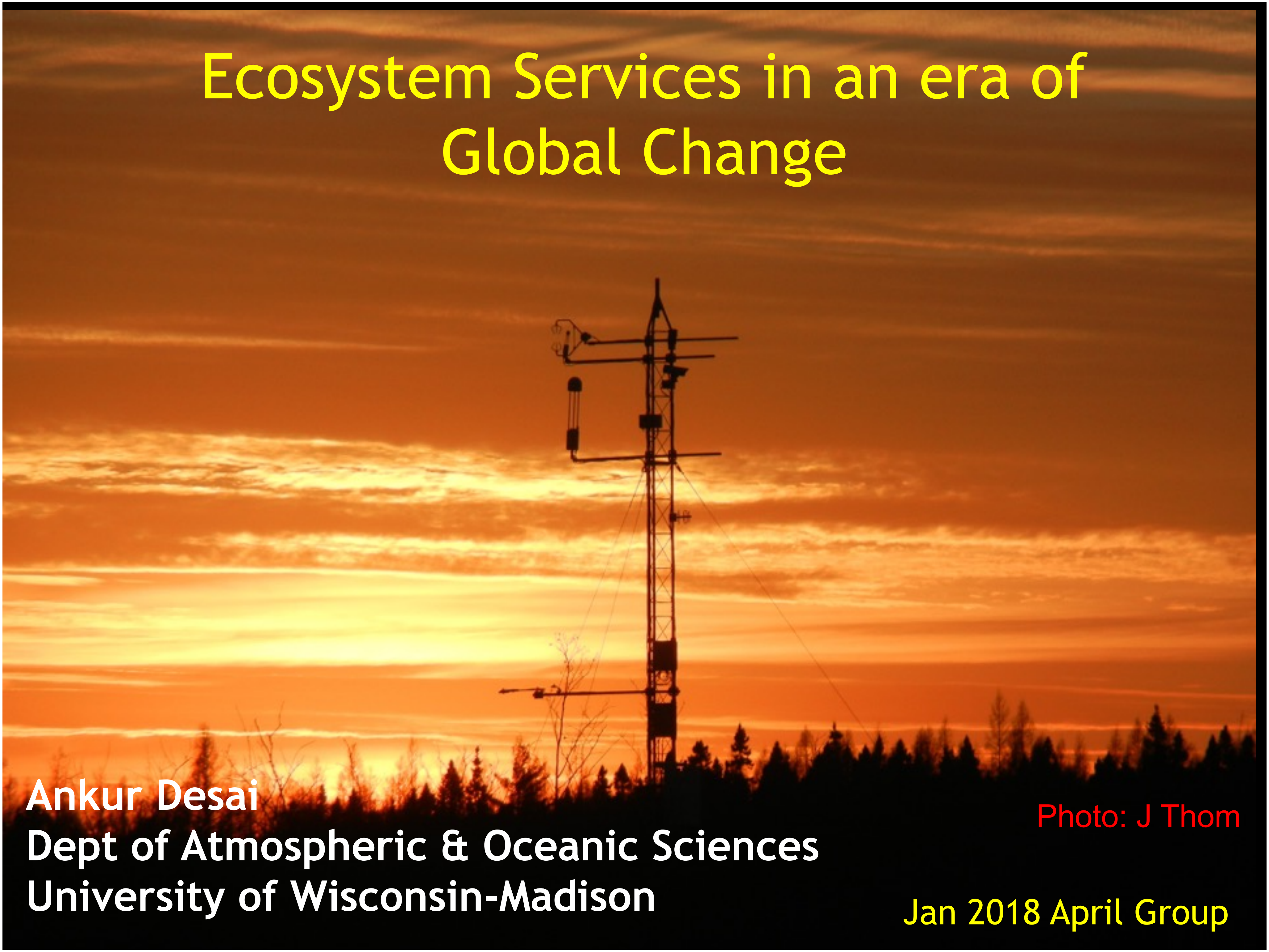


Ecosystem Services in an era of Global Change

Ankur Desai
Dept of Atmospheric & Oceanic Sciences
University of Wisconsin-Madison

Photo: J Thom

Jan 2018 April Group


WISCONSIN

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

Dec 21, 2017 The Straits Times

Jakarta court rules in government's favour in case involving pulp company April

The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

3d per Copy.

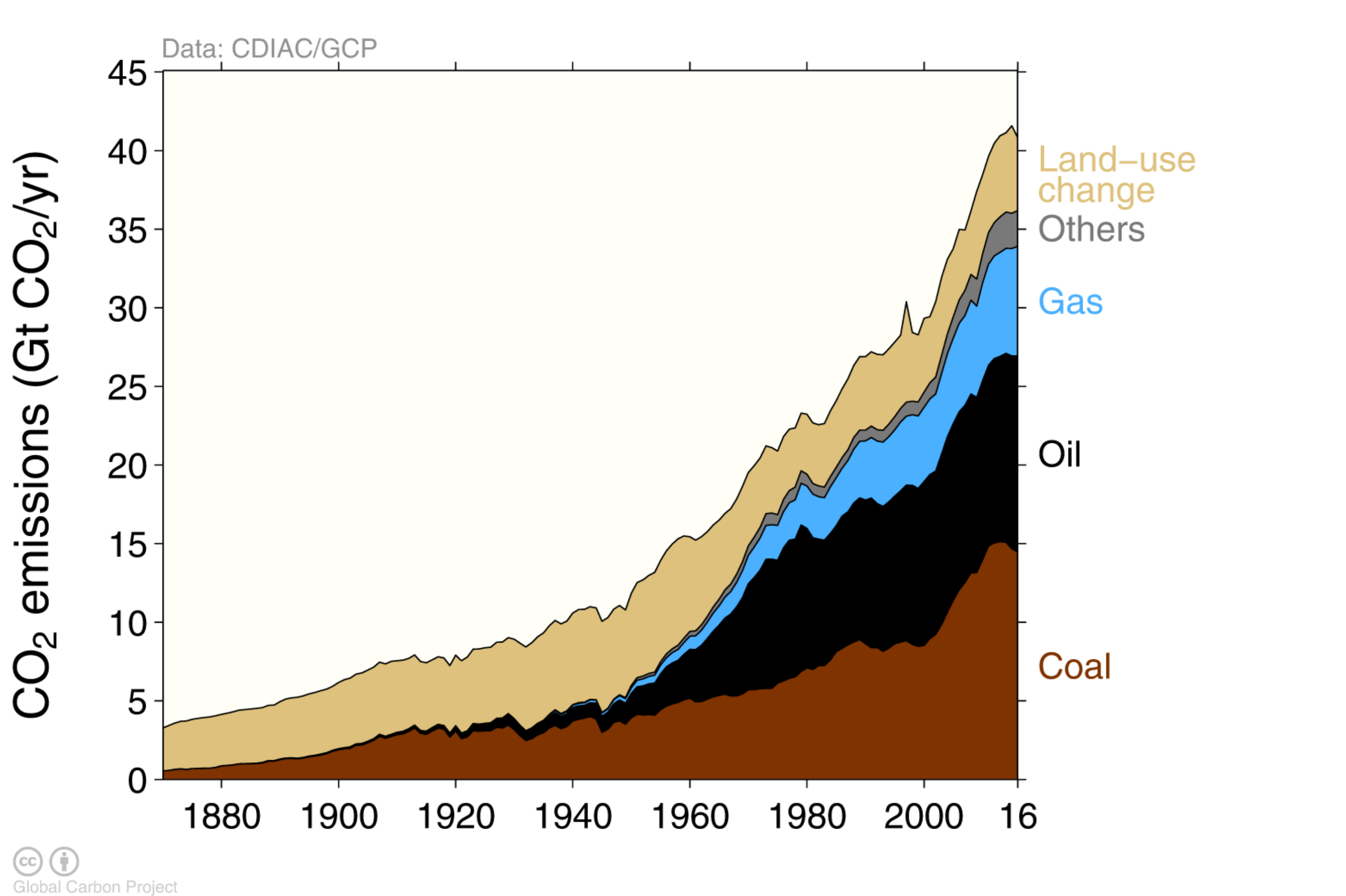
Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Total global emissions by source

Land-use change was the dominant source of annual CO_2 emissions until around 1950



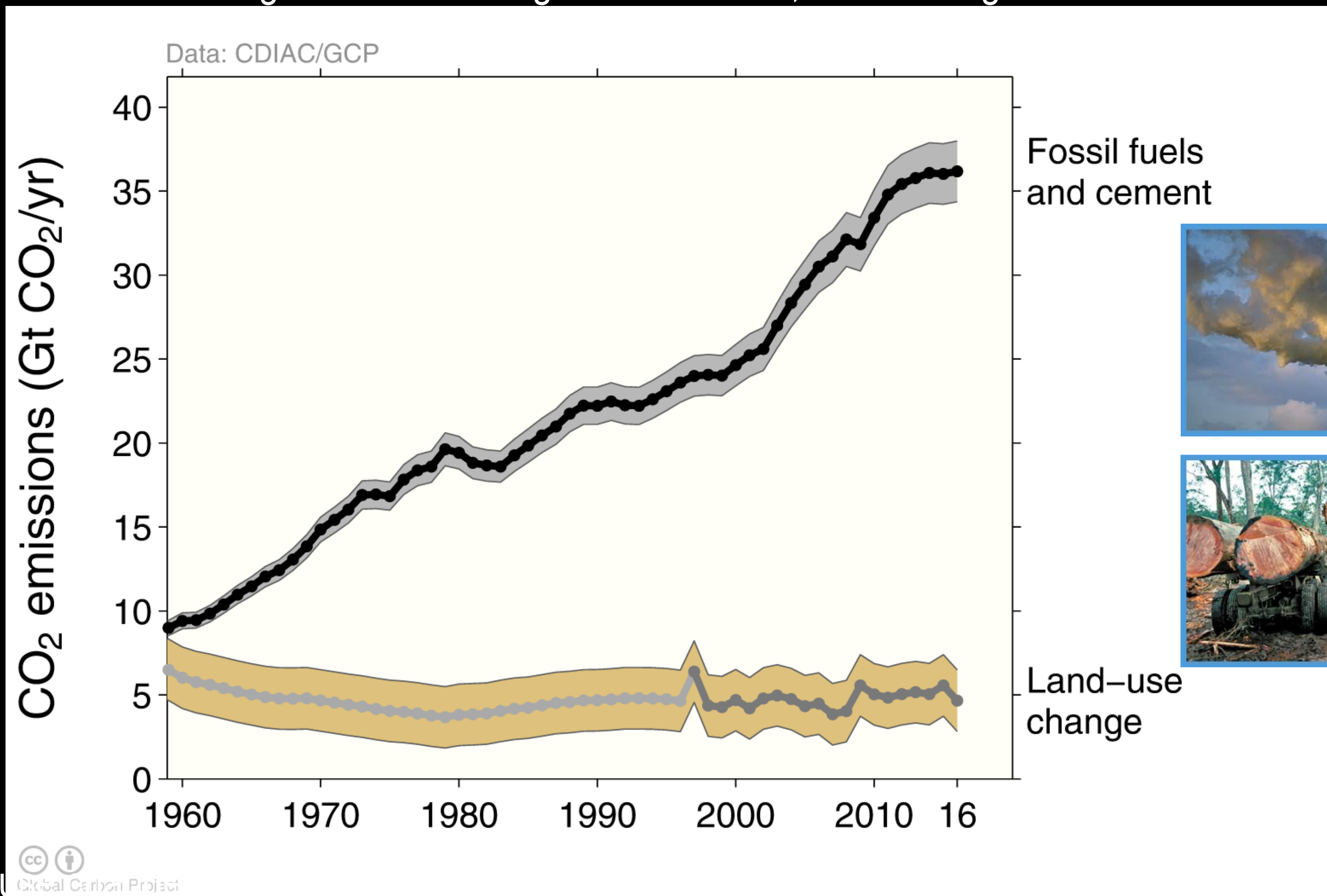
Source: CDIAC; Houghton and Nassikas 2017; Hansis et al 2015; Le Quéré et al 2017; Global Carbon Budget 2017

GLOBAL CARBON PROJECT

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

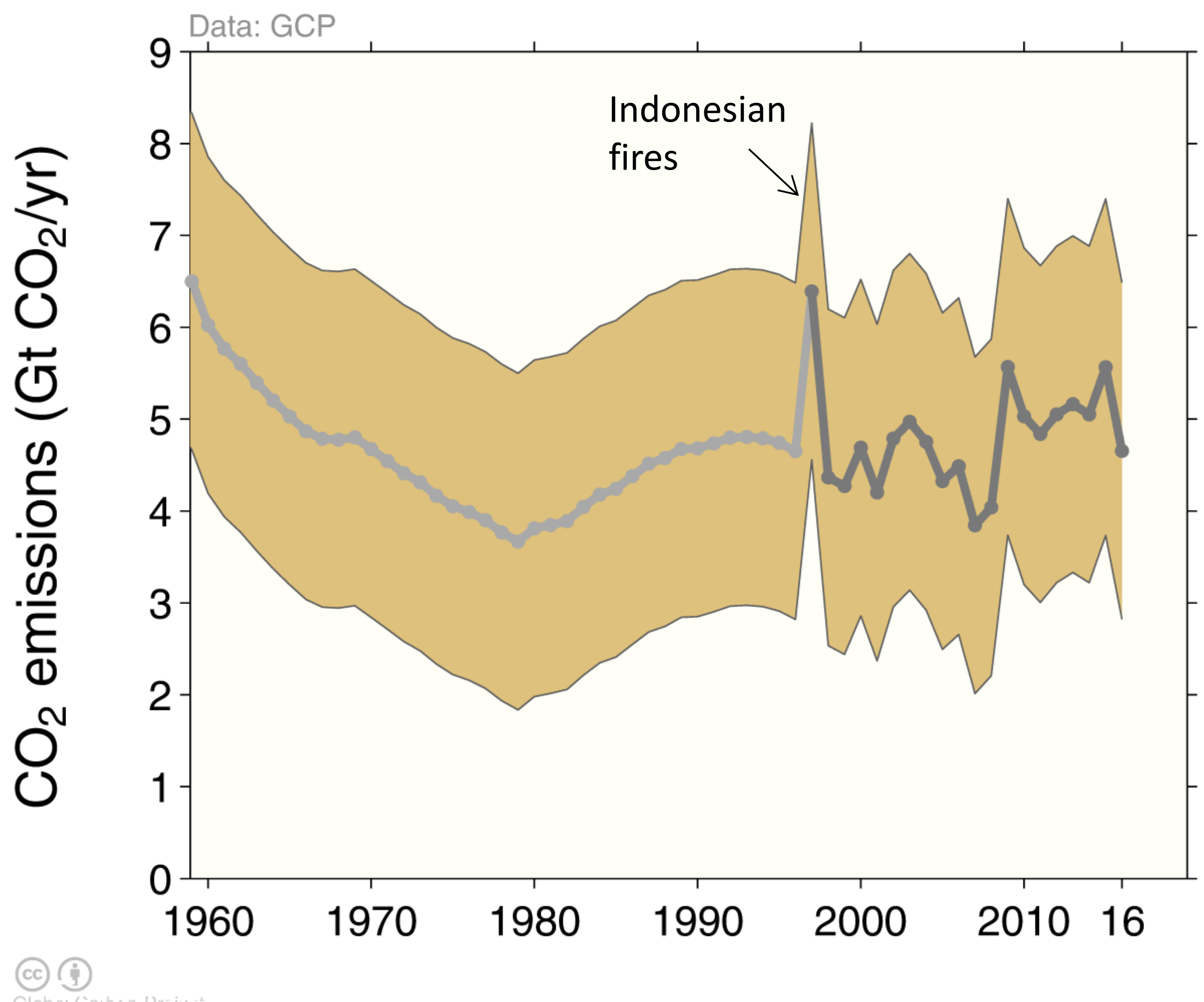


Land-u … 1997

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

Land-use change emissions

Land-use change emissions are highly uncertain. Higher emissions in 2016 are linked to increased fires during dry El Niño conditions in tropical Asia

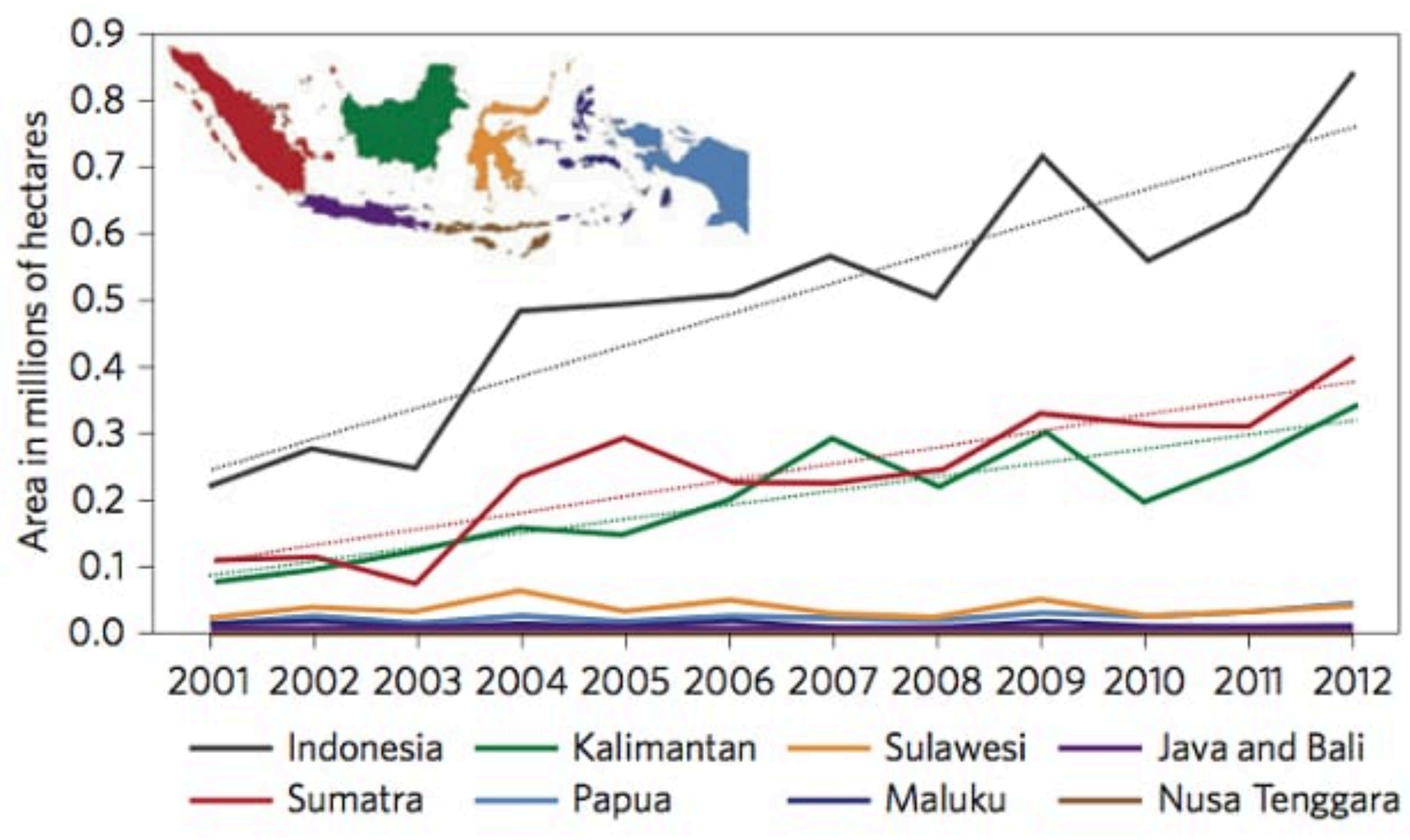


Source: Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Le Quéré et al 2017; Global Carbon Budget 2017

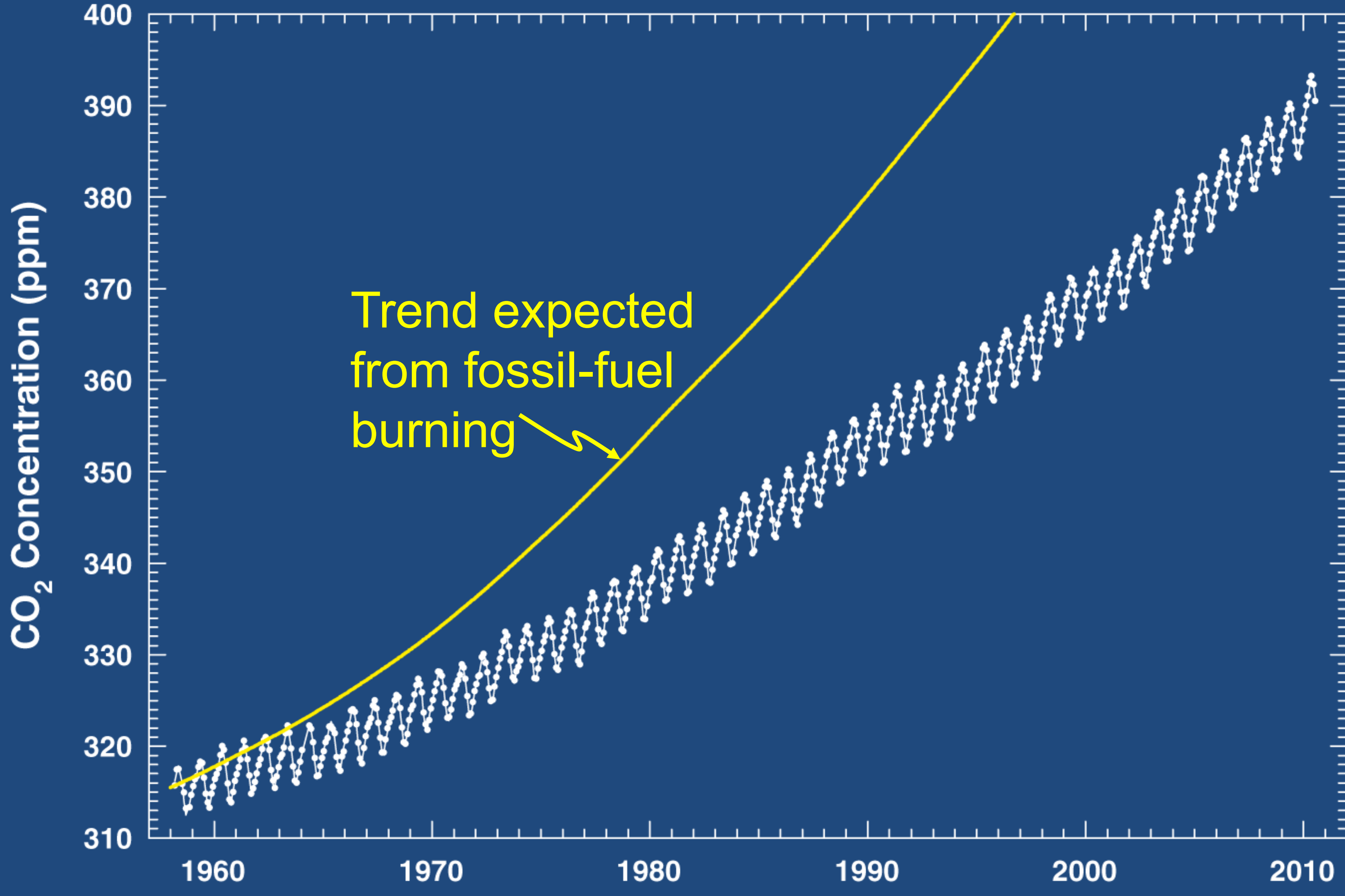
ARTICLES
PUBLISHED ONLINE: 29 JUNE 2014 | DOI: 10.1038/NCLIMATE2277
nature climate change

Primary forest cover loss in Indonesia over 2000–2012

Belinda Arunarwati Margono[1,2]*, Peter V. Potapov[1], Svetlana Turubanova[1], Fred Stolle[3] and Matthew C. Hansen[1]

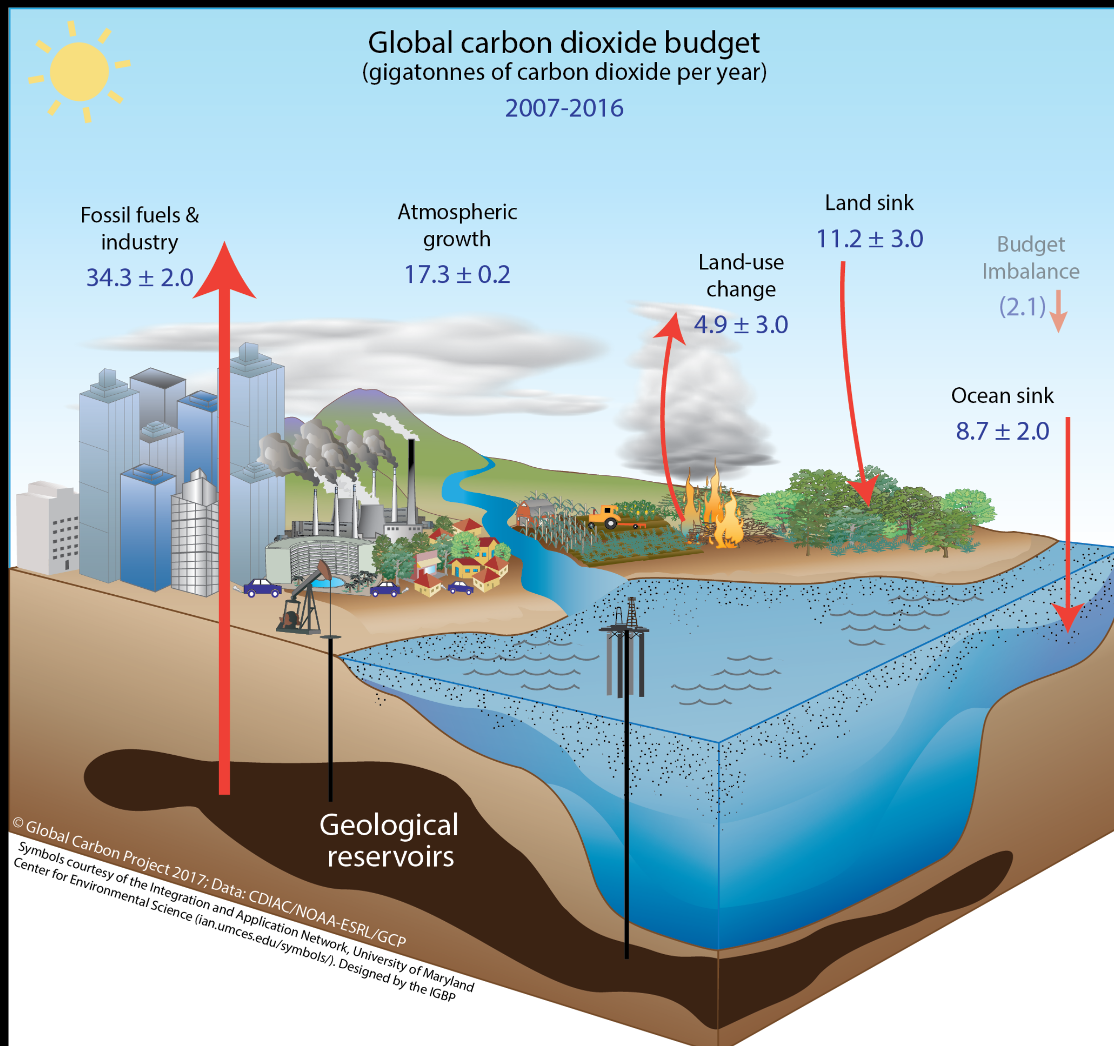


Atmospheric CO_2 records



Anthropogenic perturbation of the global carbon cycle

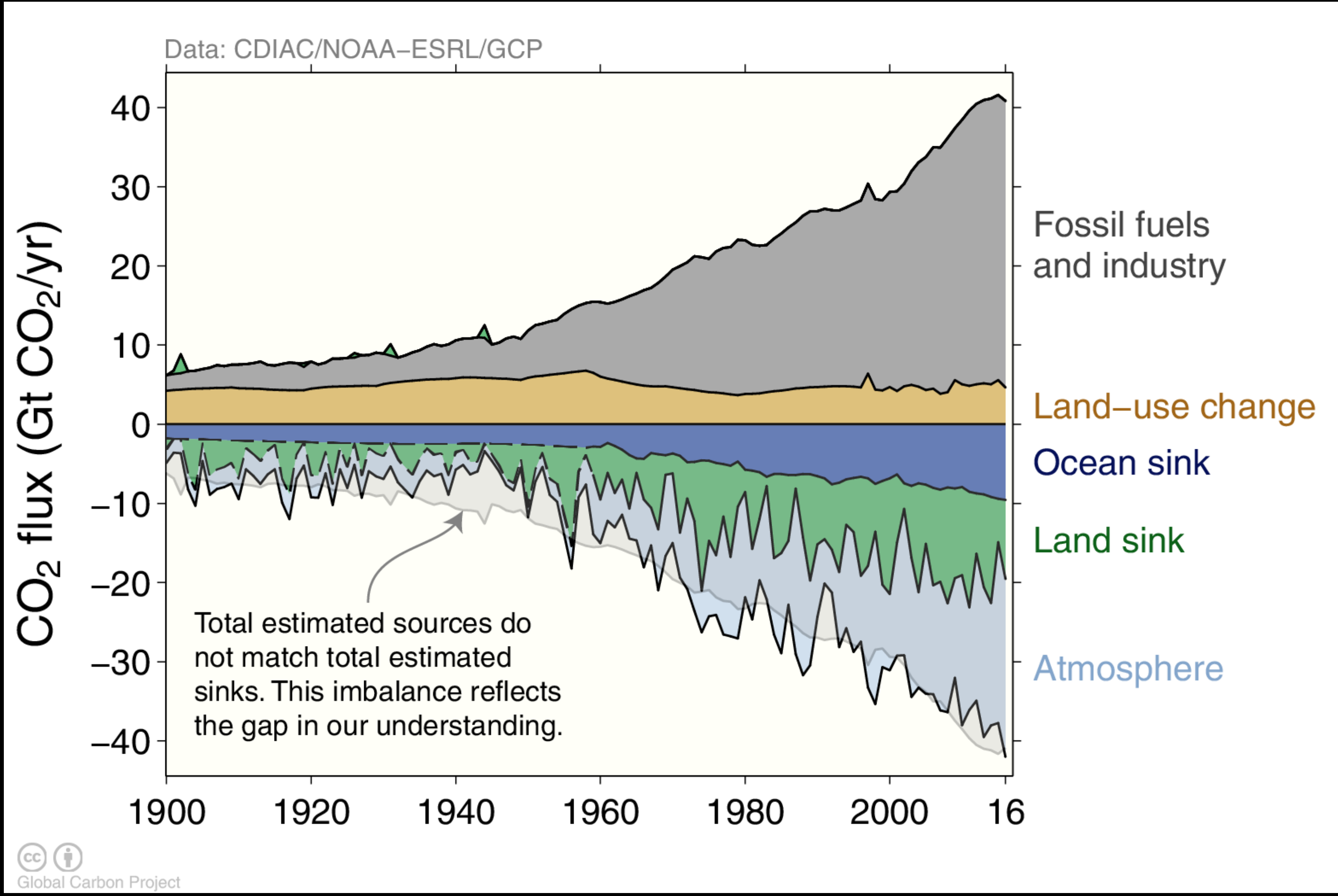
Perturbation of the global carbon cycle caused by anthropogenic activities,
averaged globally for the decade 2007–2016 ($GtCO_2$/yr)



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

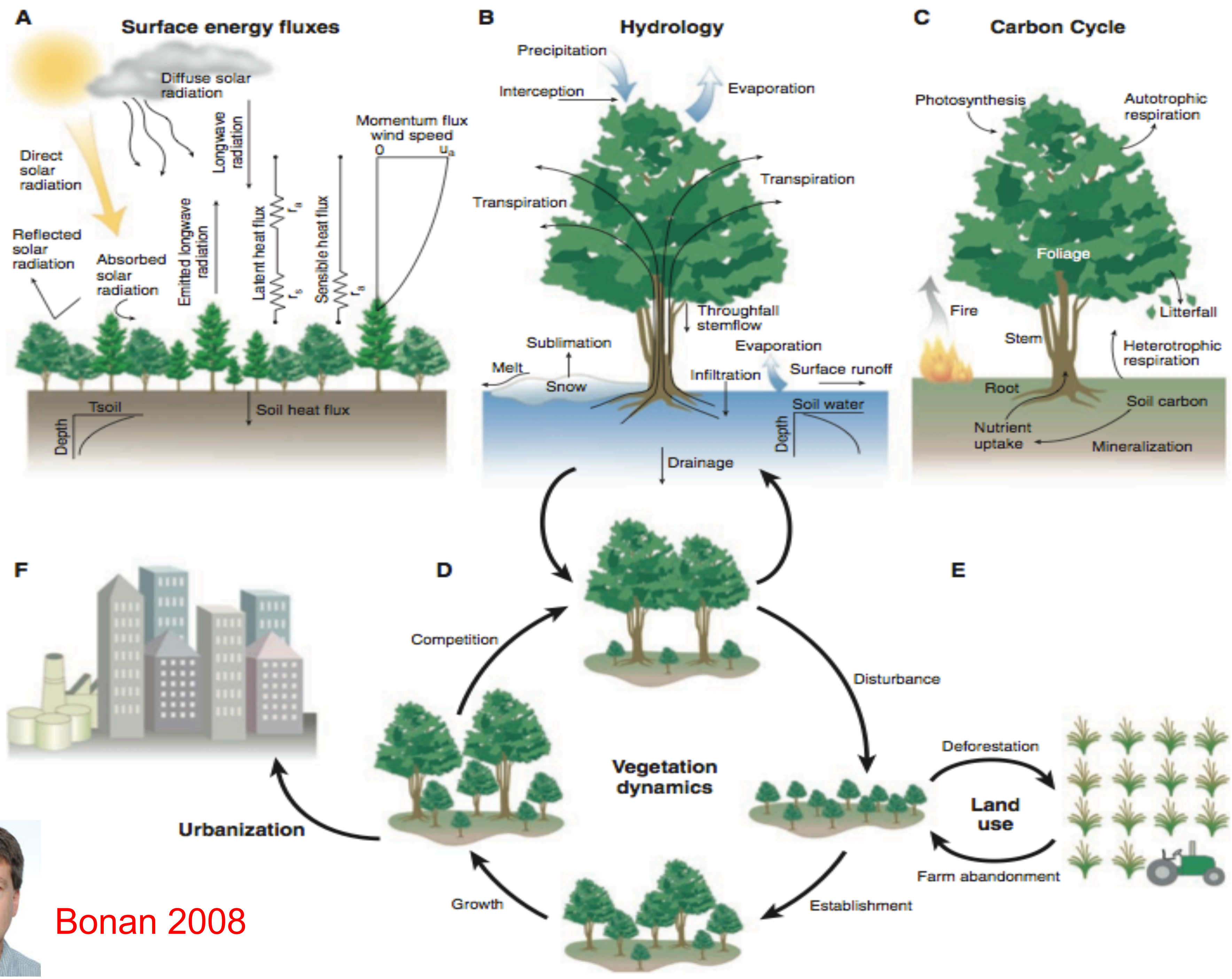
Global carbon budget

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

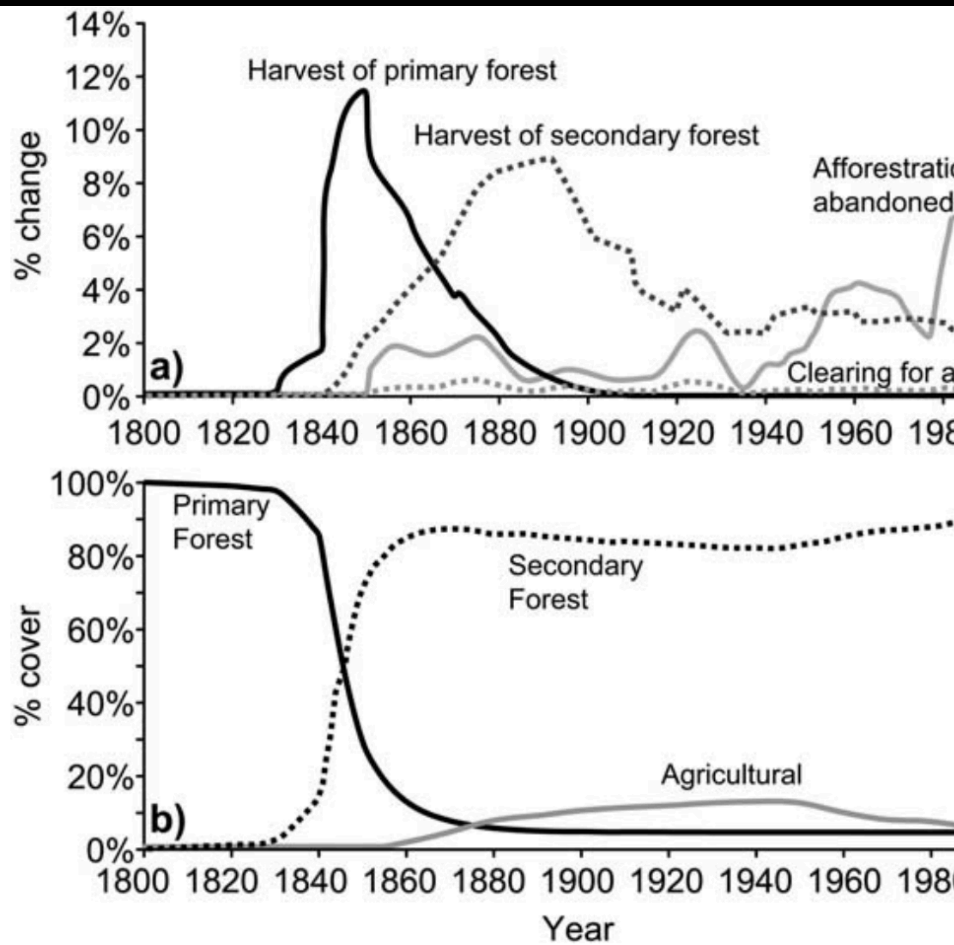
Forests in Flux

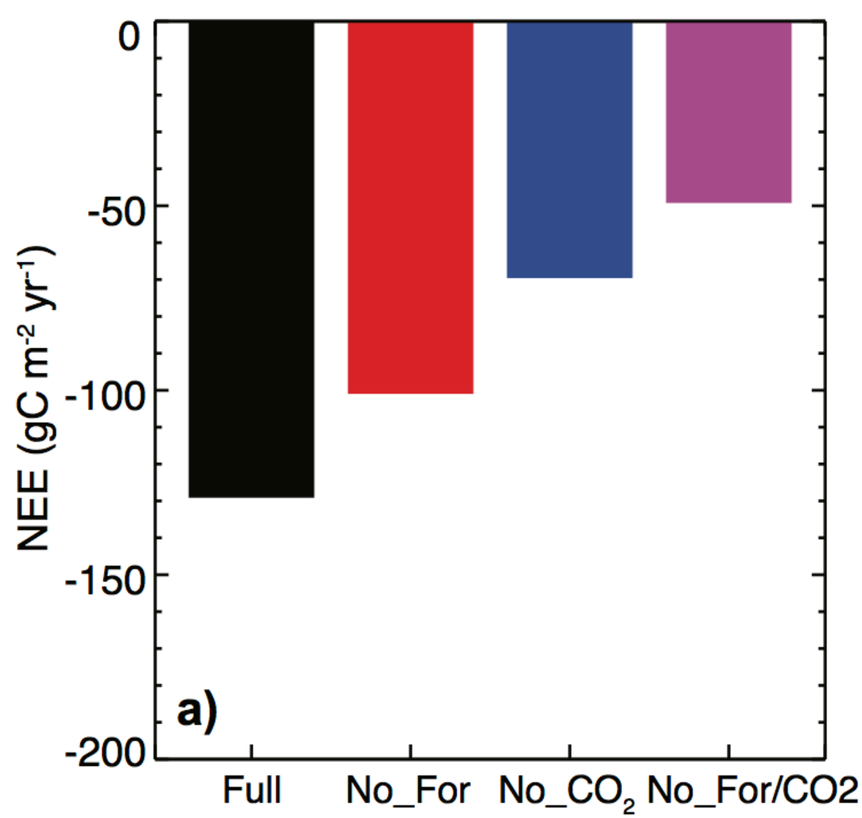


Bonan 2008

Regional carbon fluxes from an observationally constrained dynamic ecosystem model: Impacts of disturbance, CO_2 fertilization, and heterogeneous land cover

Ankur R. Desai,[1,2] Paul R. Moorcroft,[3] Paul V. Bolstad,[4] and Kenneth J. Davis[5]





Assessing Interactions Among Changing Climate, Management, and
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JUSTIN M.
PAUL A. D
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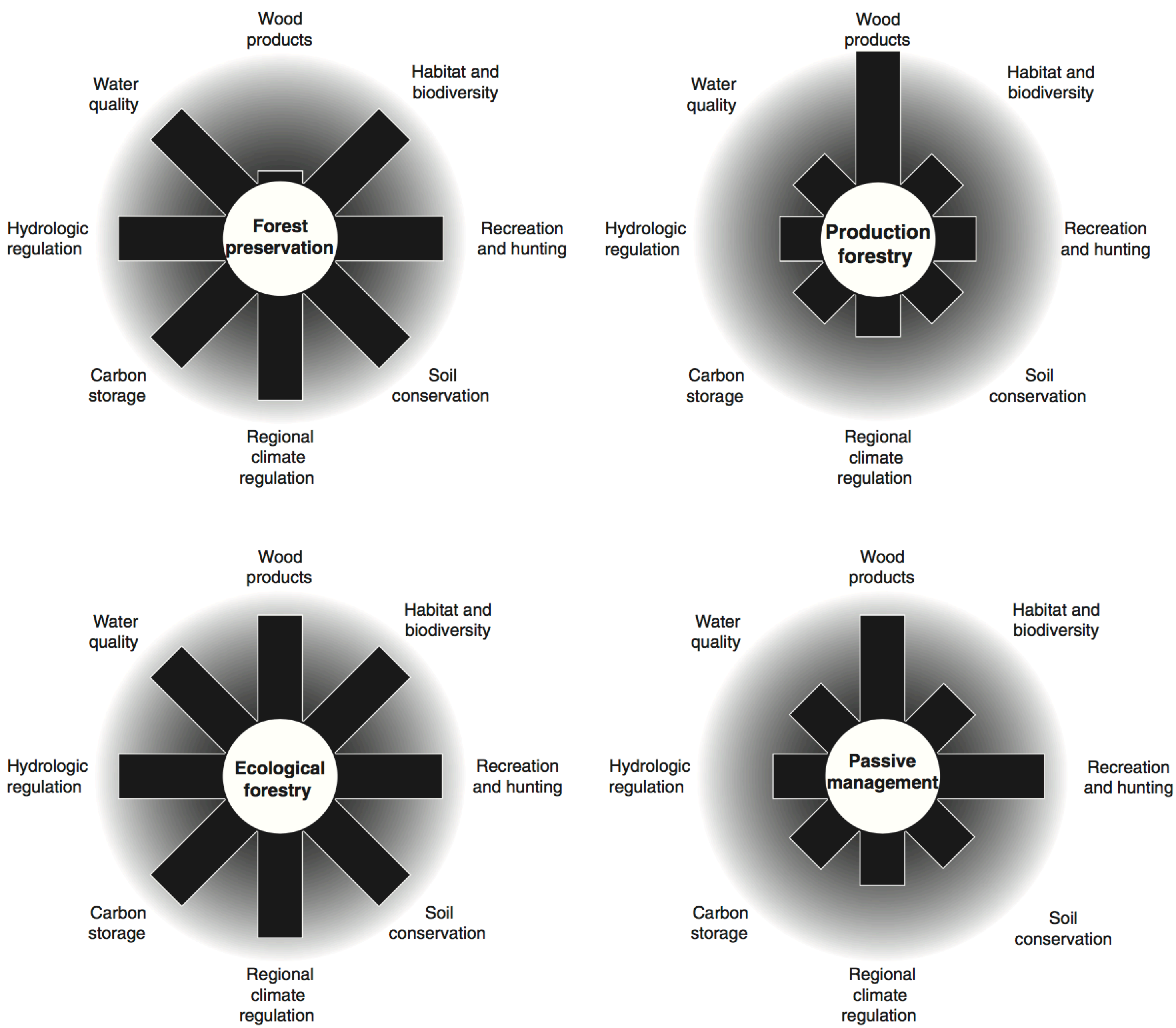
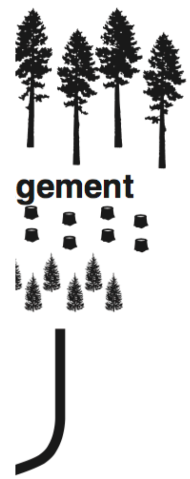


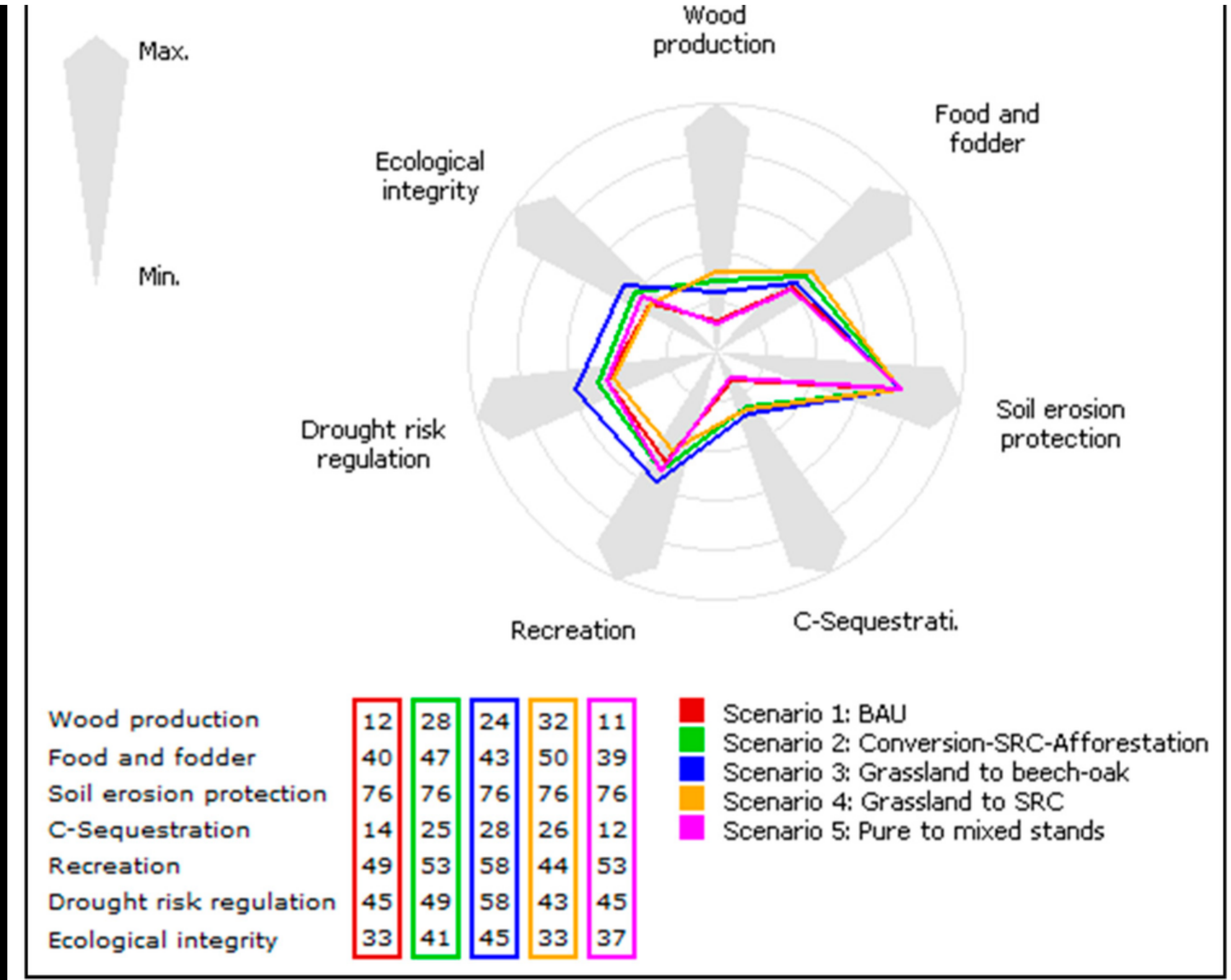


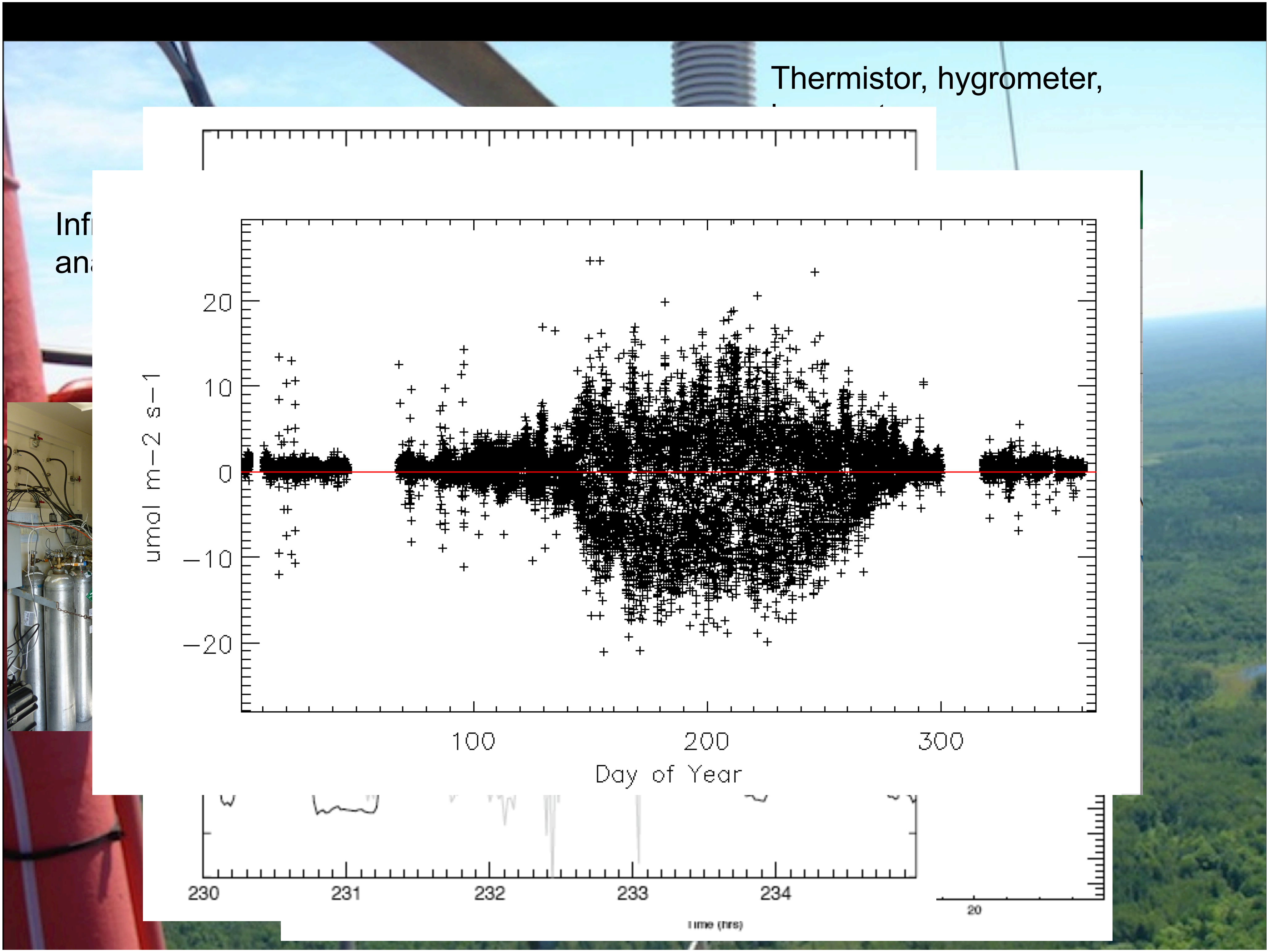
nd various

Forests **2015**, *6*(3), 533-560; doi:10.3390/f6030533 Open Access Article

Cross-Sectoral Resource Management: How Forest Management Alternatives Affect the Provision of Biomass and Other Ecosystem Services

Susanne Frank [1,*], Christine Fürst [1] and Frank Pietzsch [2]



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

Major challenges to EC

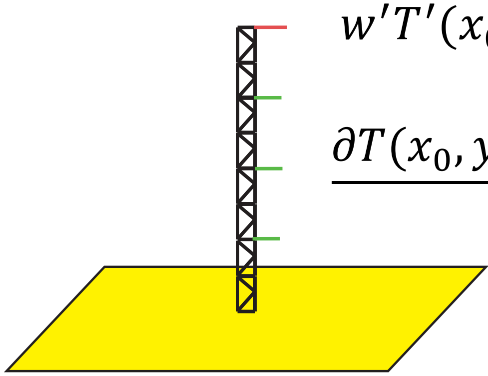
- Quality control for violation of EC assumptions (Mauder *et al*., 2013)
- Gap-filling of quality controlled and missing data for seasonal-annual sums (Desai *et al*., 2008)
- Systematic bias from unmeasured terms (Metzger, 2017)
- Representation error (Xu *et al*., 2017)

Full net surface-atmosphere exchange in a box

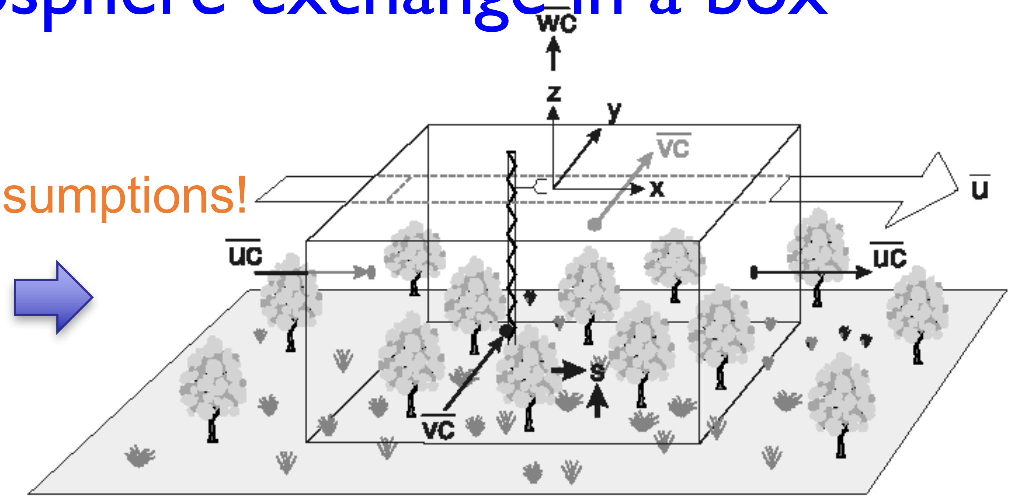
Eddy Covariance

$$w'T'(x_0, y_0, h)$$

$$\frac{\partial T(x_0, y_0, (z_1 \dots z_m))}{\partial t}$$



3 Assumptions!



modified after Finnigan (2004)

Assumption 1:

storage change $\int_0^h \frac{\partial \bar{c}}{\partial t} dz$ **<-** $\int_0^h \left[\frac{1}{4L^2} \int_{-L}^{+L} \int_{-L}^{+L} \frac{\partial \bar{c}}{\partial t} dx\, dy \right] dz$

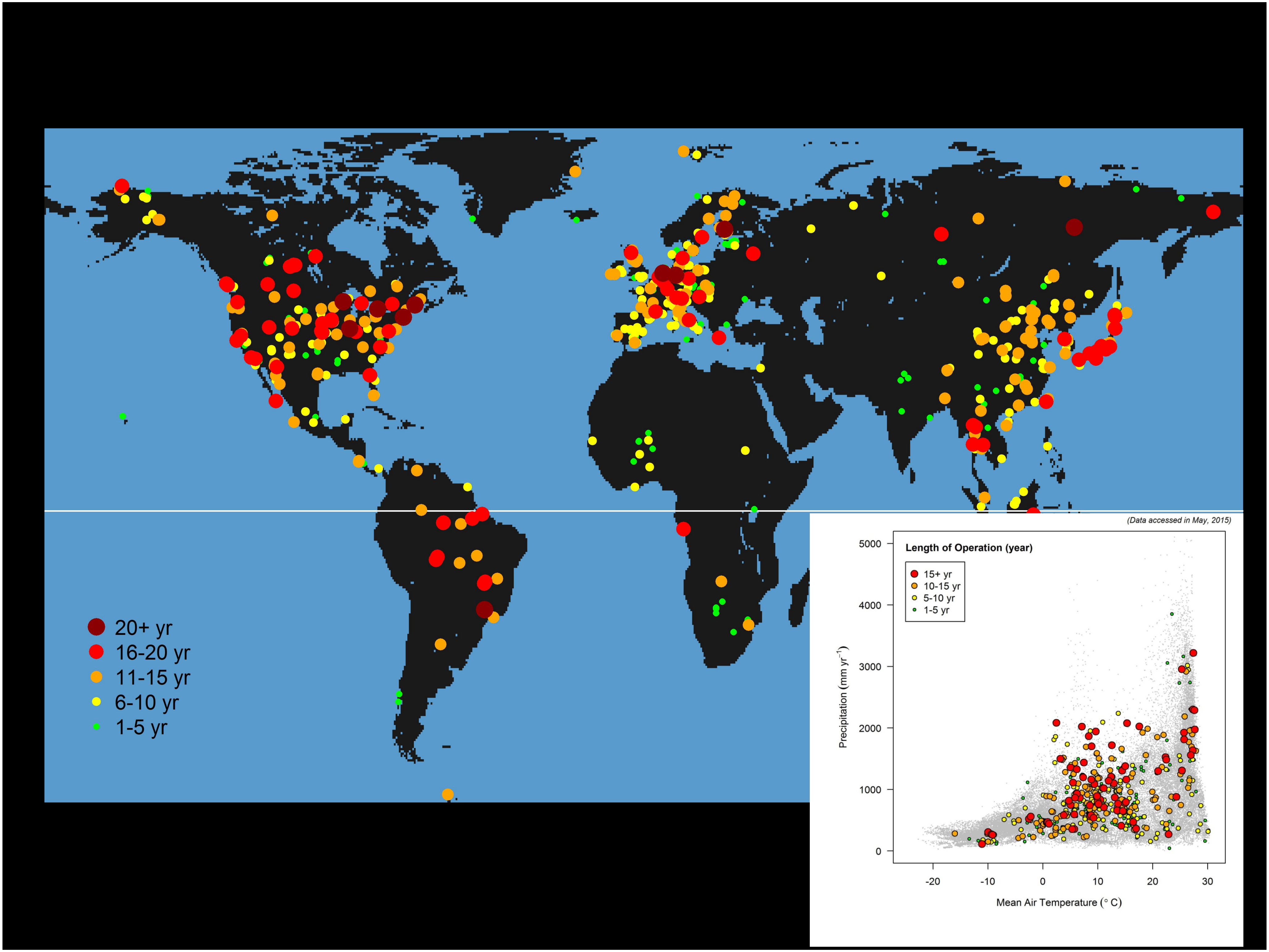
Assumption 2:

horizontal transport 0 **<-** $\int_0^h \left[\frac{1}{4L^2} \int_{-L}^{+L} \int_{-L}^{+L} \left\{ \frac{\partial \bar{u}\bar{c}}{\partial x} + \frac{\partial \overline{u'c'}}{\partial x} + \frac{\partial \bar{v}\bar{c}}{\partial y} + \frac{\partial \overline{v'c'}}{\partial y} \right\} dx\, dy \right] dz$

Assumption 3:

vertical transport $\overline{w'c'}(h)$ **<-** $\int_0^h \left[\frac{1}{4L^2} \int_{-L}^{+L} \int_{-L}^{+L} \left\{ \frac{\partial \bar{w}\bar{c}}{\partial z} + \frac{\partial \overline{w'c'}}{\partial z} \right\} dx\, dy \right] dz$

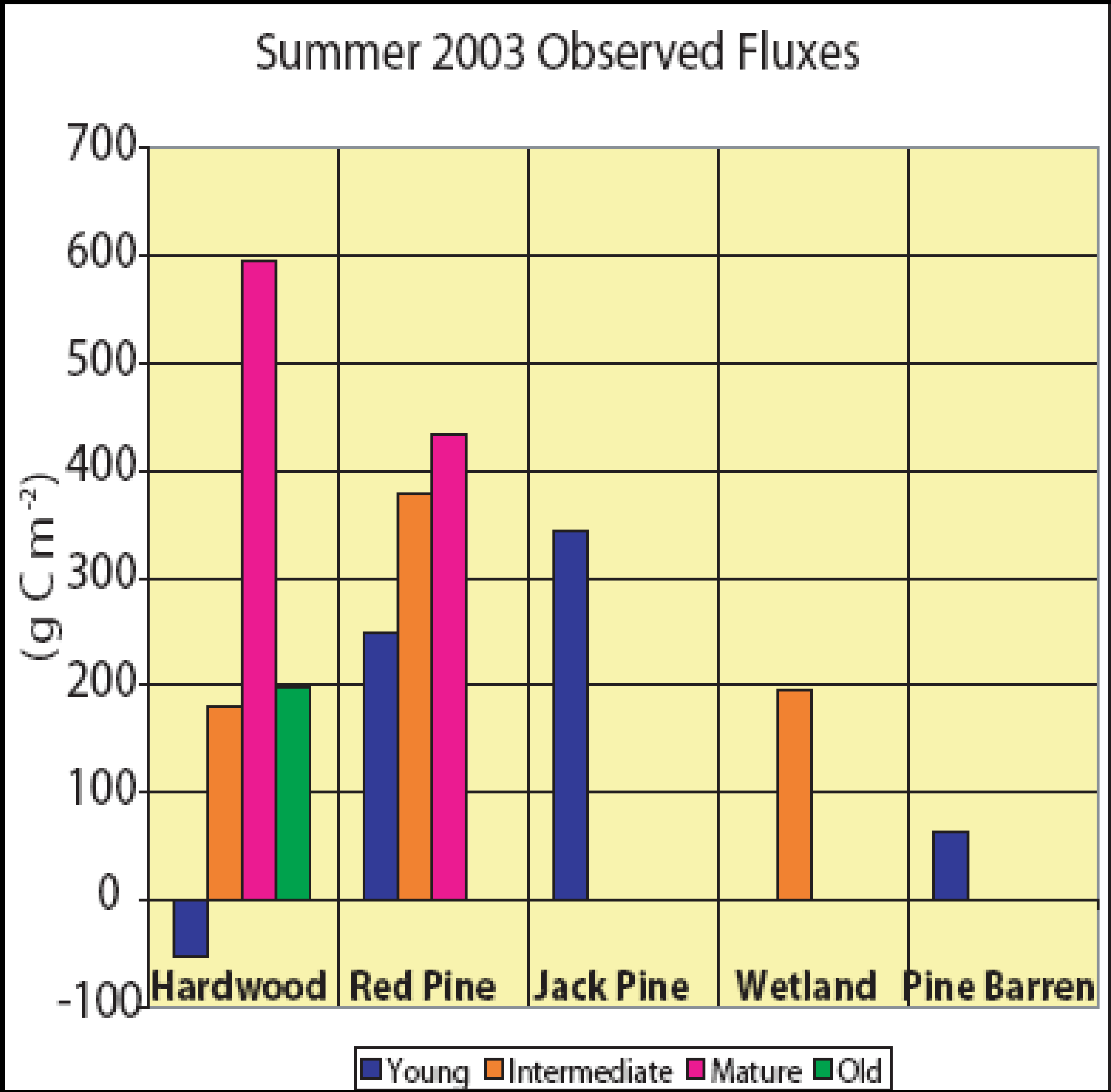
Coutesy S. Metzger, NEON



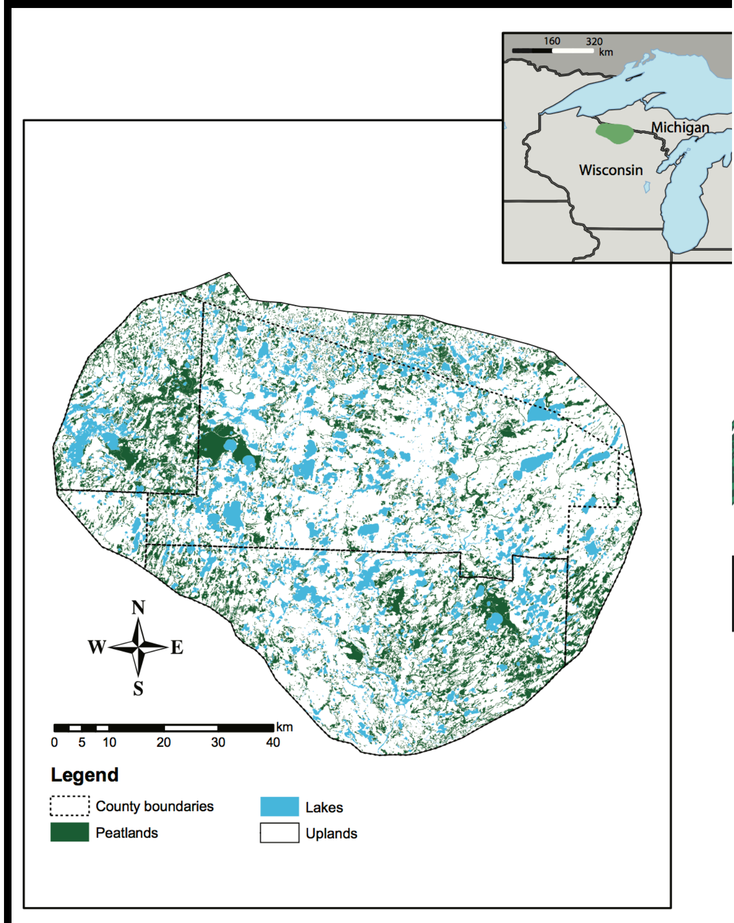
20+ yr
16-20 yr
11-15 yr
6-10 yr
1-5 yr
(Data accessed in May, 2015)
Length of Operation (year)
15+ yr
10-15 yr
5-10 yr
1-5 yr
Precipitation (mm yr^{-1})
Mean Air Temperature (° C)

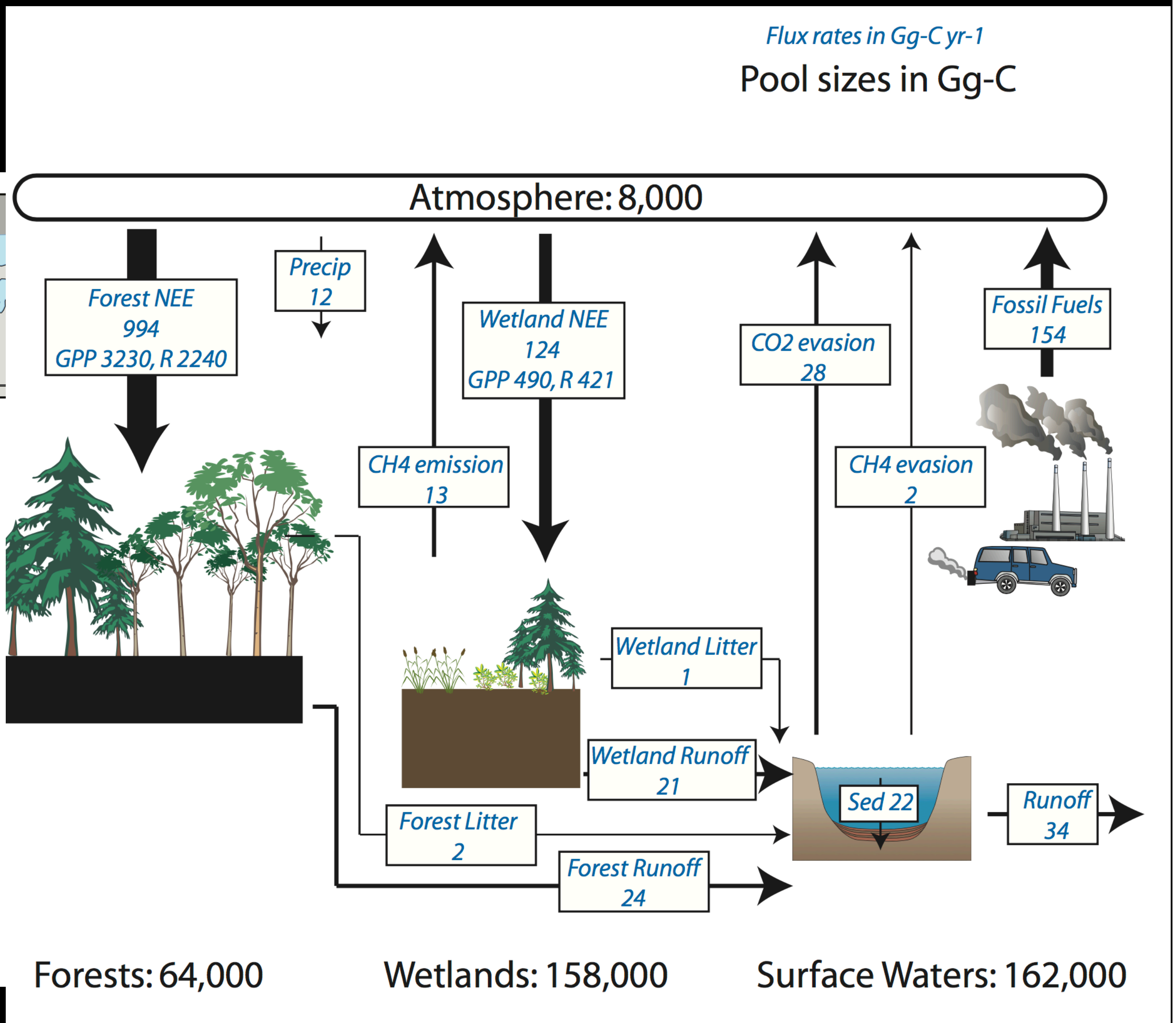
Land cover and age influences NEE

- NEP (=-NEE)
- 13 flux towers
- One summer
- Stand age matters
- Ecosystem type matters
- Desai et al, 2008, Ag For Met



Scaling (Buffam *et al*., 2010)



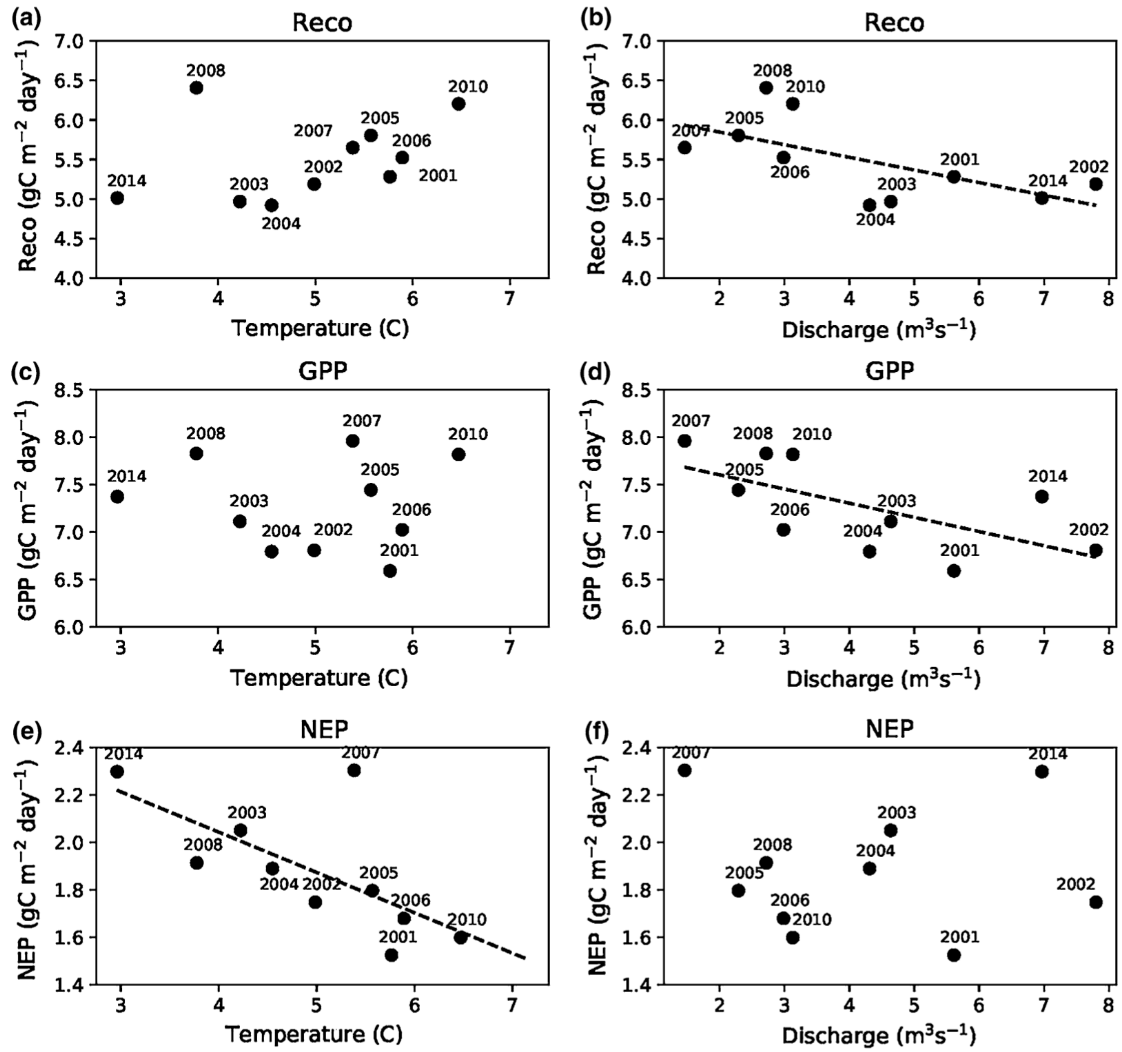


Biogeochemistry
https://doi.org/10.1007/s10533-017-0414-x

BIOGEOCHEMISTRY LETTERS

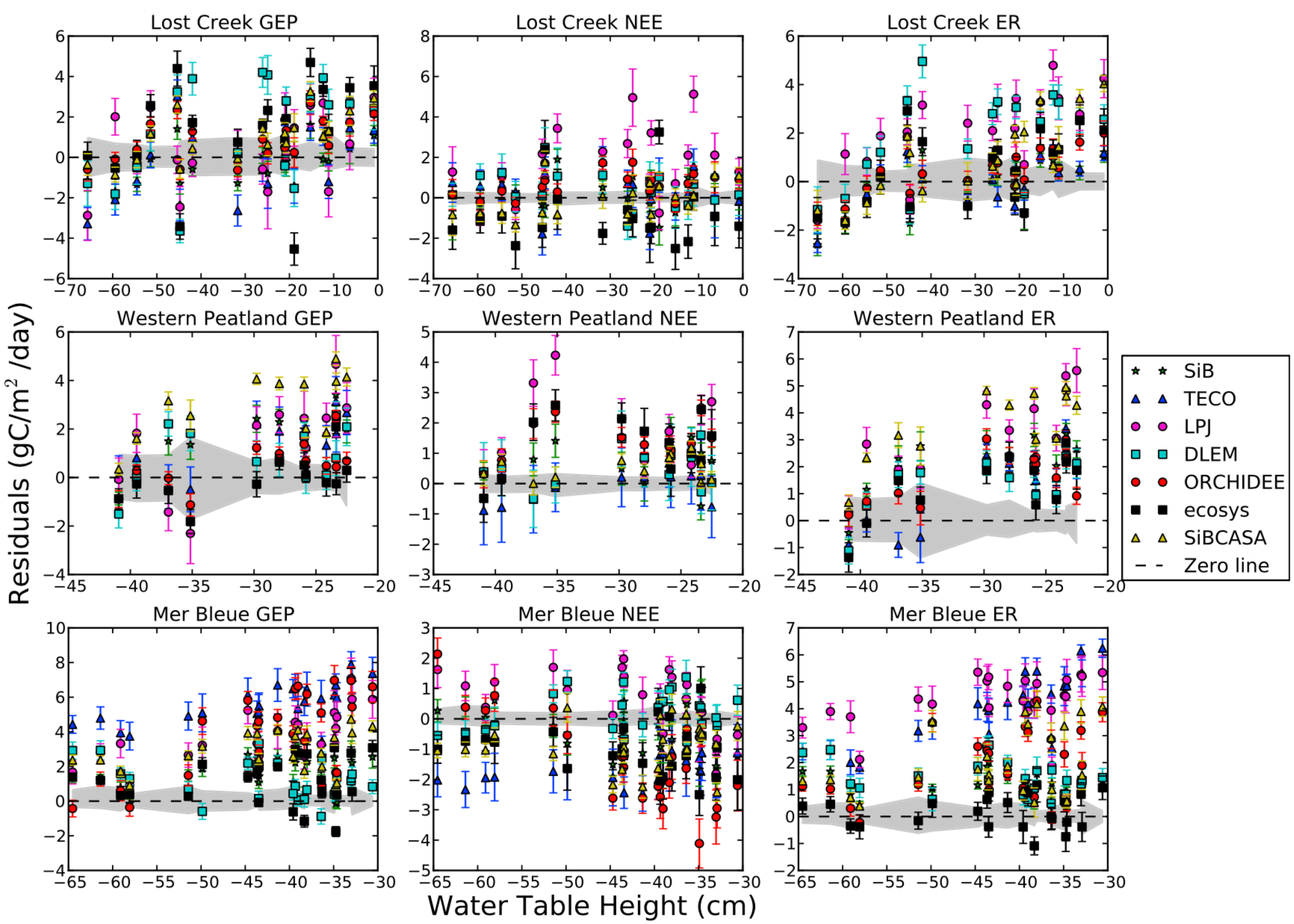
Wetland flux controls: how does interacting water table levels and temperature influence carbon dioxide and methane fluxes in northern Wisconsin?

Ca



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

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



Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2016-36, 2016
Manuscript under review for journal Earth Syst. Sci. Data
Published: 23 August 2016

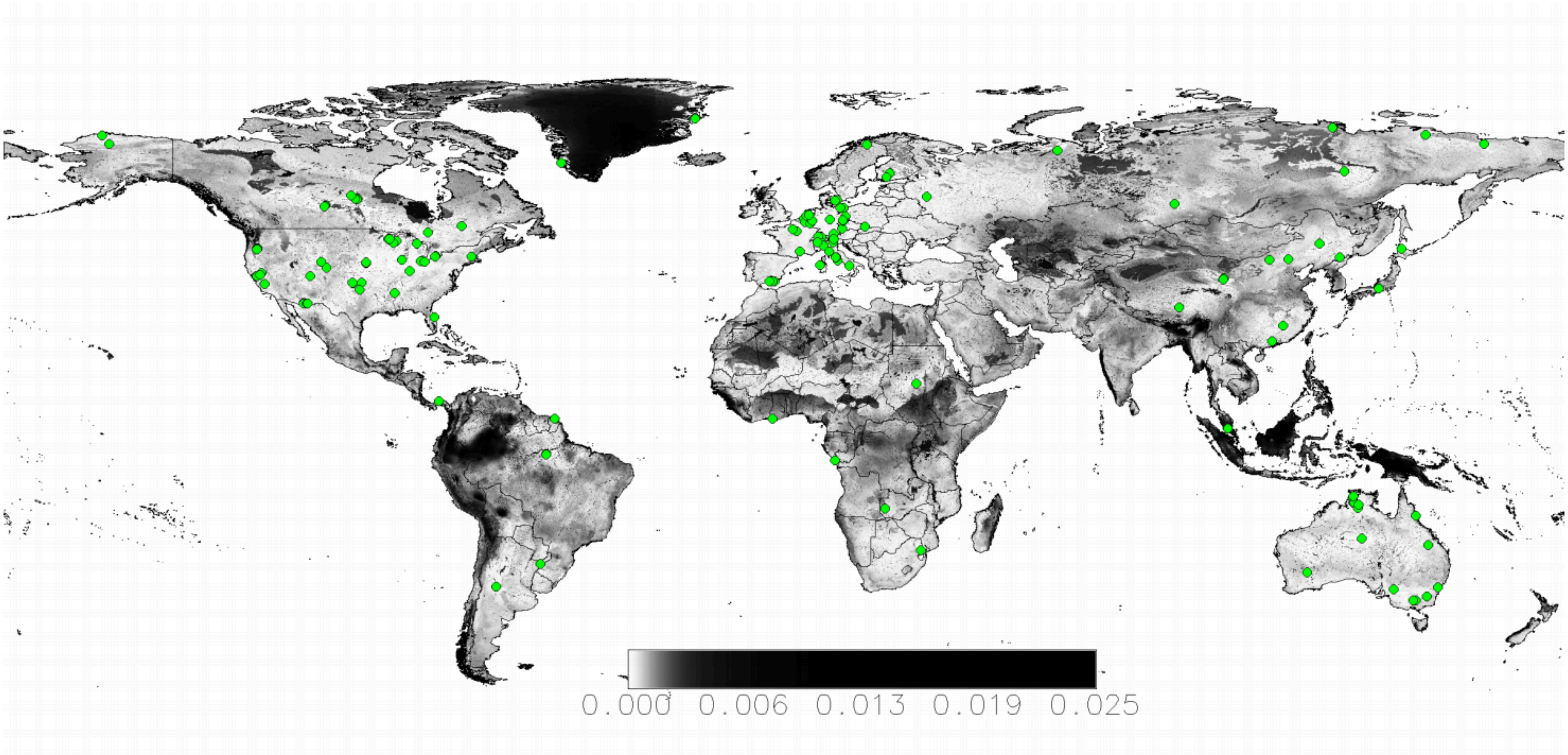


Figure 4. Network representativeness for all of the FLUXNET2015 sites (164 sites).

Global Change Biology (2011) **17**, 798–818, doi: 10.1111/j.1365-2486.2010.02279.x

Global and regional importance of the tropical peatland carbon pool

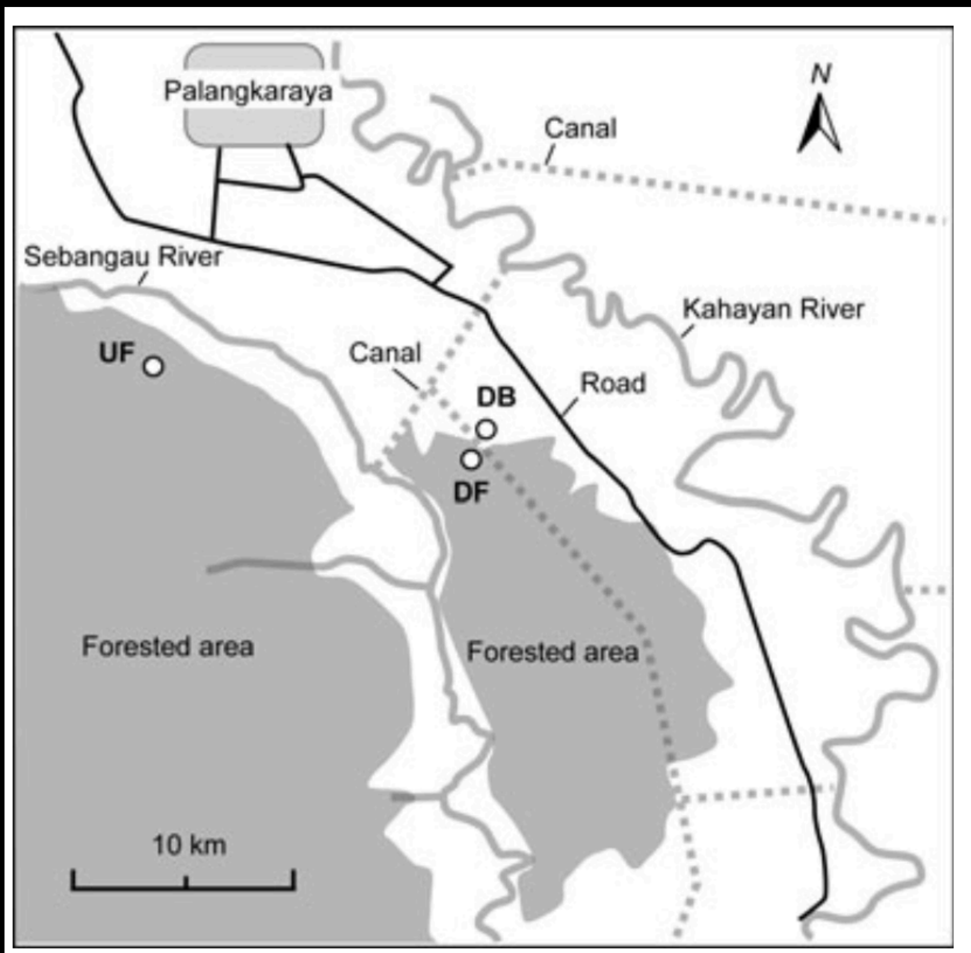
SUSAN E. PAGE*, JOHN O. RIELEY† and CHRISTOPHER J. BANKS*[1]
**Department of Geography, University of Leicester, University Road, Leicester LE1 7RH, UK, †School of Geography, The University of Nottingham, University Park, Nottingham NG7 2RD, UK*

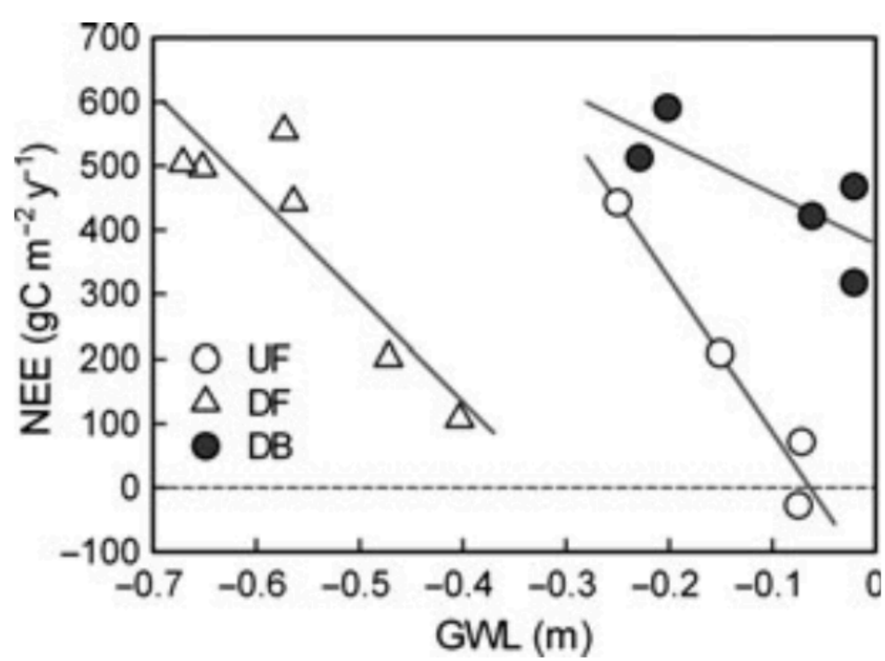
- Best estimate of 88.6 Gt (range 81.7–91.9 Gt) equal to 15–19% of the global peat carbon pool. Of this, 68.5 Gt (77%) is in Southeast Asia, equal to 11–14% of global peat carbon. A single country, Indonesia, has the largest share of tropical peat carbon (57.4 Gt, 65%), followed by Malaysia (9.1 Gt, 10%).

Global Change Biology (2012) **18**, 3410–3422, doi: 10.1111/j.1365-2486.2012.02793.x

Effects of disturbances on the carbon balance of tropical peat swamp forests

TAKASHI HIRANO*, HENDRIK SEGAH†, KITSO KUSIN‡, SUWIDO LIMIN‡, HIDENORI TAKAHASHI§ and MITSURU OSAKI*

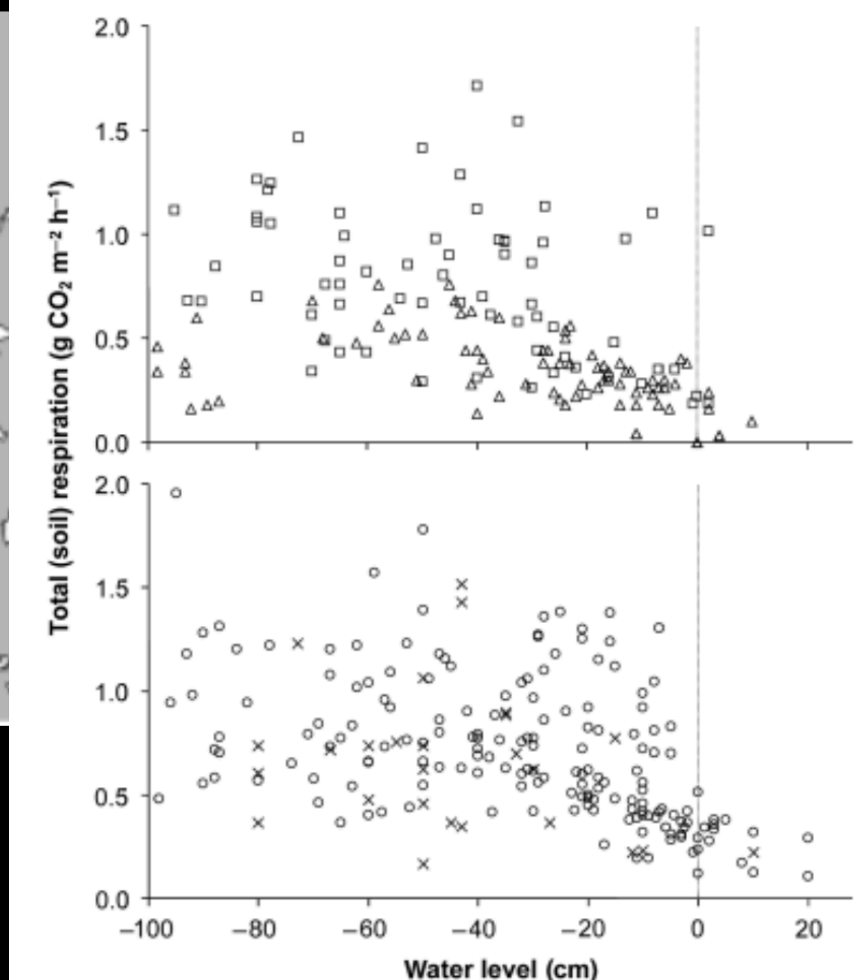




Global Change Biology (2010) **16**, 1715–1732, doi: 10.1111/j.1365-2486.2009.02016.x

Greenhouse gas fluxes from tropical peatlands in south-east Asia

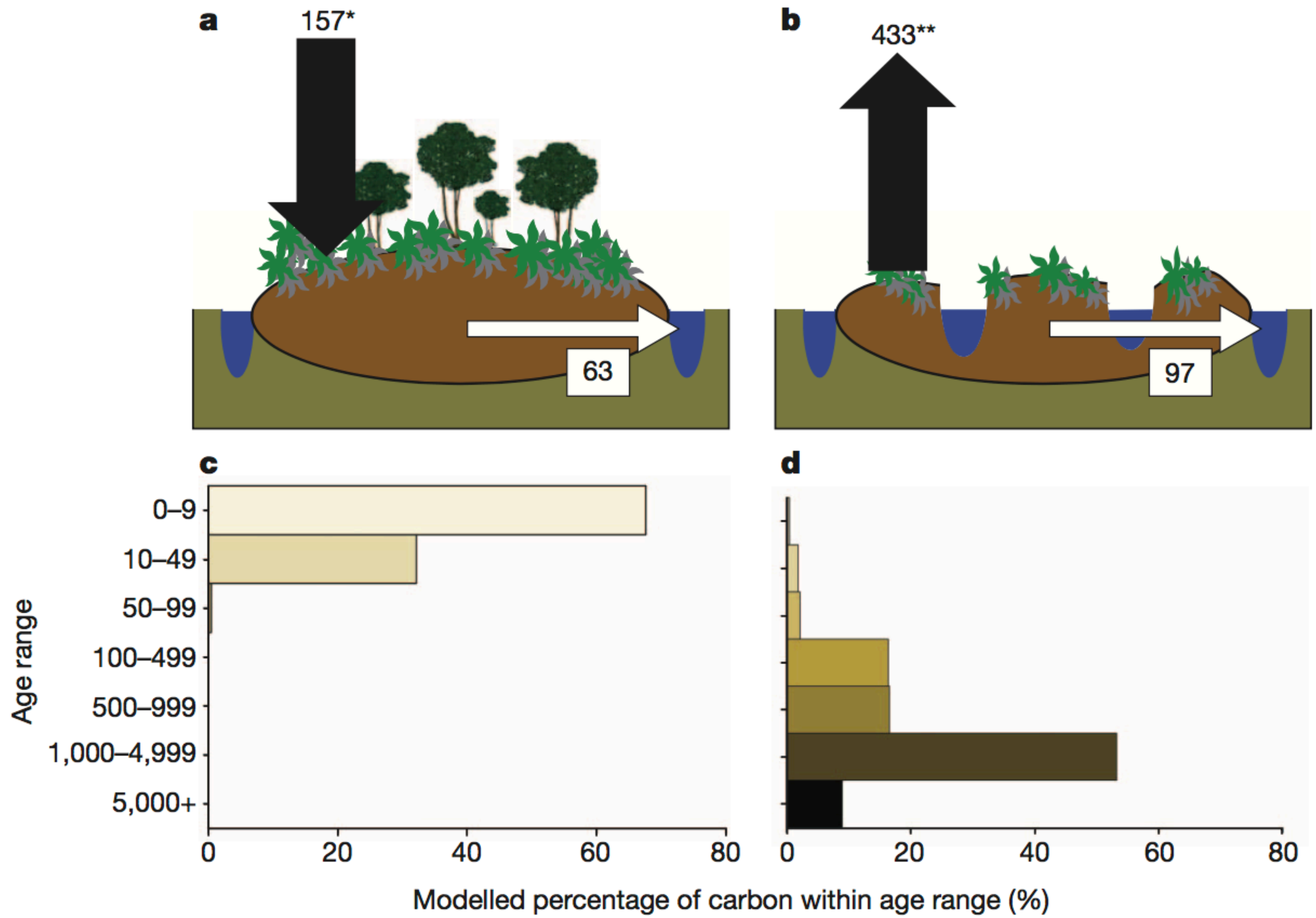
JOHN COUWENBERG, RENÉ DOMMAIN and HANS JOOSTEN



Physical controls on CH_4 emissions from a newly flooded subtropical freshwater hydroelectric reservoir: Nam Theun 2

C. Deshmukh[1,2,*], D. Serça[1], C. Delon[1], R. Tardif[3], M. Demarty[4], C. Jarnot[1], Y. Meyerfeld[1], V. Chanudet[5], P. Guédant[3], W. Rode[3], S. Descloux[5], and F. Guérin[6,7]

LETTER

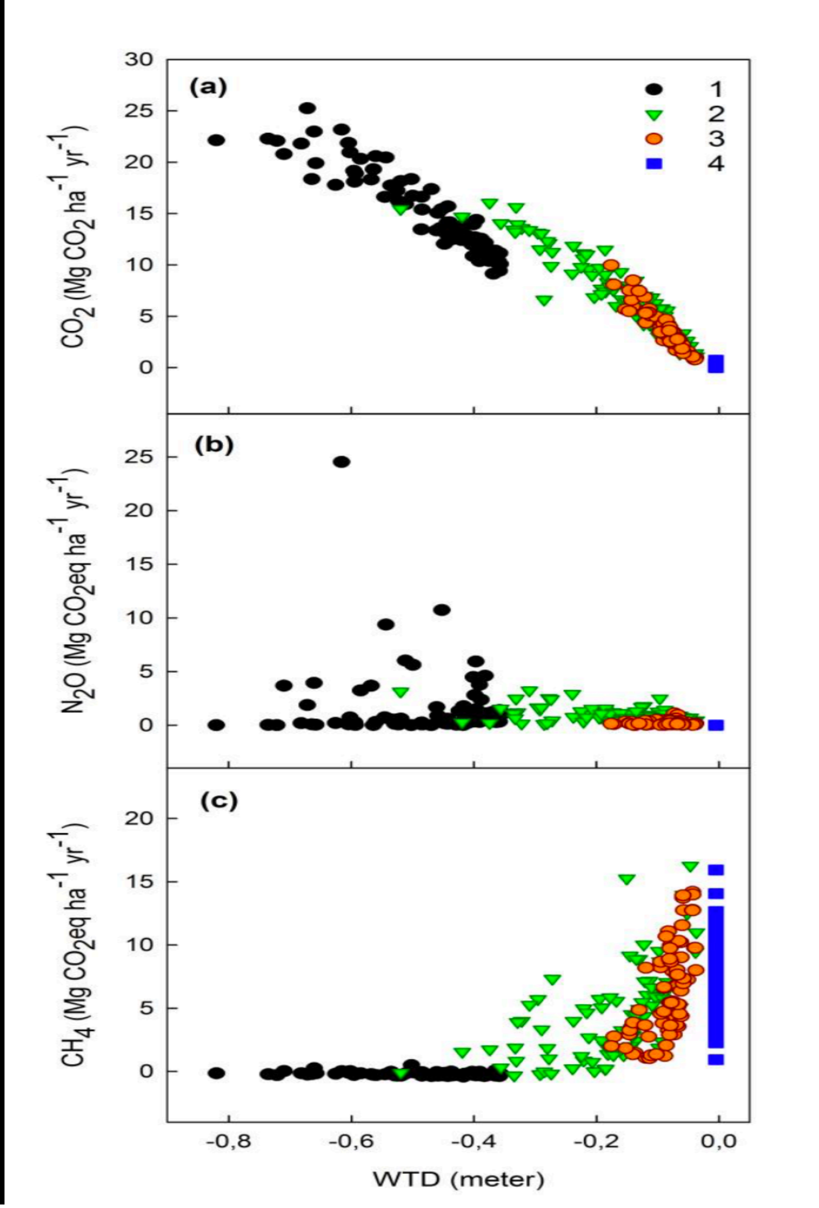


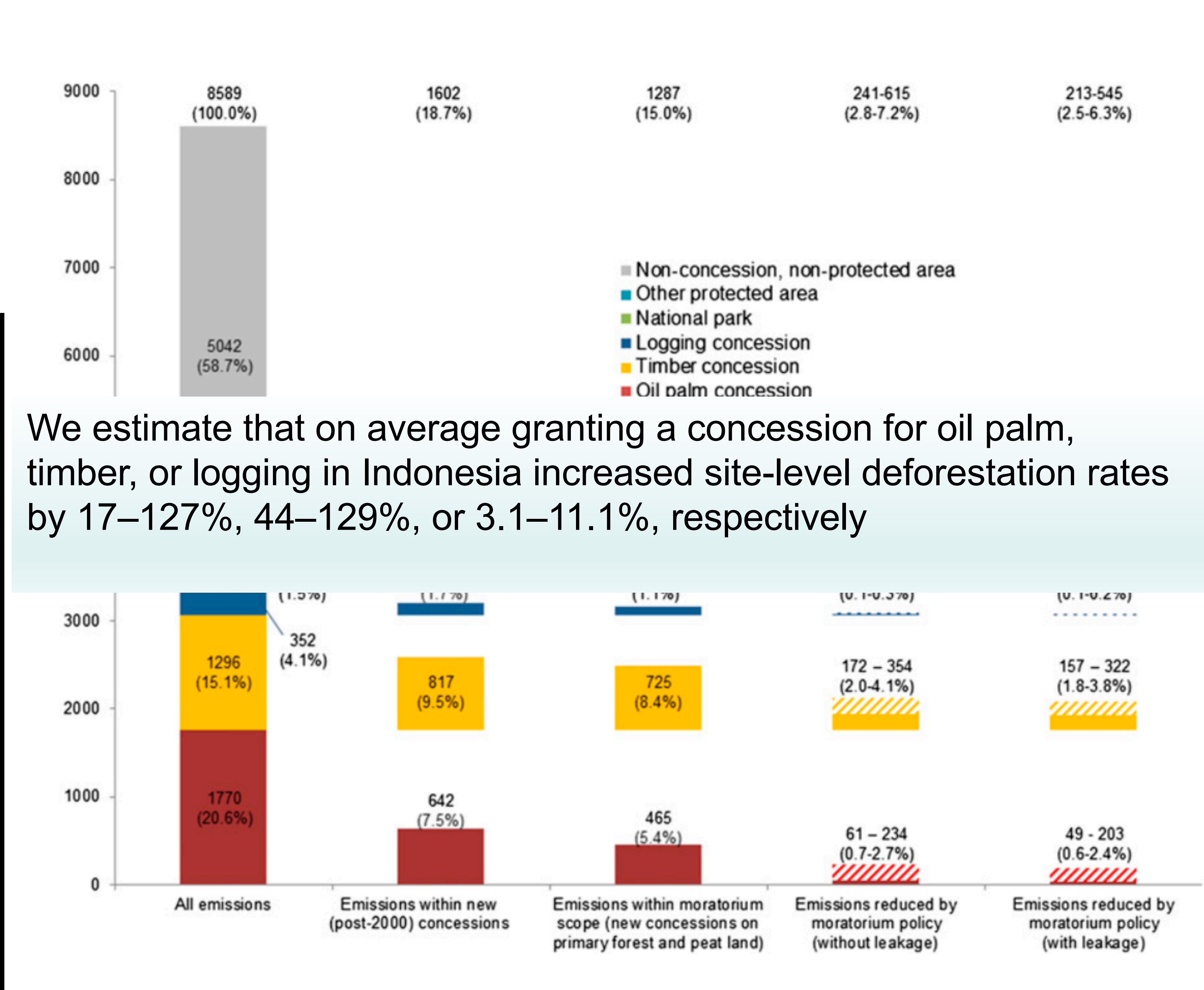
Land use of drained peatlands: greenhouse gas fluxes, plant production, and economics

Kasimir et al 2017, GCB

1 = Norway spruce
2 = Willow
3= Reed canary
4 = Peatland

Saving peat and avoiding methane release using fairly wet conditions can significantly reduce GHG emissions, and this strategy should be considered for land use planning and policy-making.

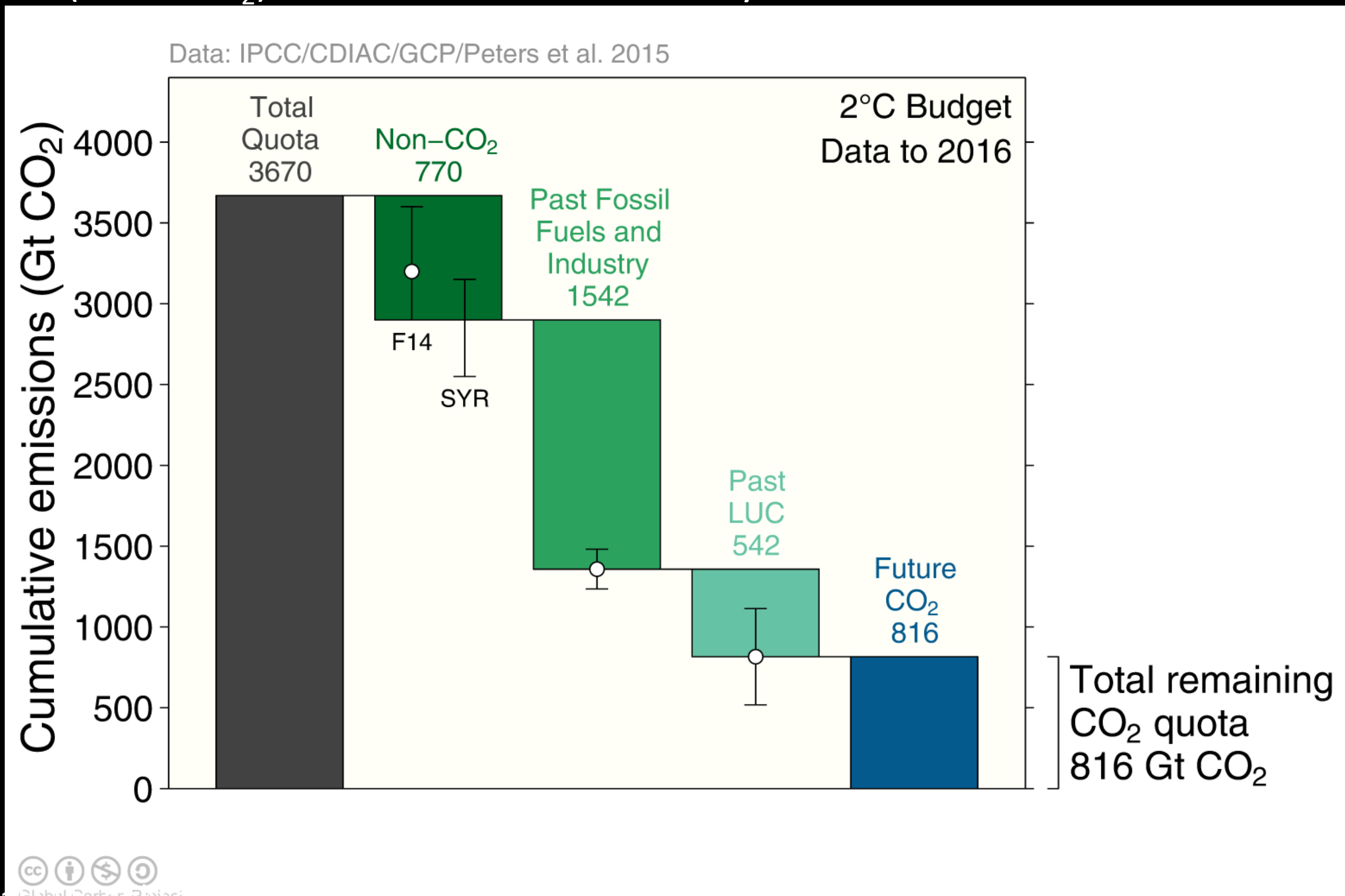




We estimate that on average granting a concession for oil palm, timber, or logging in Indonesia increased site-level deforestation rates by 17–127%, 44–129%, or 3.1–11.1%, respectively

Carbon quota for a 66% chance to keep below 2° C

The total remaining emissions from 2017 to keep global average temperature below 2° C ($800GtCO_2$) will be used in around 20 years at current emission rates



Grey: Total CO_2 only quota for 2° C with 66% chance. Green: Removed from CO_2 only quota. Blue: Remaining CO_2 quota.

The remaining quotas are indicative and vary depending on definition and methodology

Source: Peters et al 2015; Global Carbon Budget 2016

What do you need?

- Making a flux measurement is one thing
- Getting useful science out of it is another
  - Quality control / representation / gap-filling
  - Ancillary data: water table, peat depth, C export, microclimate, vegetation biomass, management history of site, remotely sensed phsyiology
  - Testable hypotheses, relying on space for time substitution, evaluated with ecosystem models
- Our lab has a track record in much of the above, and students/post-docs in my lab have potential to advance this work

Questions?

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+1-608-520-0305, http://flux.aos.wisc.edu

Funding:
NSF, DOE Ameriflux, NASA
APRIL Group