




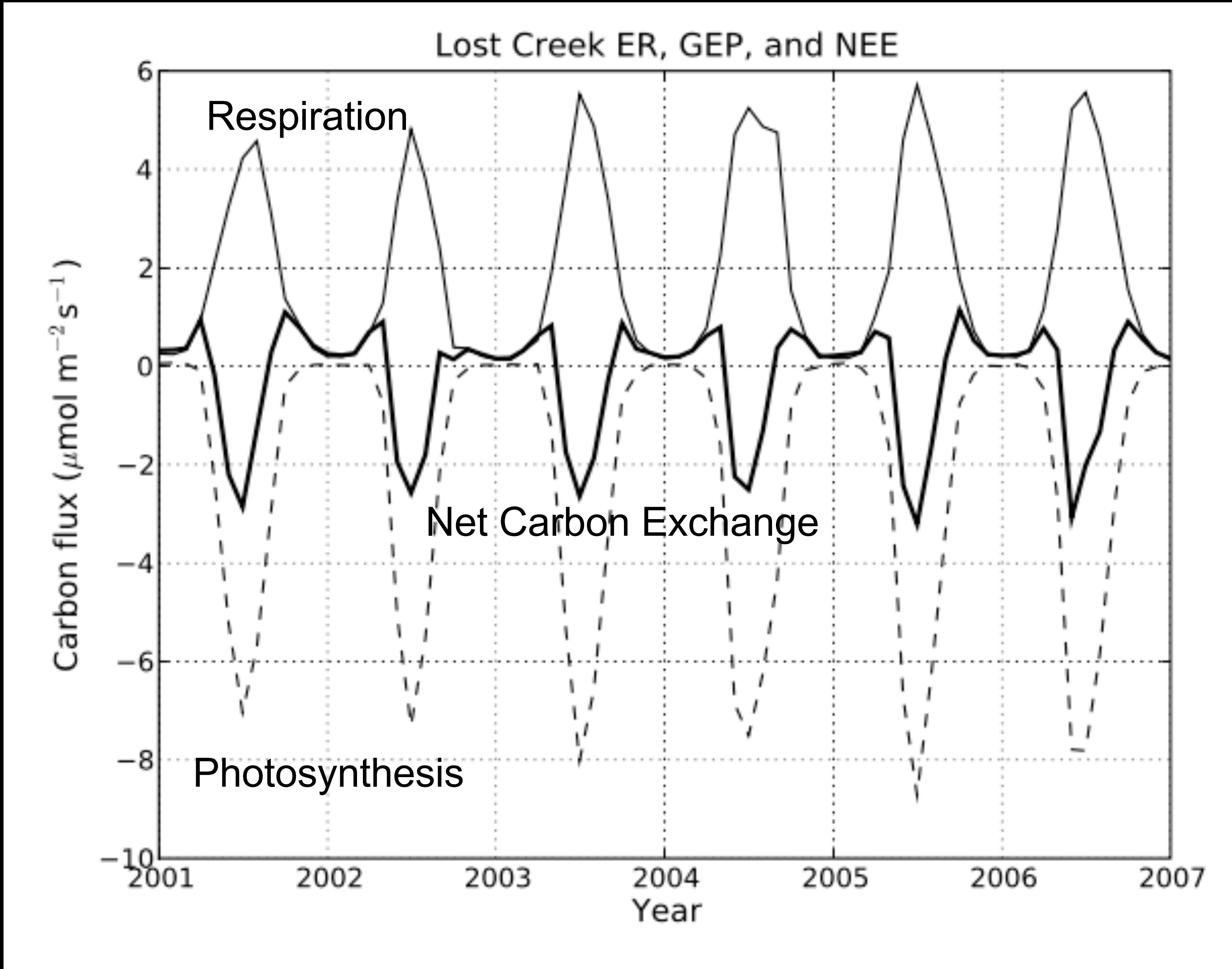
What drives this carbon uptake?



Sulman et al. (submitted)



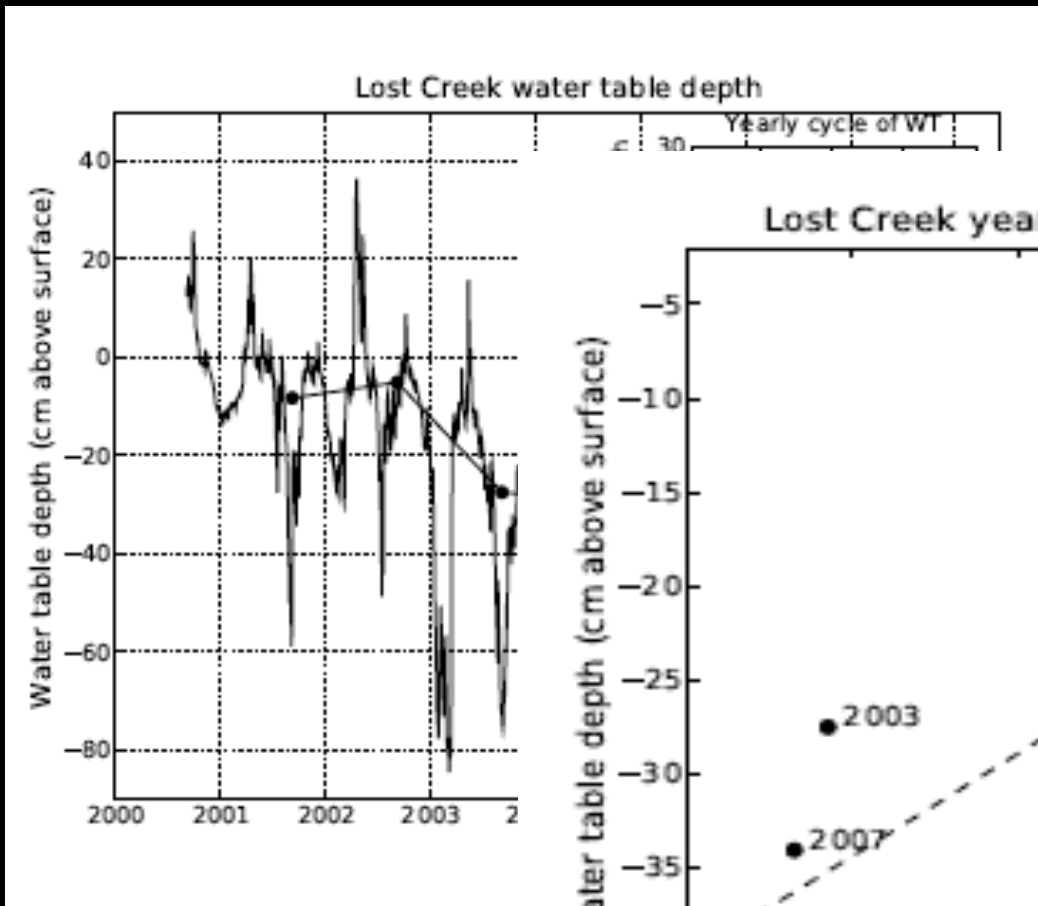
Thermistor, hygrometer,
umol m−2 s−1
20
10
0
−10
−20
100
200
300
Day of Year
230
231
232
233
234
20

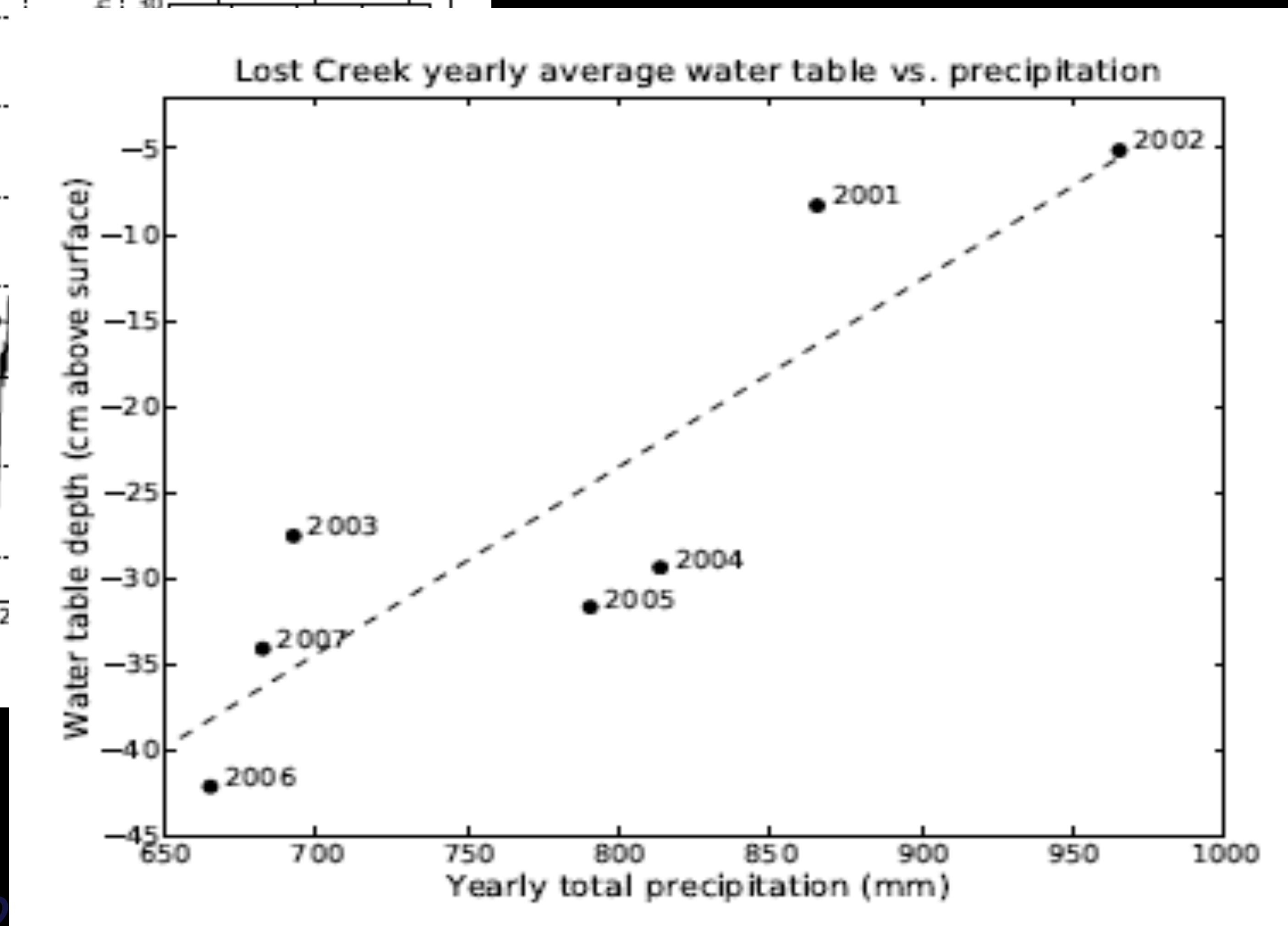


Sulman *et al., Biogeosciences*, 2009

What drives water table position?

Sulman *et al.*, *Biogeosciences*, 2009





Sulman et al. (2

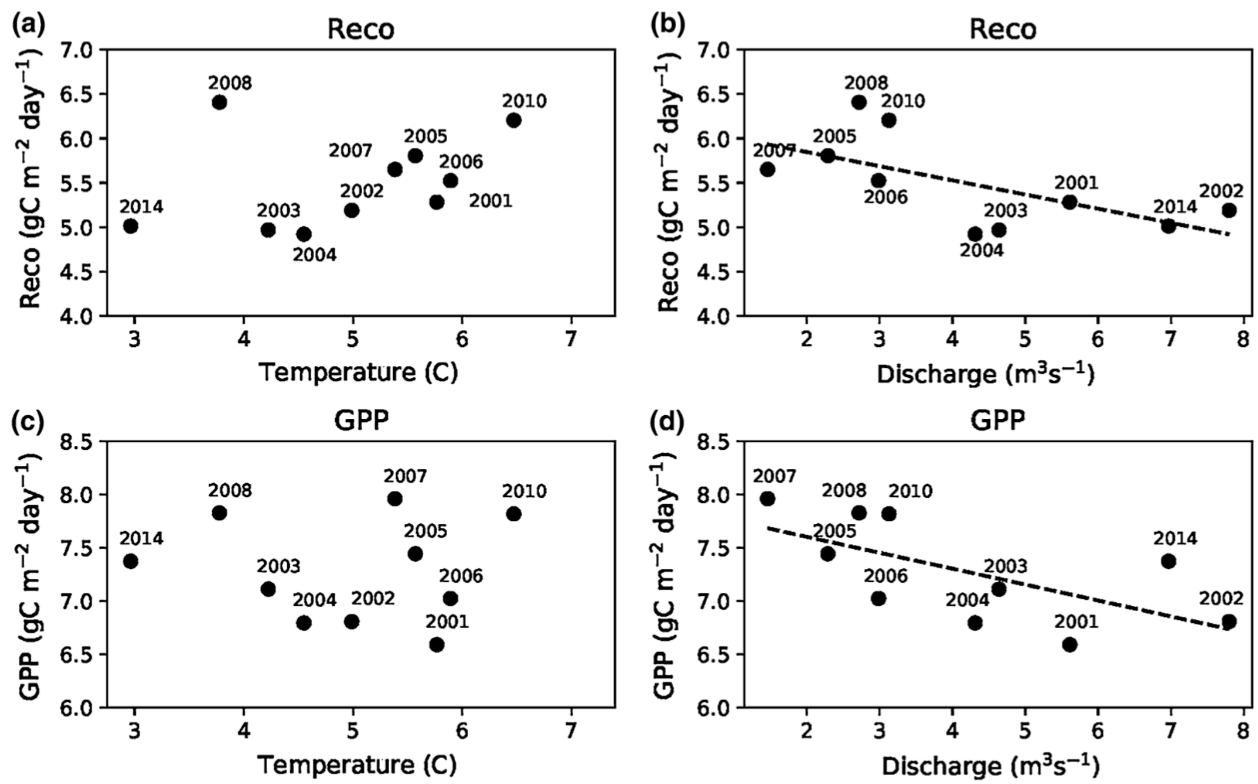
Biogeochemistry
https://doi.org/10.1007/s10533-017-0414-x

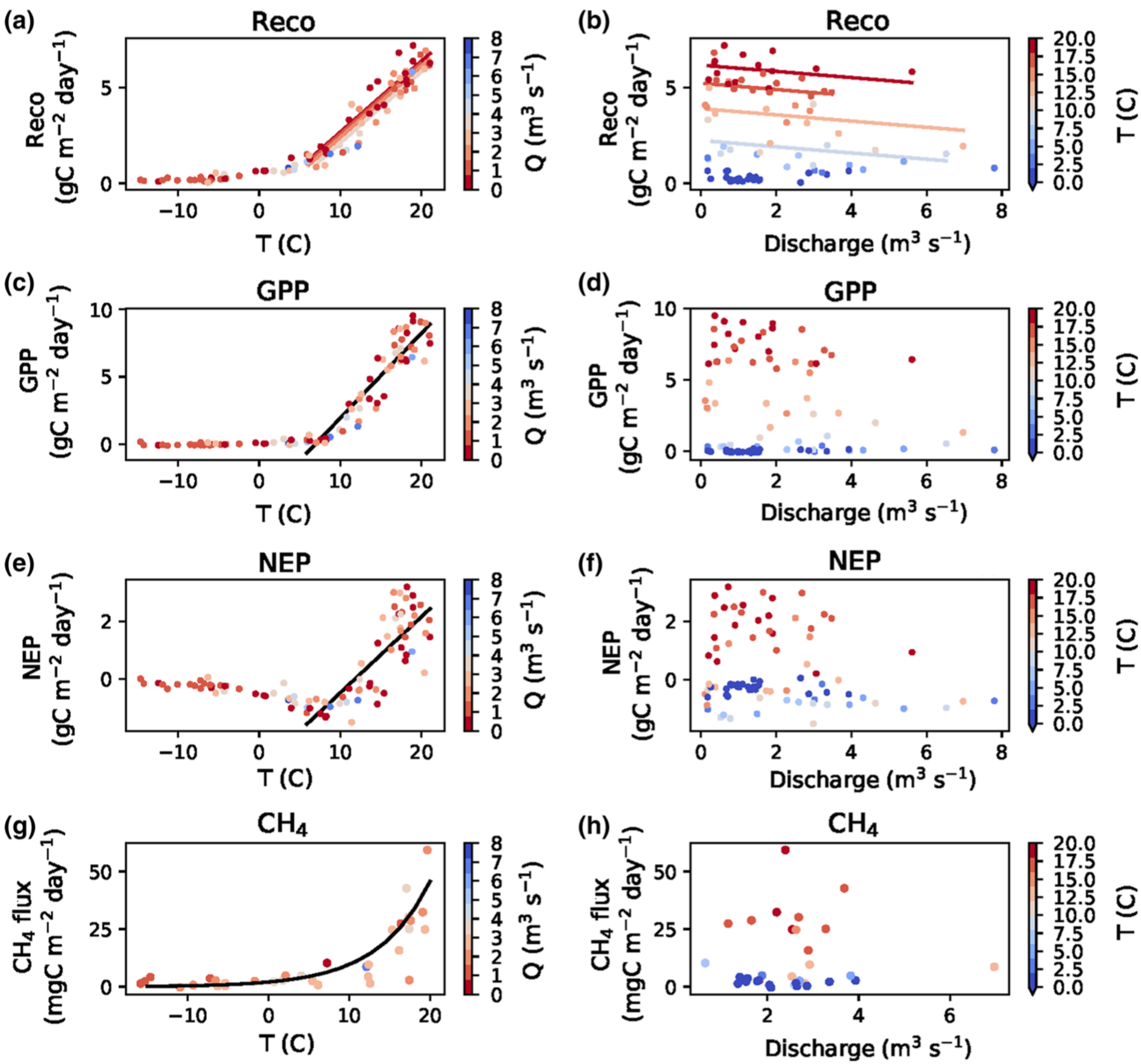
BIOGEOCHEMISTRY LETTERS

Wetland flux controls: how does interacting water table levels and temperatu and methane fluxes in nort

Carolyn A. Pugh · David E. Reed · Anku

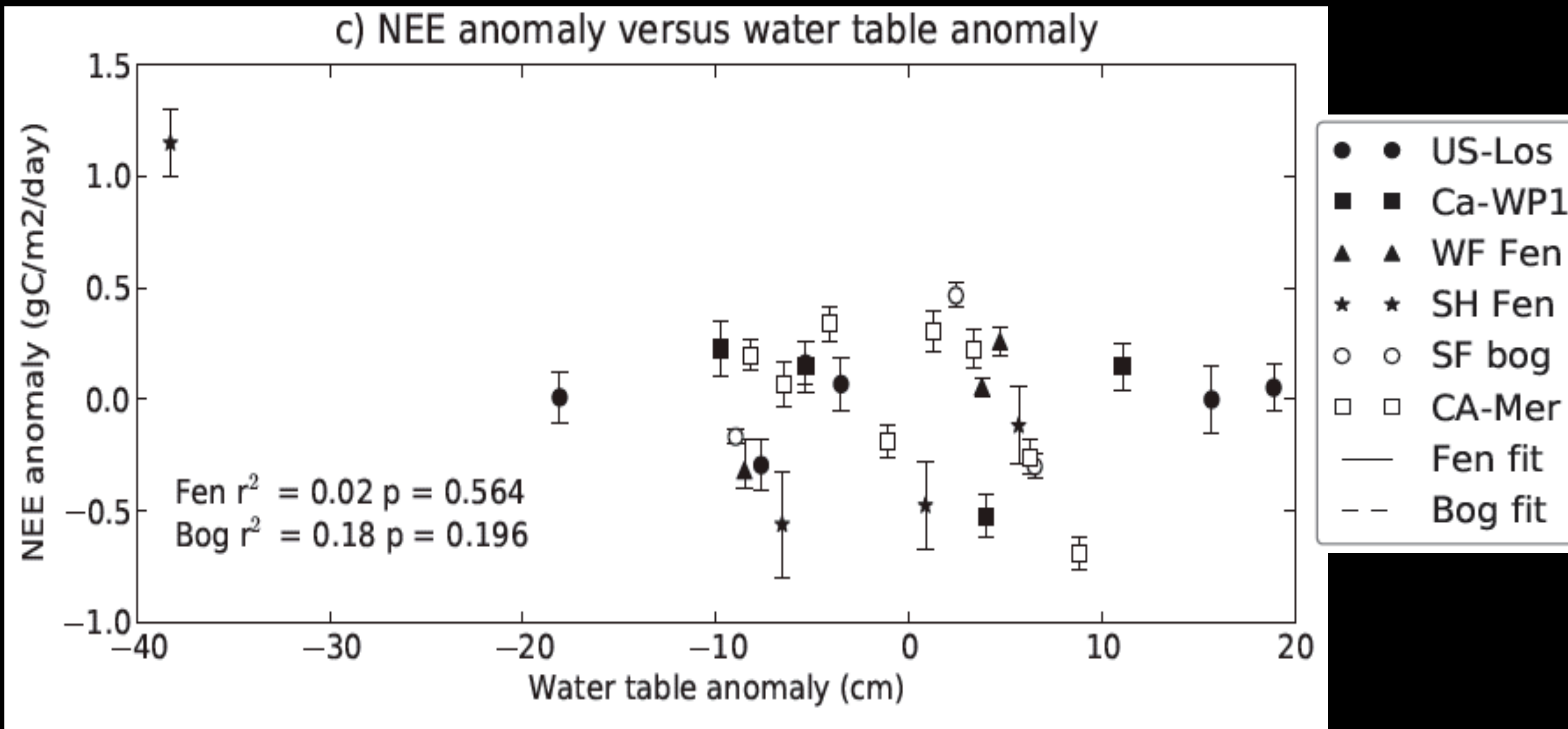
[redacted]



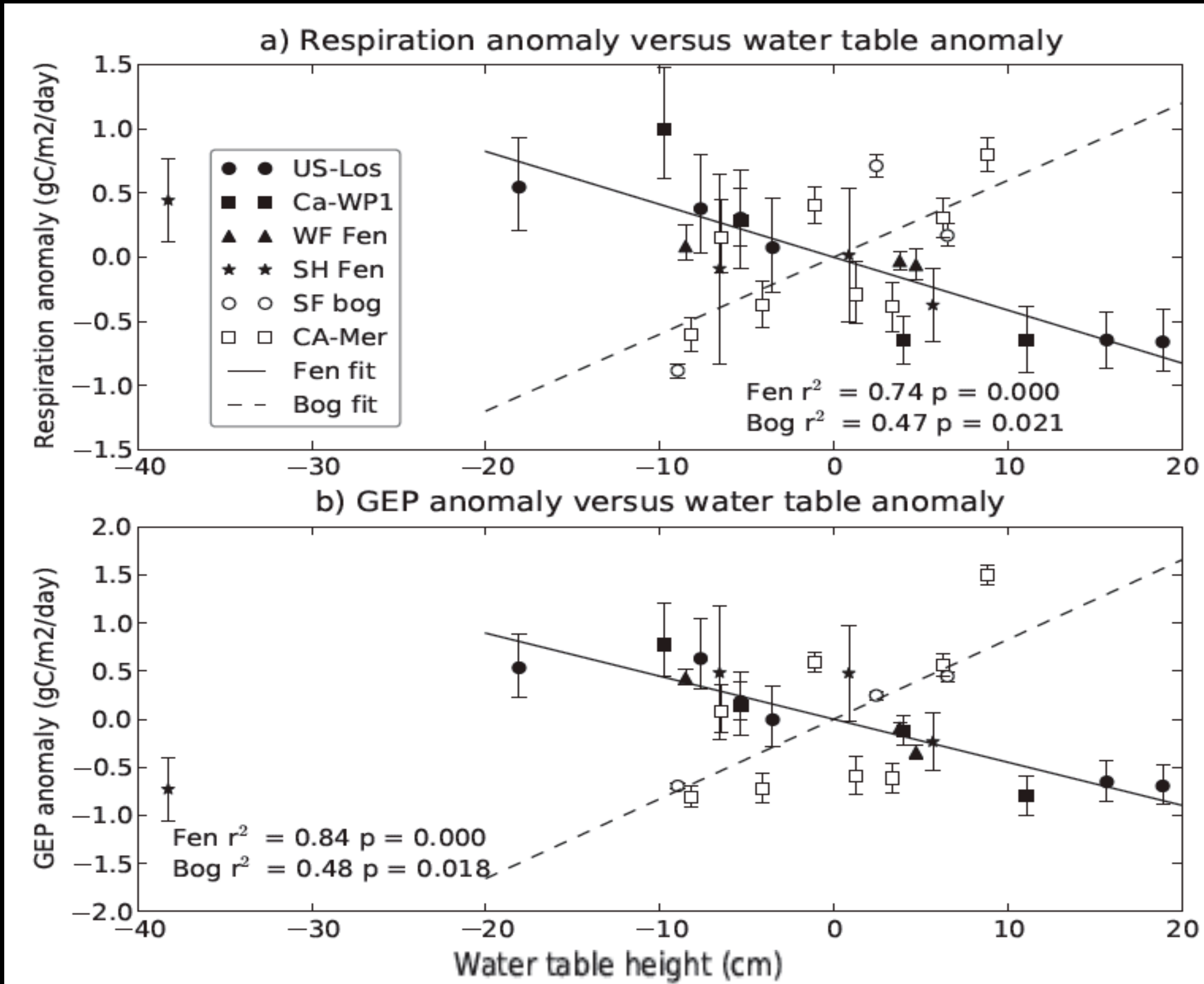


(a)
Reco
Reco (gC m−2 day−1)
T (C)
Q (m3 s−1)
(b)
Reco
Reco (gC m−2 day−1)
Discharge (m3 s−1)
T (C)
(c)
GPP
GPP (gC m−2 day−1)
T (C)
Q (m3 s−1)
(d)
GPP
GPP (gC m−2 day−1)
Discharge (m3 s−1)
T (C)
(e)
NEP
NEP (gC m−2 day−1)
T (C)
Q (m3 s−1)
(f)
NEP
NEP (gC m−2 day−1)
Discharge (m3 s−1)
T (C)
(g)
CH4
CH4 flux (mgC m−2 day−1)
T (C)
Q (m3 s−1)
(h)
CH4
CH4 flux (mgC m−2 day−1)
Discharge (m3 s−1)
T (C)

Is this water table (non)effect common?



Sulman *et al., Geophys. Res. Lett,* 2010

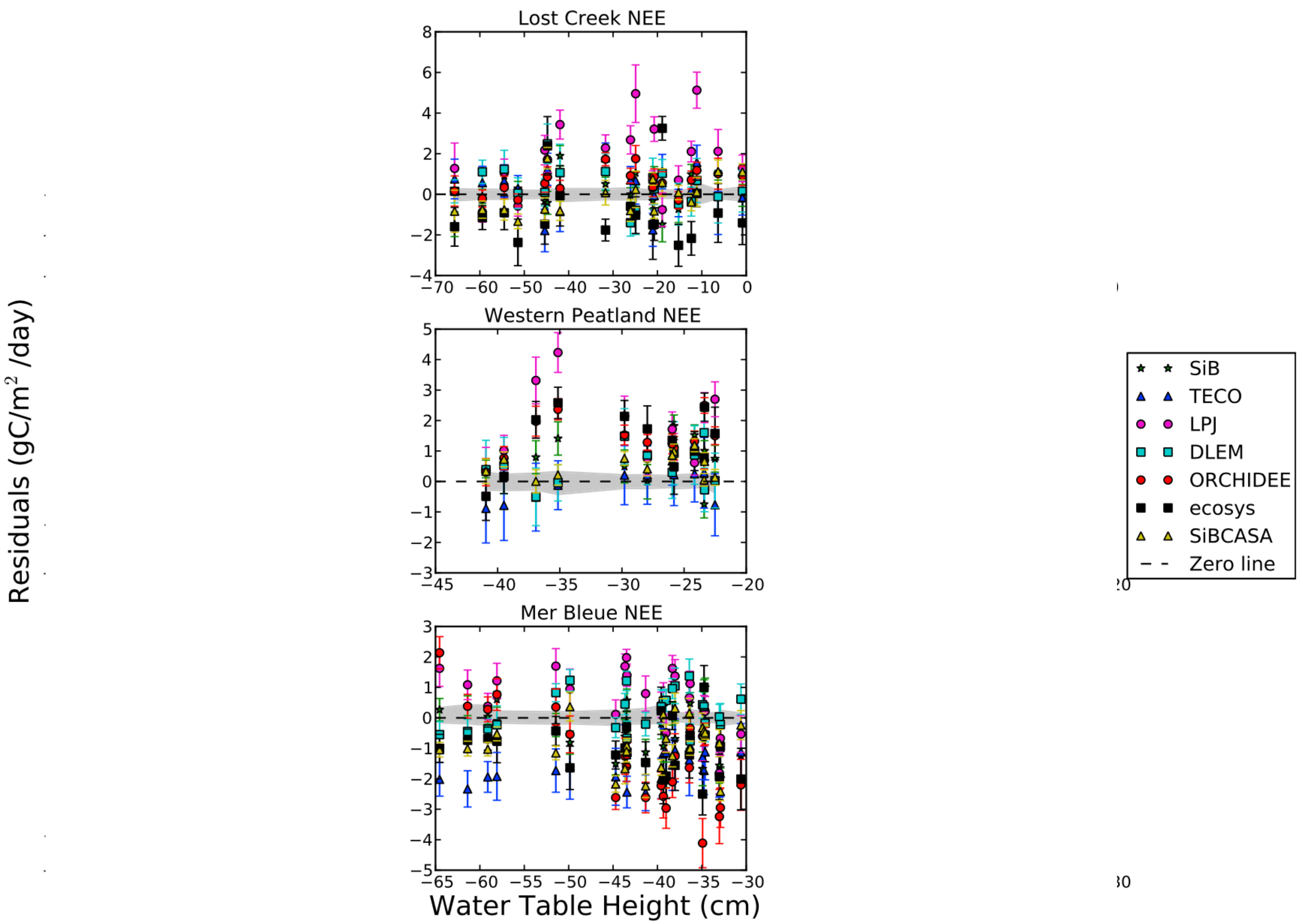


Sulman *et al., Geophys. Res. Lett*, 2010

Impact of hydrological variations on modeling of peatland CO_2 fluxes: Results from the North American Carbon Program site synthesis

J. Geophys Res-G, 2012

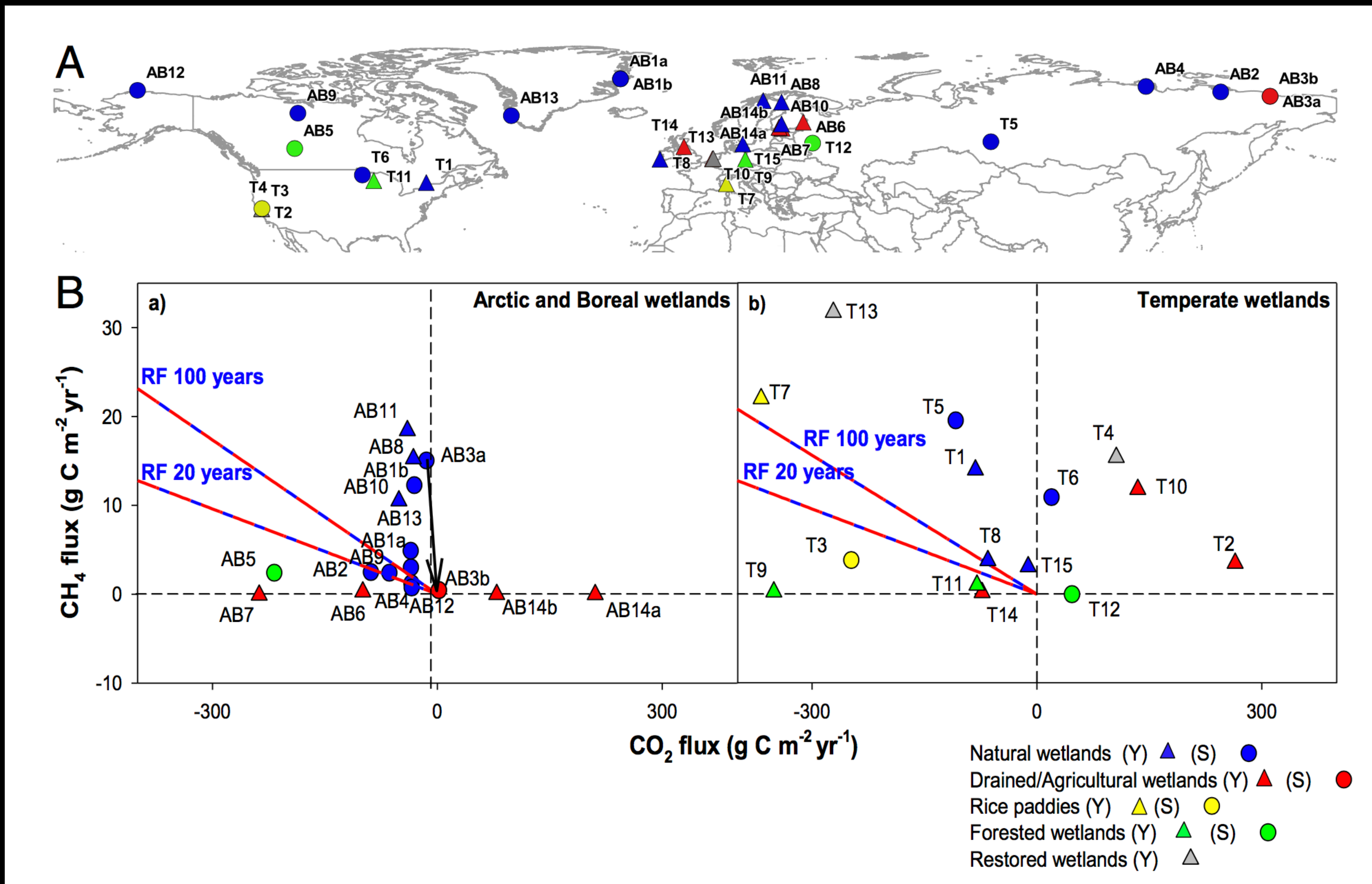
Benjamin N. Sulman,[1] Ankur R. Desai,[1] Nicole M. Schroeder,[1] Dan Ricciuto,[2] Alan Barr,[3]



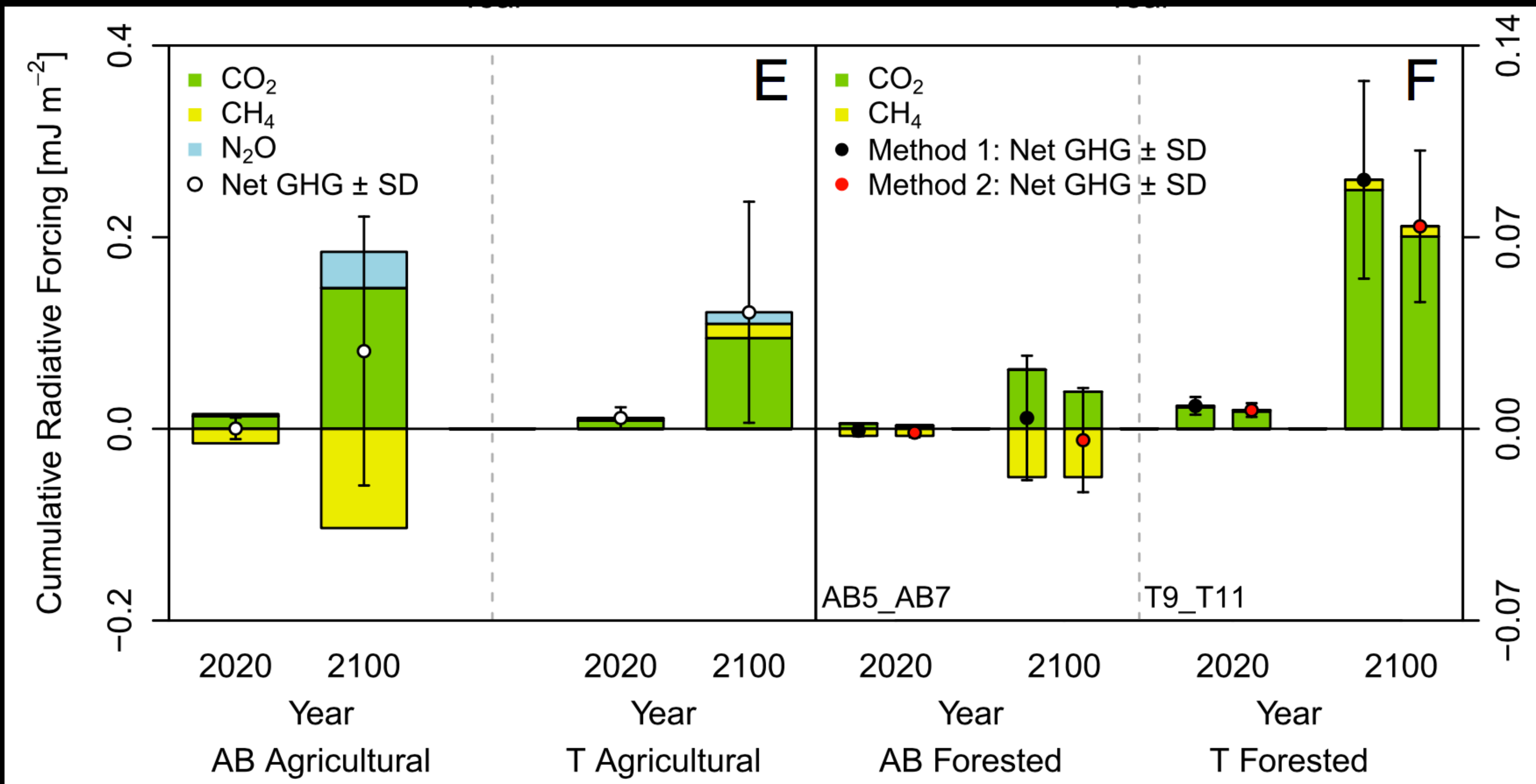
The uncertain climate footprint of wetlands under human pressure

2015, *PNAS*

Ana Maria Roxana Petrescu[a], Annalea Lohila[b], Juha-Pekka Tuovinen[b], Dennis D. Baldocchi[c], Ankur R. Desai[d],

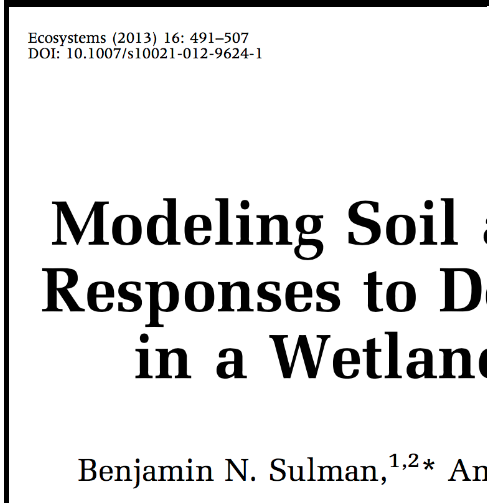


Net carbon effect of wetland drainage depends on location, type of conversion, and timescale



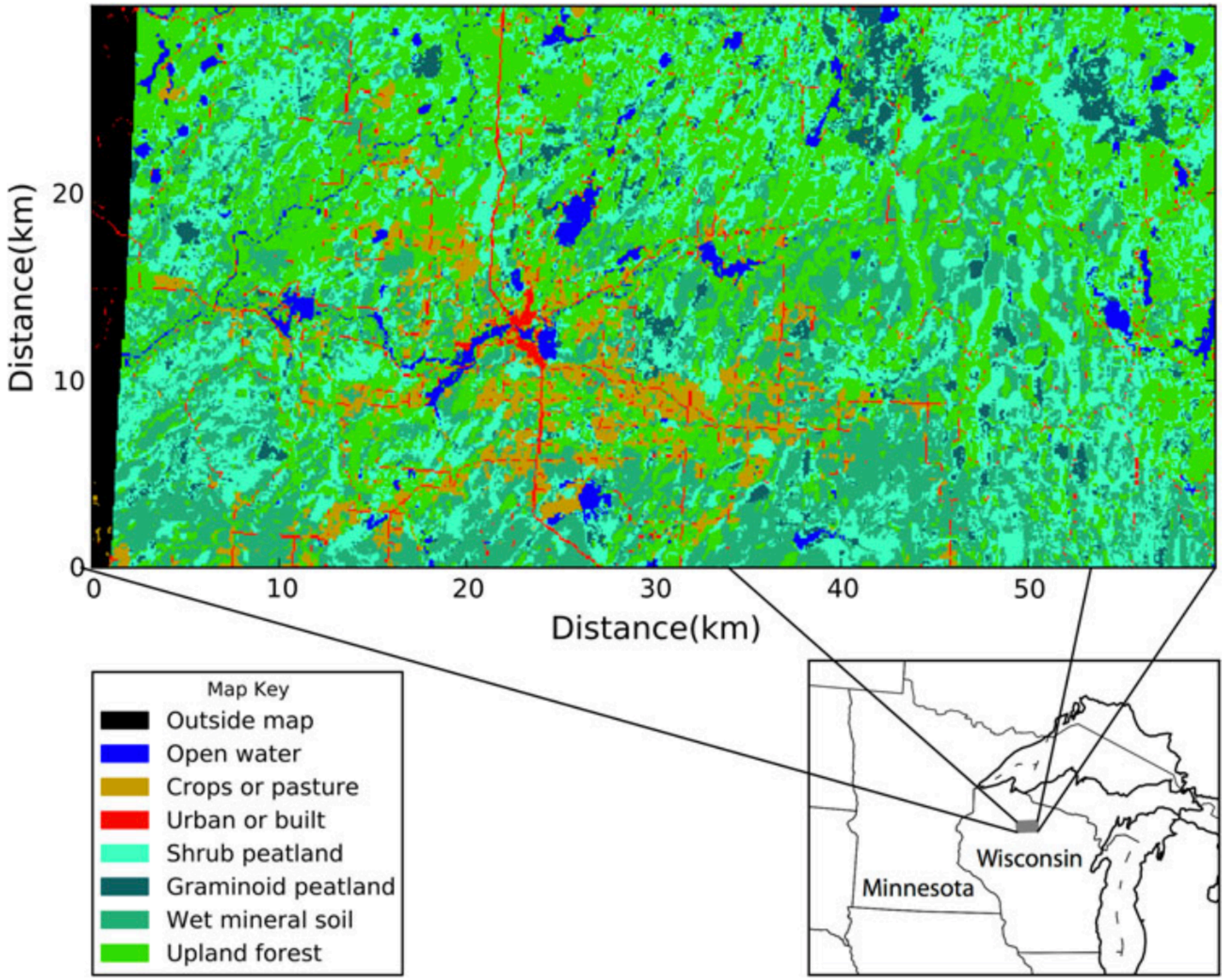
Petrescu *et al*, *PNAS*, 2015

It also depends on the landscape setting

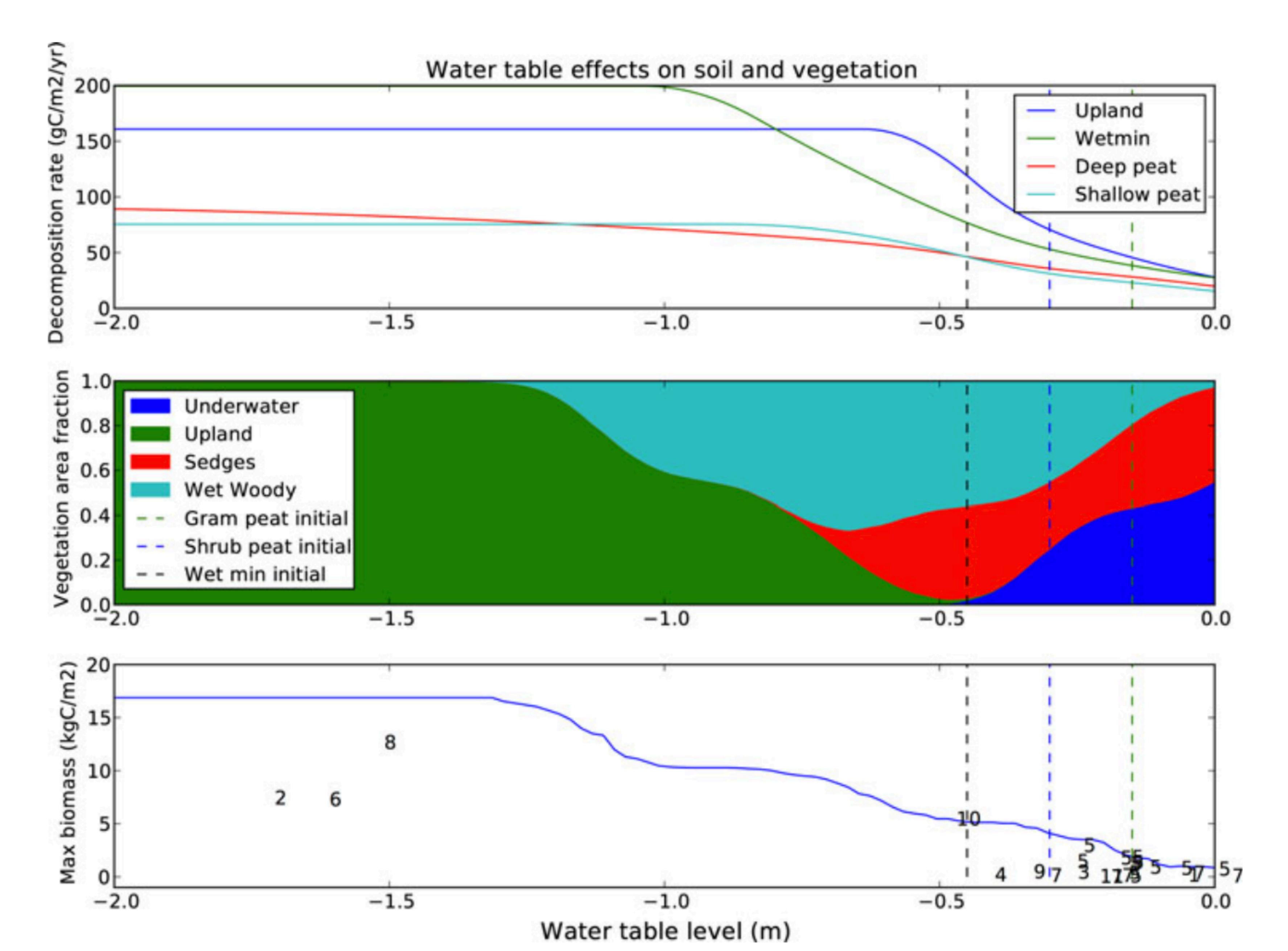

Ecosystems (2013) 16: 491–507
DOI: 10.1007/s10021-012-9624-1

Modeling Soil ...
Responses to D...
in a Wetlan...

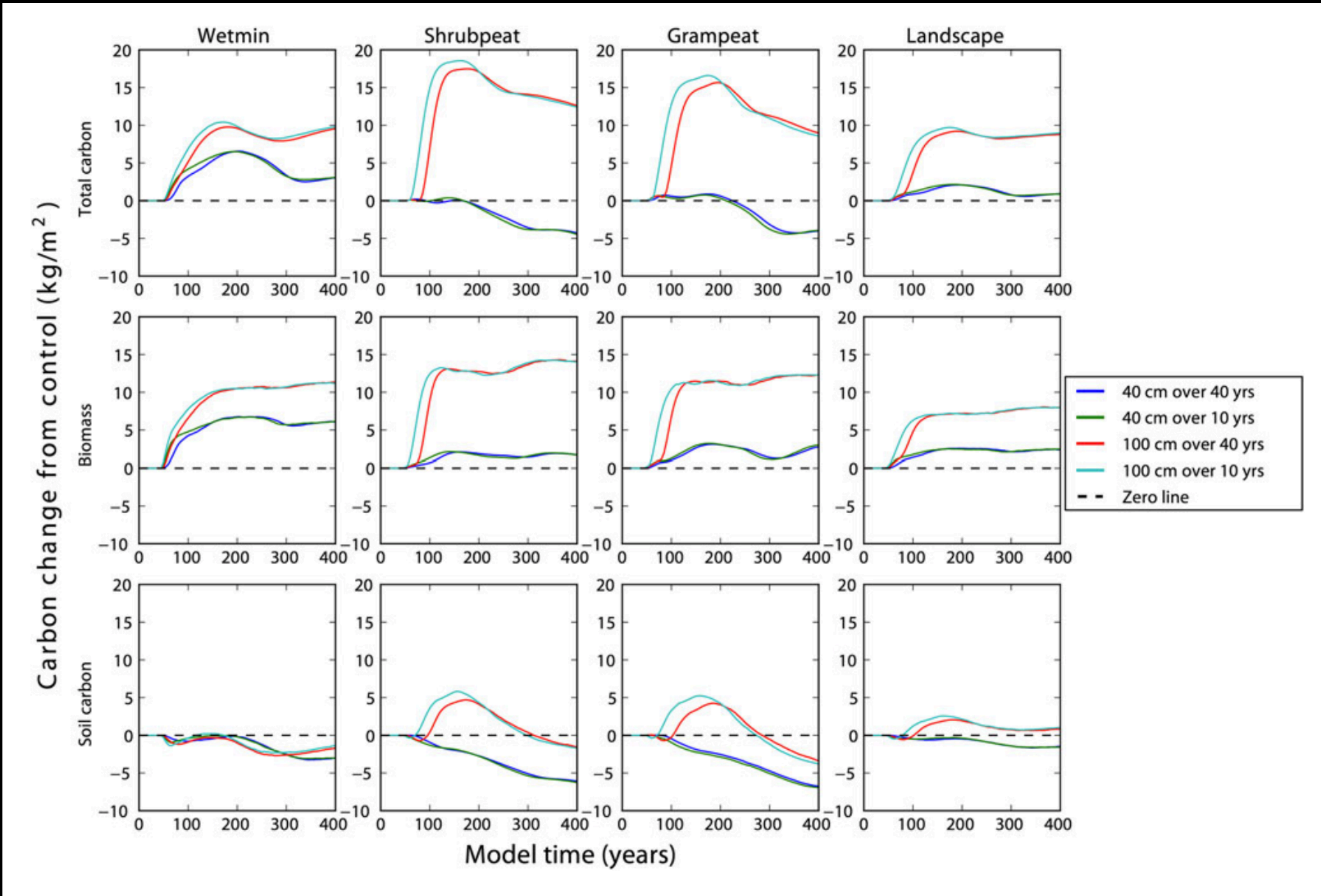
Benjamin N. Sulman,[1,2]* An...



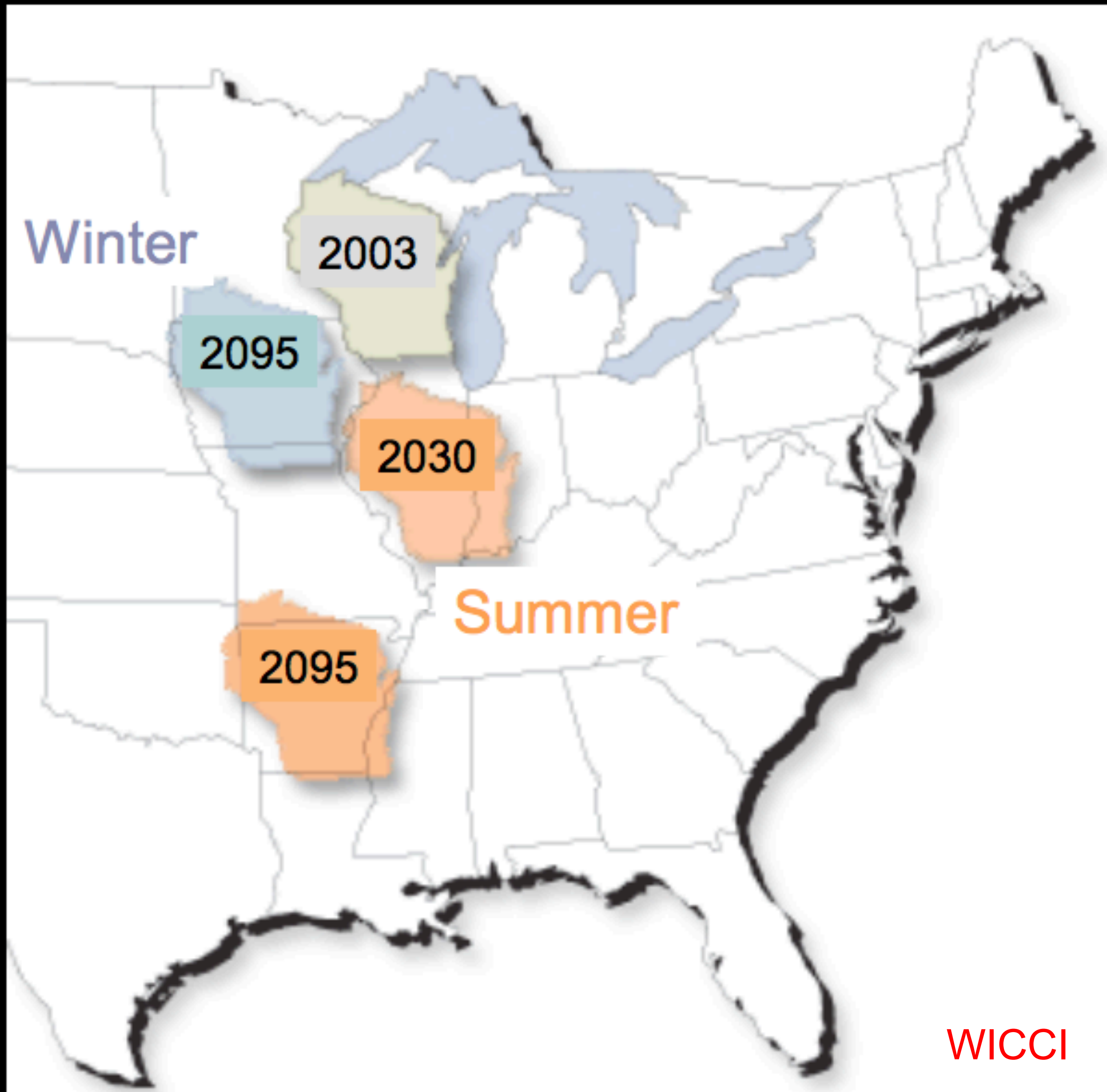
Sulman *et al.*, *Ecosystems*, 2013



Sulman *et al.*, *Ecosystems*, 2013



Wisconsin Migrating Climate



Parting thoughts

- Wetlands in Wisconsin store and exchange large quantities of carbon
- Net carbon exchange is more of a function of temperature than water table position
- Continuous methane exchange has a different atmospheric lifetime than either fossil fuel methane pulse emissions or wetland carbon dioxide exchange
- Estimating ecosystem service of carbon uptake requires considering type of potential land use change, timescale, & landscape setting

Questions?

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