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

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Photo: J Thom
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WI Wetlands Assoc.
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Wetlands provide many ecosystem goods and services

### Millennium Ecosystem Assessment

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

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

Trend expected from fossil-fuel burning

R. Keeling
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
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.

Wetlands are important part of Wisconsin’s carbon cycle

Buffam et al, 2010
What drives this carbon uptake?

Sulman et al. (submitted)
Infrared gas analyzer

Sonic anemometer
Thermistor, hygrometer, barometer

\[ \rho w' q' \]

\[ \rho w' t' \]

LE = Latent Heat flux

\[ \frac{F_{ws} w s}{\rho} \]

\[ H = \text{Sensible Heat flux} \]

\[ \text{Net radiation} = \text{Net solar} + \text{net Longwave} \]
Lost Creek ER, GEP, and NEE

Respiration

Net Carbon Exchange

Photosynthesis

Carbon flux (µmol m⁻² s⁻¹)

Year

2001 2002 2003 2004 2005 2006 2007

Sulman et al., Biogeosciences, 2009
What drives water table position?

Sulman et al., *Biogeosciences*, 2009
Wetland flux controls: how do interacting water table levels and temperature and methane fluxes in northern wetlands vary?

Carolyn A. Pugh · David E. Reed · Anke Jastrow
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

Benjamin N. Sulman, Ankur R. Desai, Nicole M. Schroeder, Dan Ricciuto, Alan Barr,

J. Geophys Res-G, 2012
The uncertain climate footprint of wetlands under human pressure

Ana Maria Roxana Petrescu, Anna Lohila, Juha-Pekka Tuovinen, Dennis D. Baldocchi, Ankur R. Desai

2015, PNAS

A

B

Arctic and Boreal wetlands

Temperate wetlands

CH₄ flux (g C m⁻² yr⁻¹)

CO₂ flux (g C m⁻² yr⁻¹)

RF 100 years

RF 20 years

Natural wetlands (Y) ▲ (S)
Drained/Agricultural wetlands (Y) △ (S)
Rice paddies (Y) ▲ (S)
Forested wetlands (Y) △ (S)
Restored wetlands (Y) △
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
Sulman et al., *Ecosystems*, 2013

Effects of water table level on modeled soil decomposition, vegetation area fraction, and maximum biomass.
Figure 6: Effects of nutrient blanket irrigation on ecosystem carbon balance. This plot shows results from the model time series.
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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