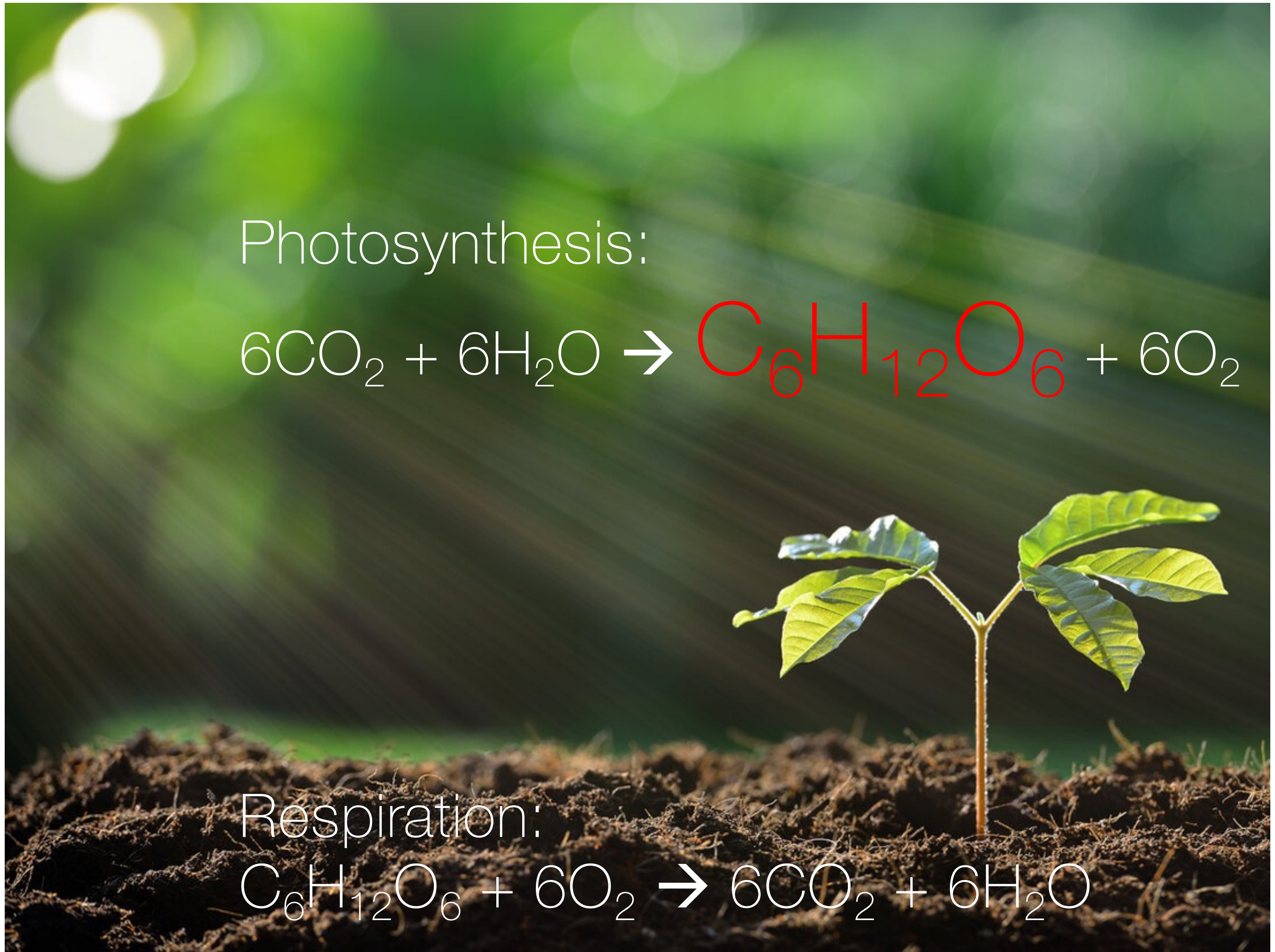
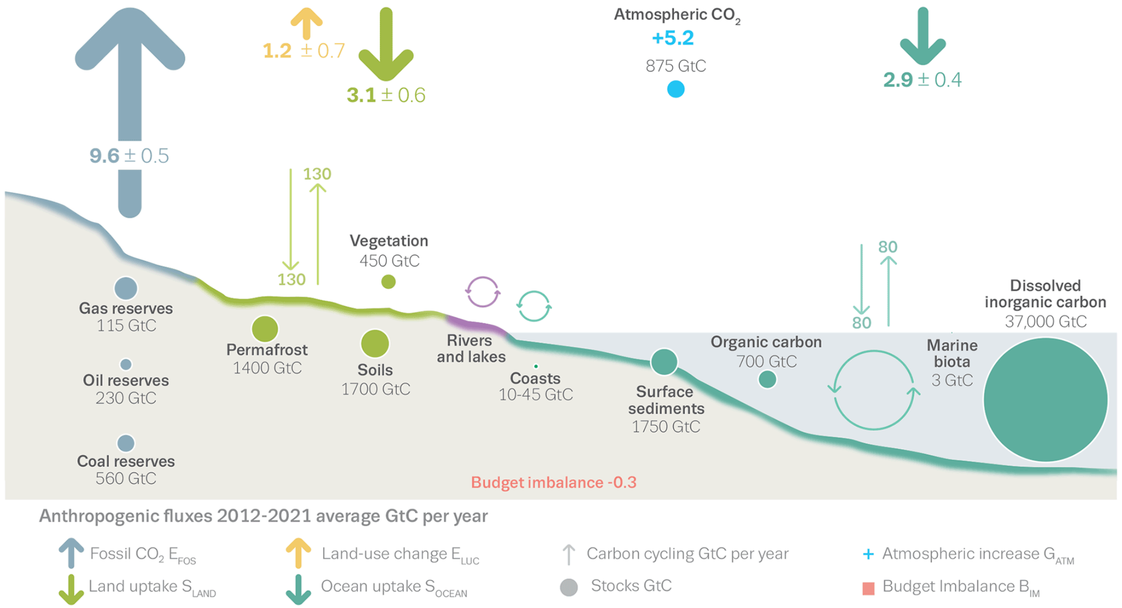
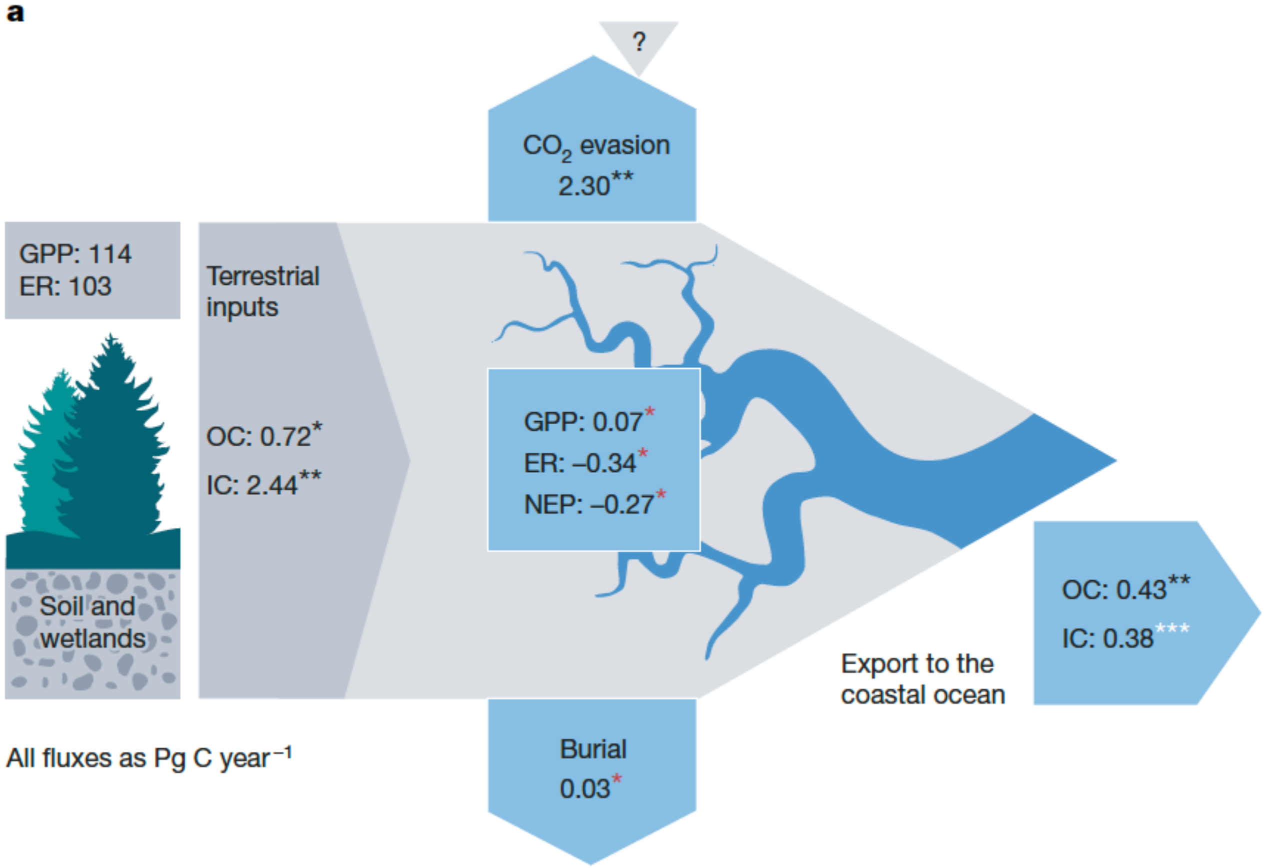
Global change ecology and fluvial ecosystems

Biogeochemistry

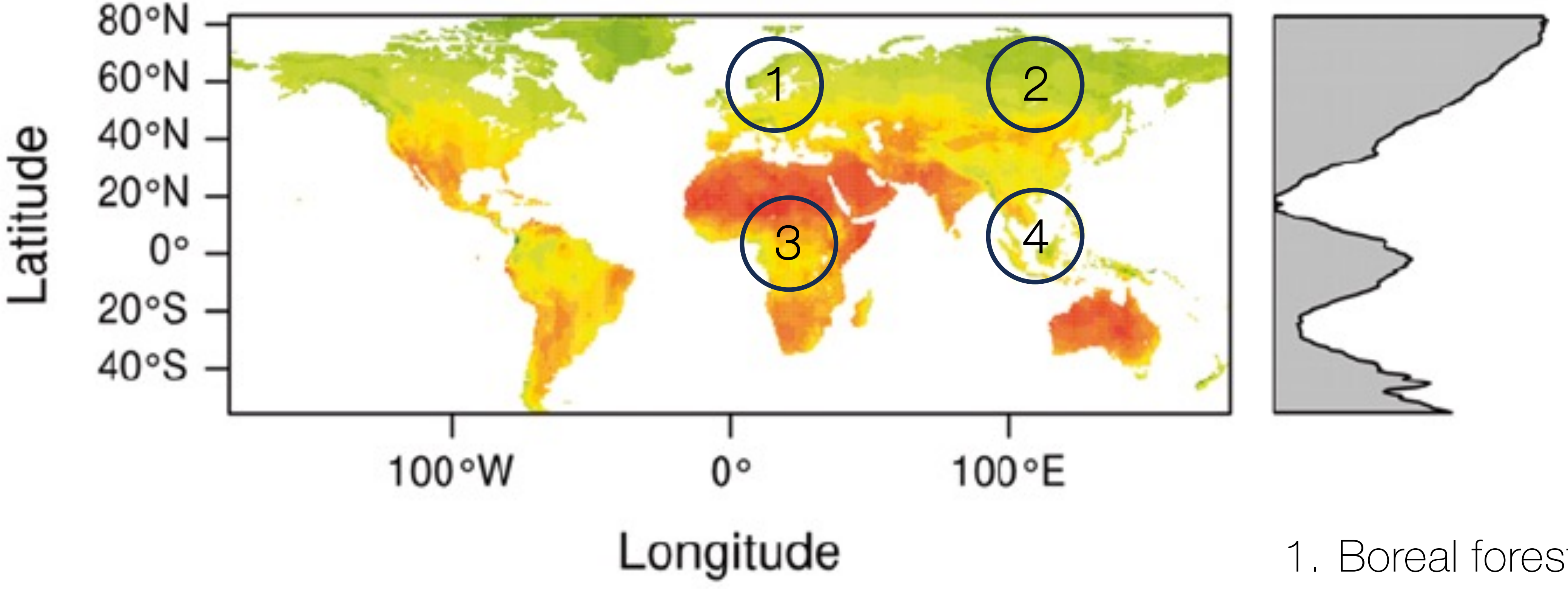


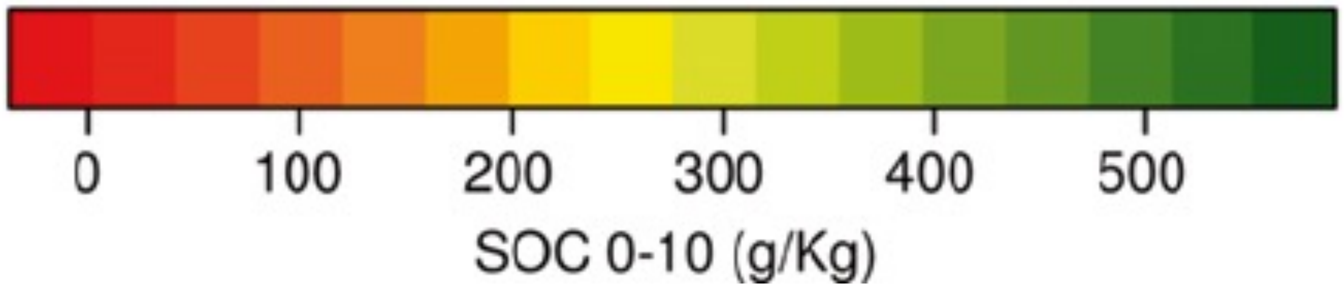
The global carbon cycle





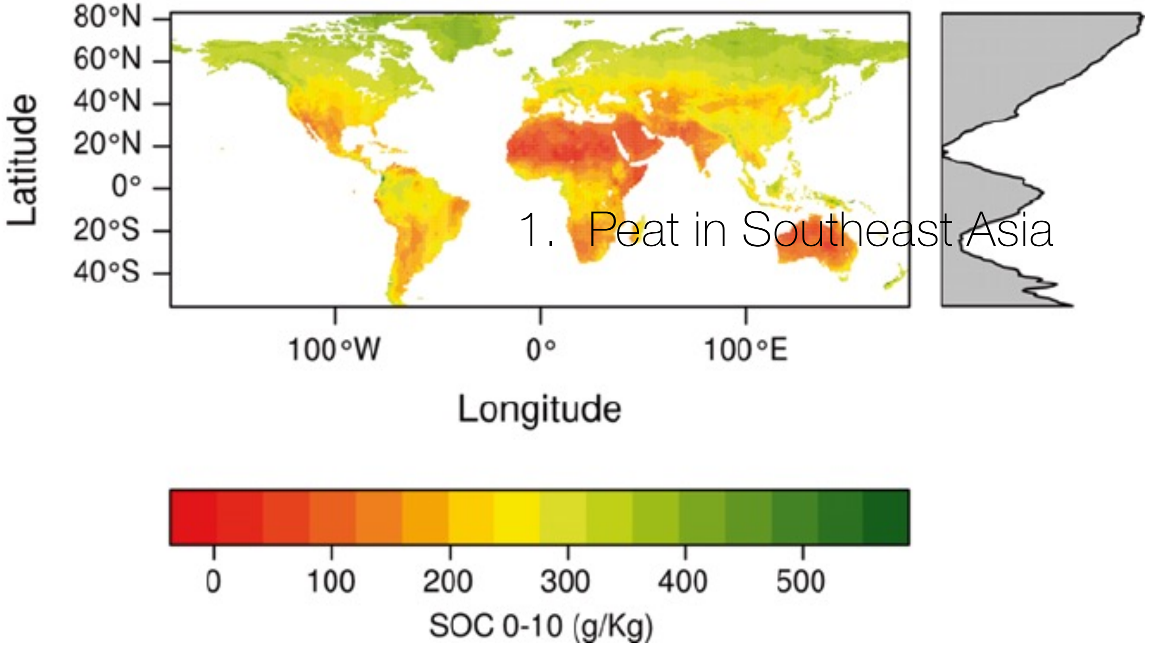
Global distribution of soil organic carbon (SOC)



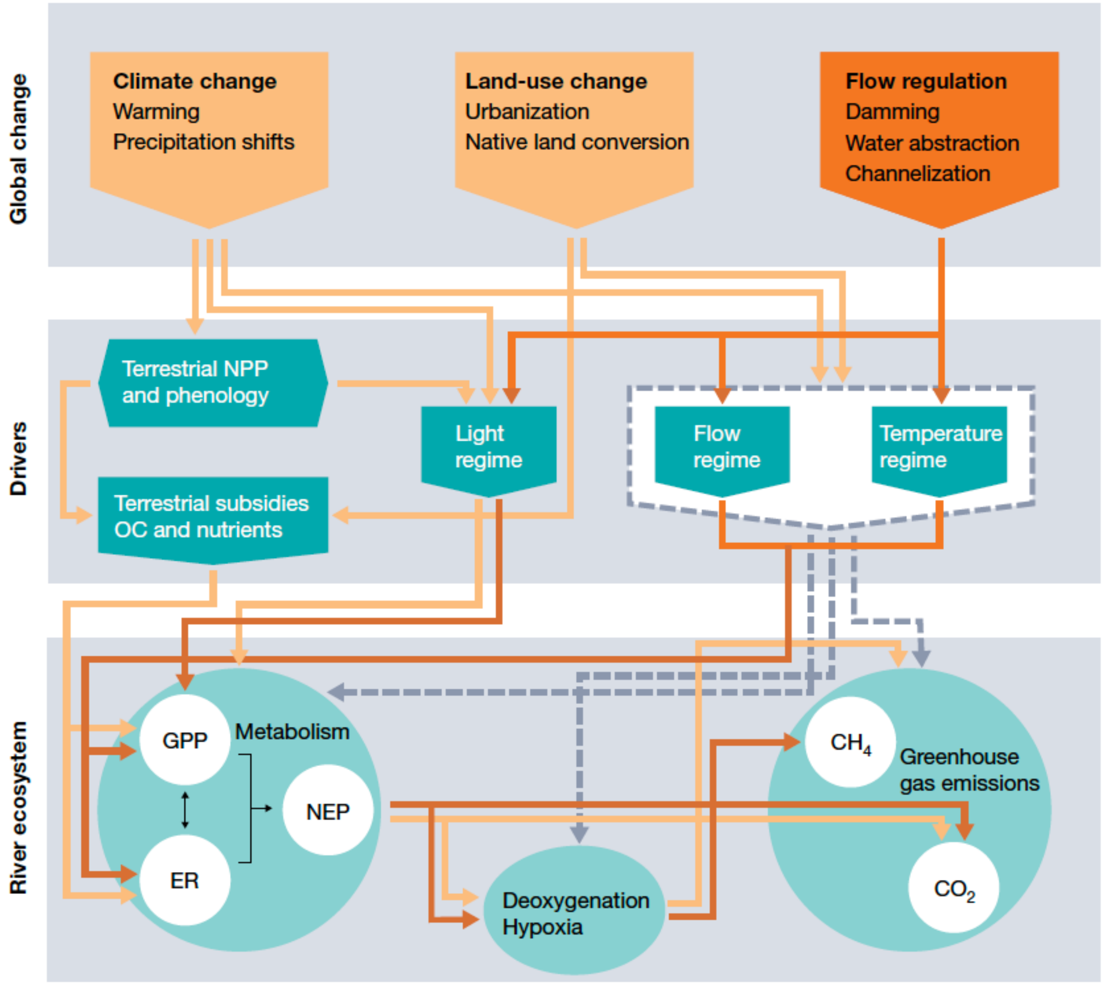


1. Boreal forests in Scandinavia
2. Permafrost in Siberia
3. Peat in Southeast Asia
4. Soils in the Congo basin

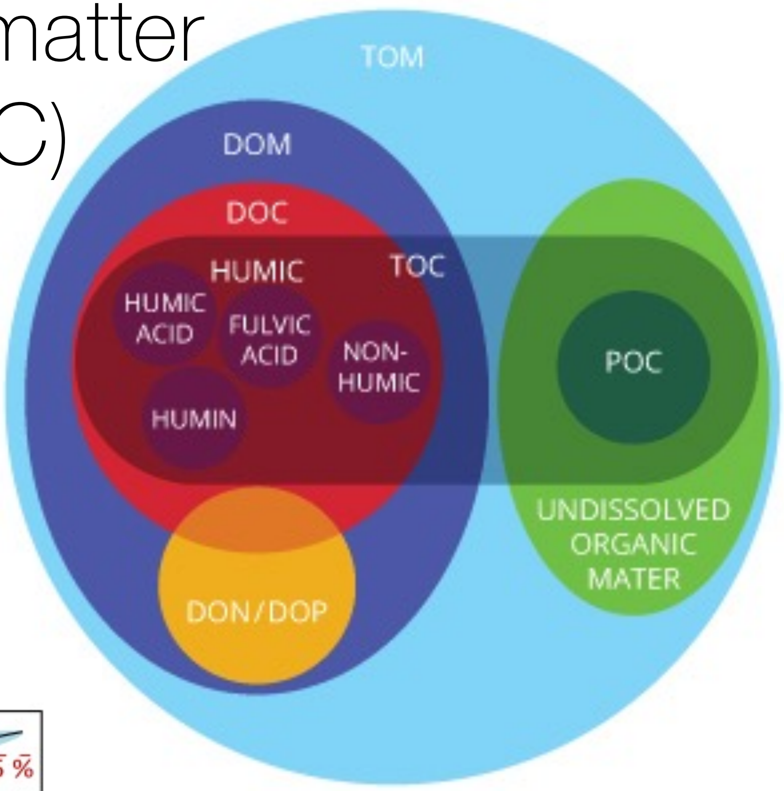
Understanding the links between global change and biogeochemistry across ecosystems



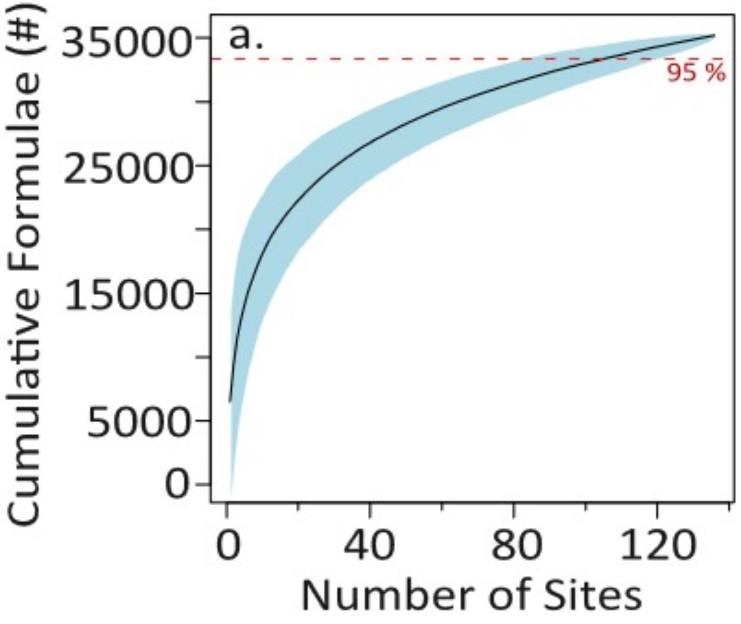
1. Peat in Southeast Asia



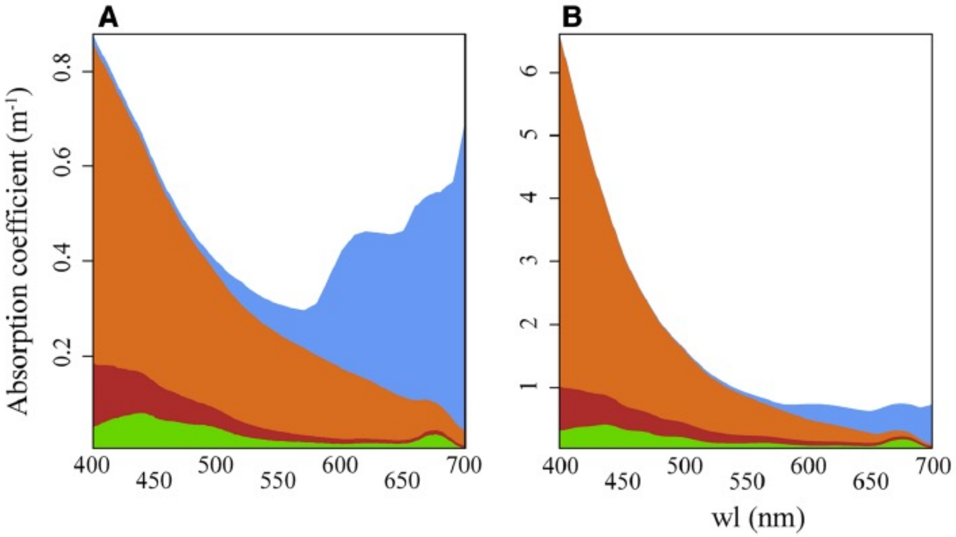
Dissolved organic matter (more than just DOC)



Highly diverse molecular composition (glacier-fed streams)

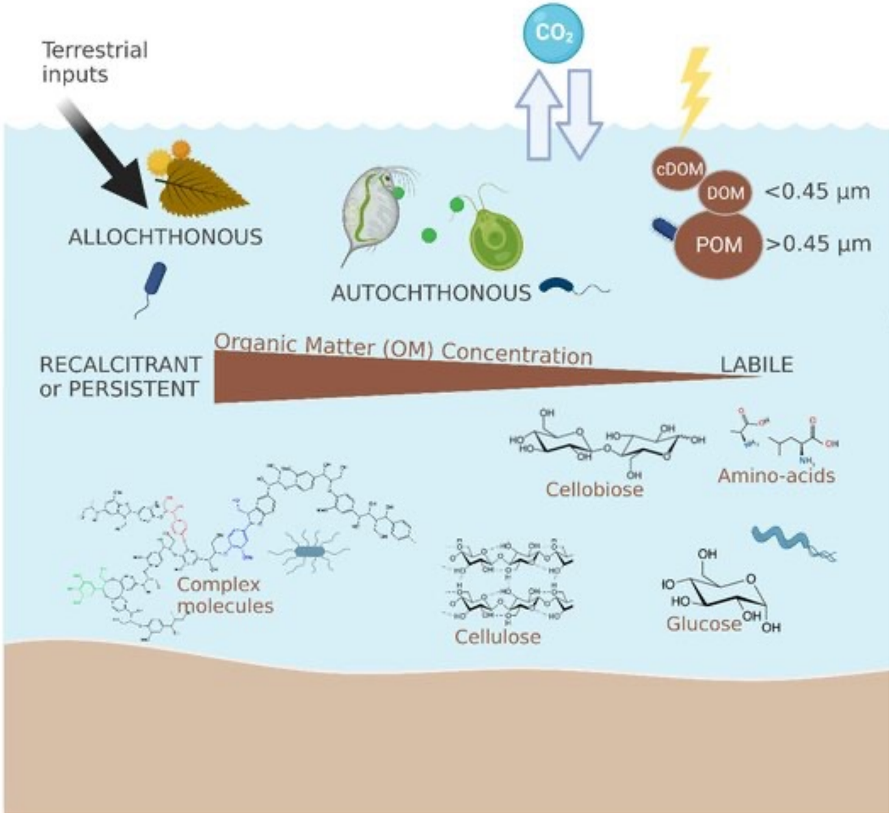


Chromophoric DOM (humics and fulvics)



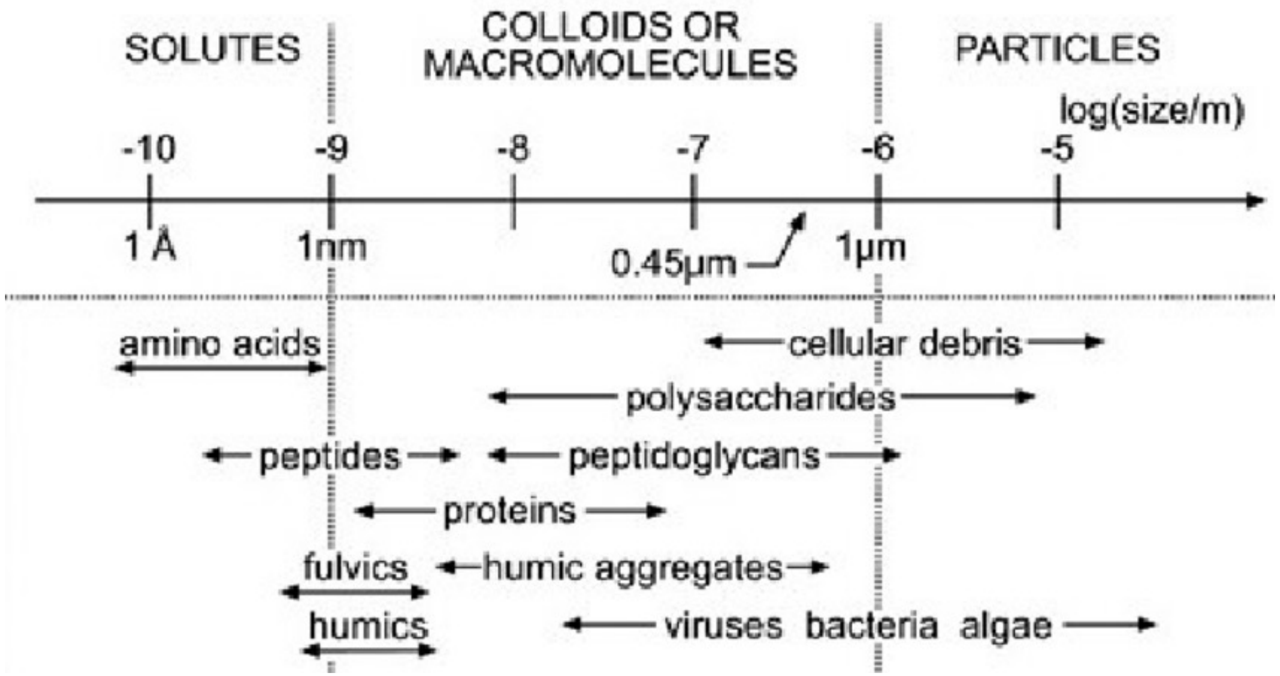
Each colored area represents the absorption spectrum of phytoplankton: green, non-algal particles: dark brown, Chromophoric DOM: light brown, and water: blue

Dissolved organic matter (more than just DOC)



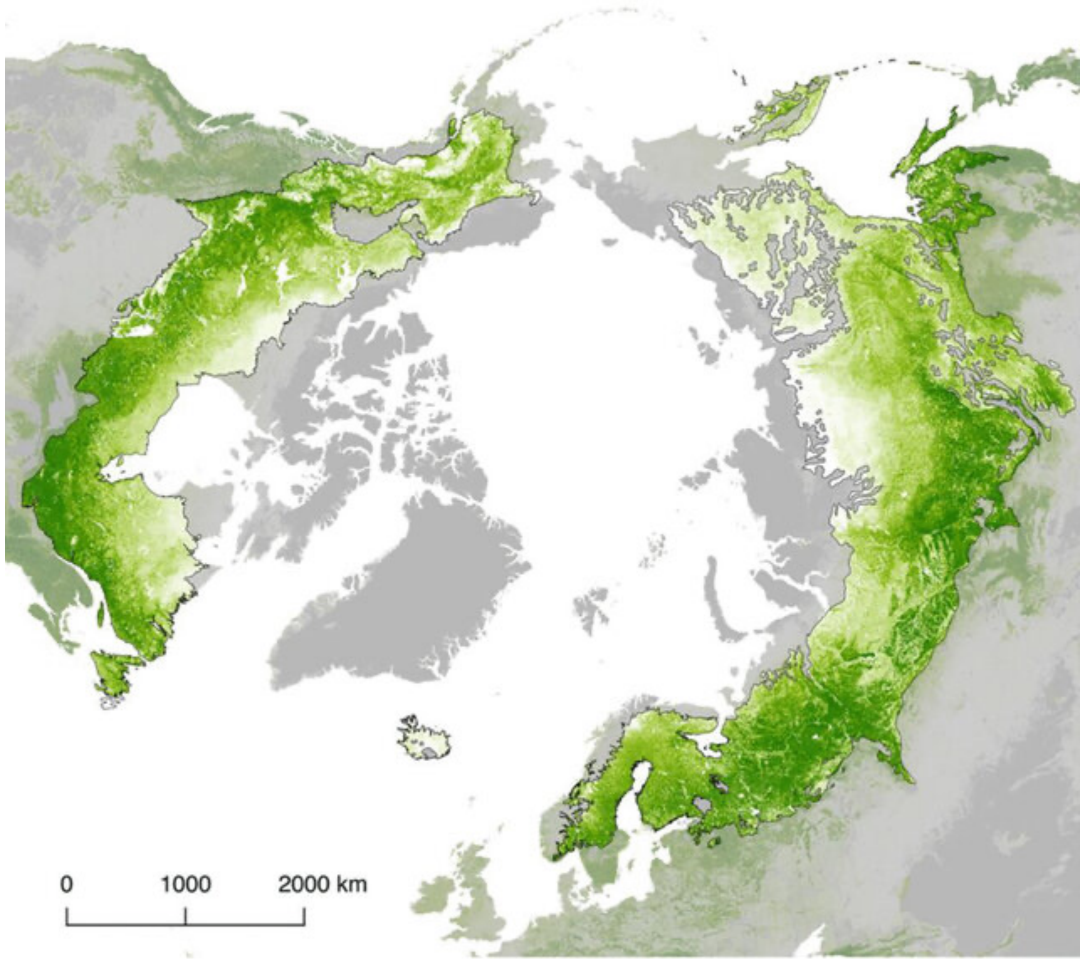
DOM: The major intermediary to the carbon cycle

- Chemistry (elemental composition)
- Light absorption
- Size (degree of polymerisation)
- Bioavailability (labile or persistent)



Boreal forests and fish populations in the Atlantic Ocean?

Terrestrial greening and aquatic browning



Greening of the boreal landscape

- Large amounts of soil organic carbon mobilized and entering streams and rivers
- Humic and fulvic acids (degradation product of vascular plant material) induce browning of surface waters
- Increases in water DOC concentration

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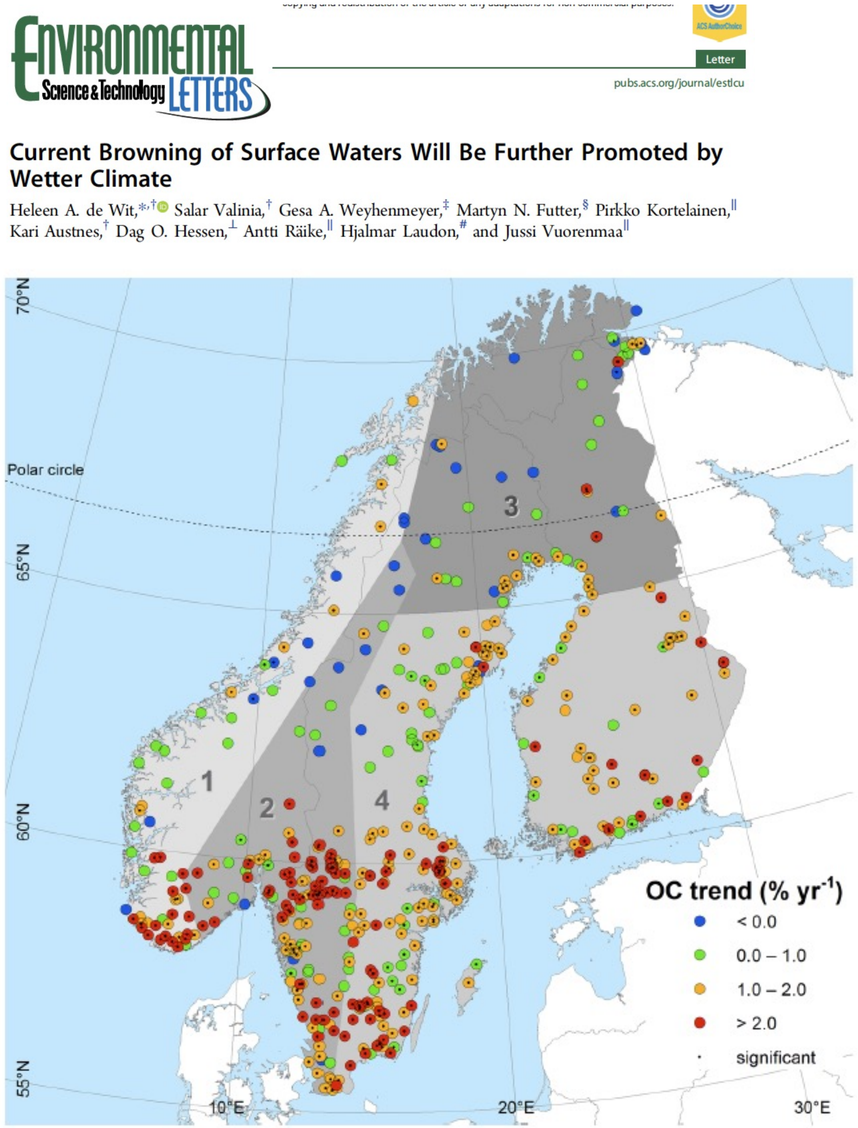
Increasing DOC concentrations in boreal freshwaters

- Interactive effects of climate , land use and acid deposition
- Increasing pool sizes (fertilization effect), mobilisation (reduced retention) and transport (increased precipitation)

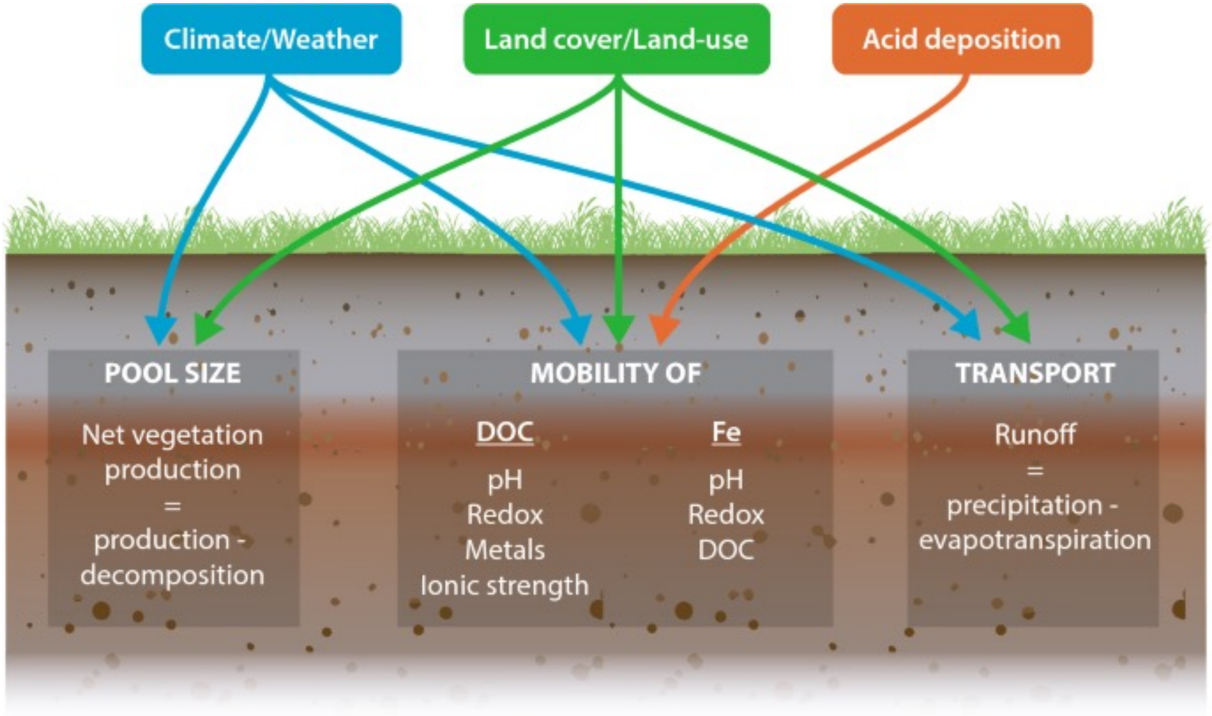

Environmental Science & Technology Letters

Letter

pubs.acs.org/journal/estlcu

Current Browning of Surface Waters Will Be Further Promoted by Wetter Climate

Heleen A. de Wit,*,† Salar Valinia,† Gesa A. Weyhenmeyer,‡ Martyn N. Futter,§ Pirkko Kortelainen,‖ Kari Austnes,† Dag O. Hessen,⊥ Antti Räike,‖ Hjalmar Laudon,# and Jussi Vuorenmaa‖



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Terrestrial greening and aquatic browning and light attenuation

LIMNOLOGY AND OCEANOGRAPHY
Letters
ASLO
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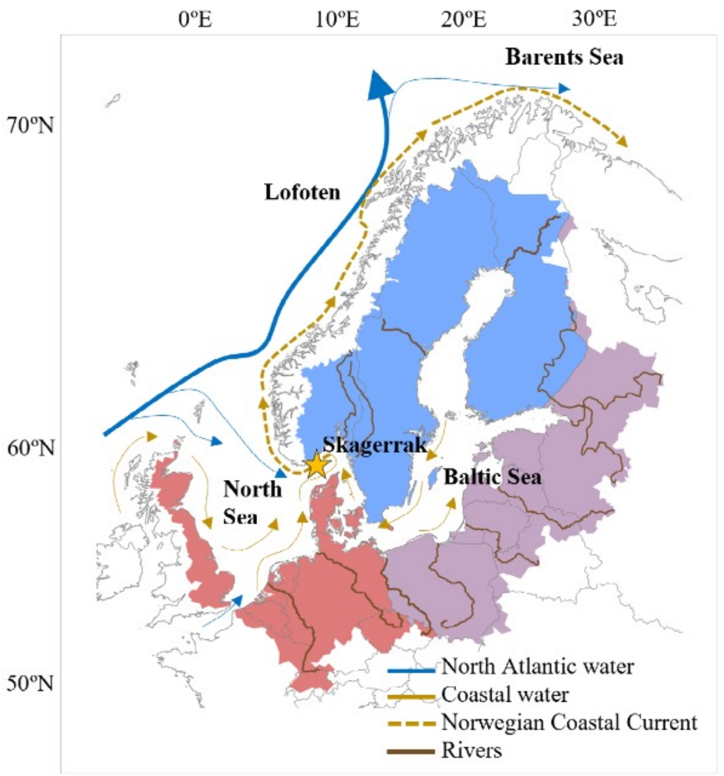
Limnology and Oceanography Letters 8, 2023, 611–619

doi: 10.1002/lol2.10320

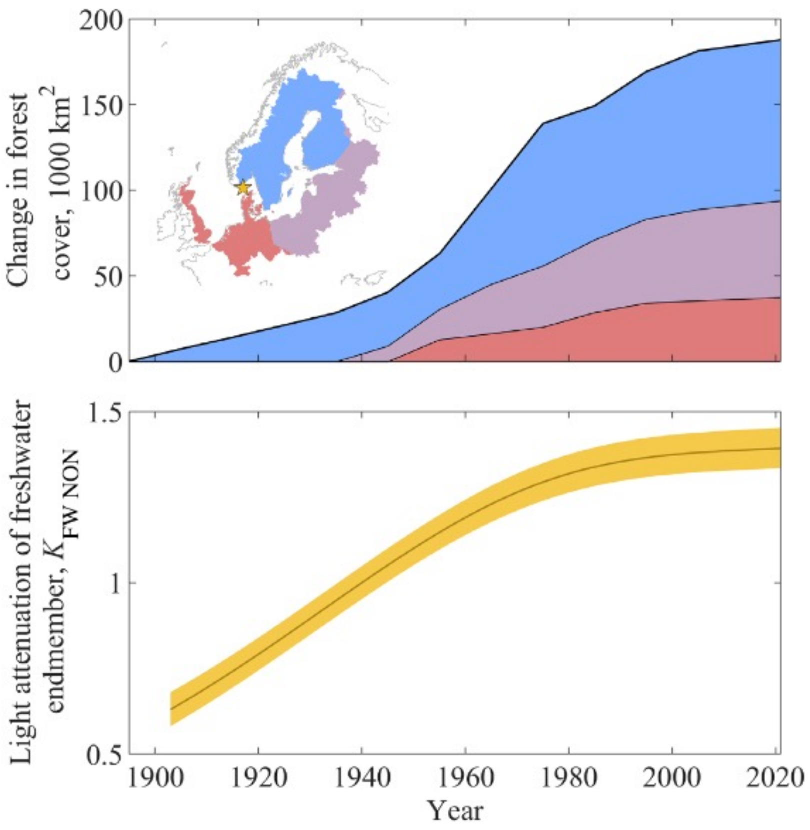
LETTER

Tracking freshwater browning and coastal water darkening from boreal forests to the Arctic Ocean

Anders Frugård Opdal,[1] Tom Andersen,[2] Dag O. Hessen,[2] Christian Lindemann,[1] Dag L. Aksnes[1]*
[1]Department of Biological Sciences, University of Bergen, Bergen, Norway; [2]Department of Biosciences, University of Oslo, Oslo, Norway



Overview of drainage area, major rivers, water masses and currents. Drainage areas to the Skagerrak, Baltic Sea and North Sea are divided into Fennoscandia (blue), North-eastern Europe (purple), and North-western Europe (red).



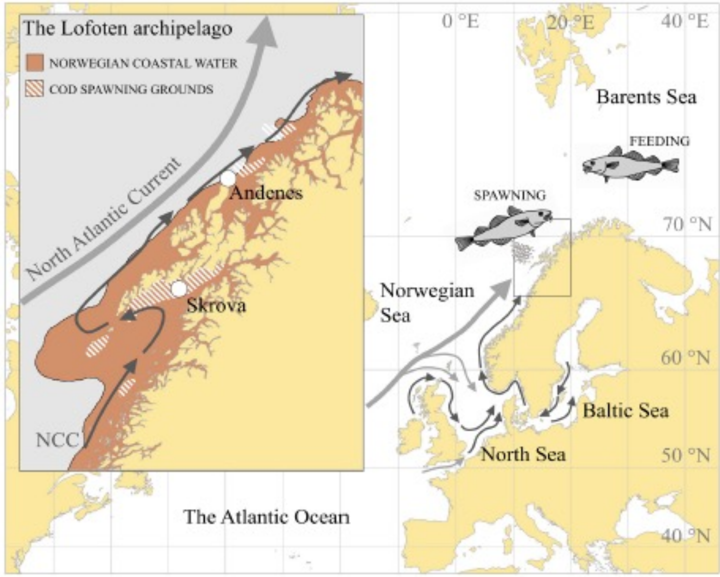
- Increasing boreal forest cover
- Increasing light attenuation in the Skagerrak Sea
- Terrestrial greening and freshwater browning around the Baltic and North Sea has ramifications for coastal water clarity across thousands of kilometers
- Pointing toward an ecosystem connectivity from the Baltic lakes and forests to the Barents Sea.

Terrestrial greening, aquatic browning and ecosystem consequences

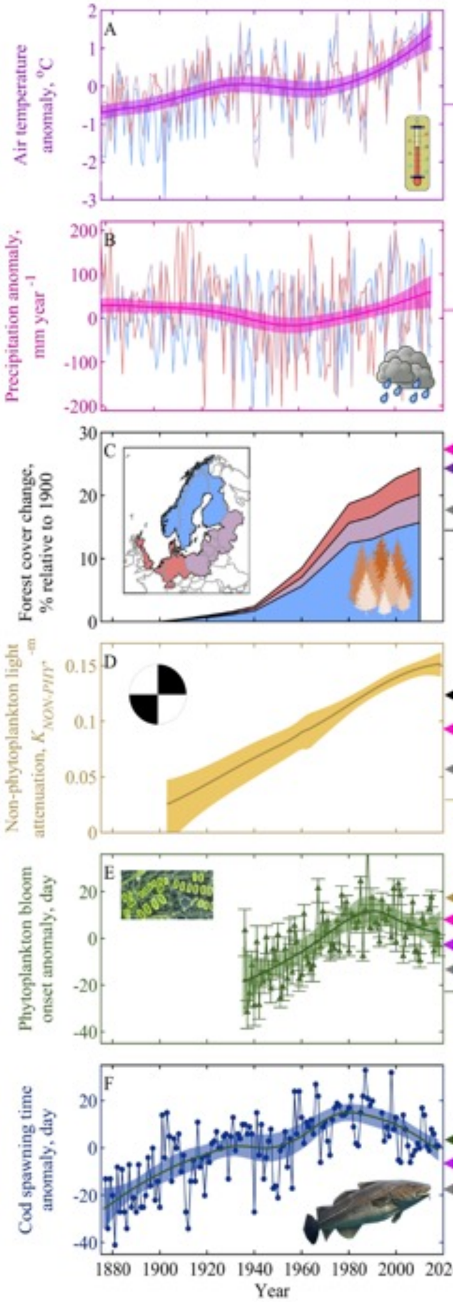
Received: 8 November 2023 | Revised: 21 March 2024 | Accepted: 18 April 2024
DOI: 10.1111/gcb.17308
RESEARCH ARTICLE
Global Change Biology WILEY

Land use change and coastal water darkening drive synchronous dynamics in phytoplankton and fish phenology on centennial timescales

Anders Frugård Opdal[1] | Christian Lindemann[1,2] | Tom Andersen[3] | Dag O. Hessen[3] | Øyvind Fiksen[1] | Dag L. Aksnes[1]



Geographical overview of the Northeast Arctic cod feeding and spawning areas. The Northeast Arctic cod has its main feeding and nursery areas in the Barents Sea. In late autumn, mature cod migrate south to spawning grounds along the Norwegian coast. Spawning takes place between January and May. Eggs and later hatched larvae are carried by the northbound Norwegian Coastal Current (NCC) back to the Barents Sea. The insert shows the main spawning grounds (hatched) around the Lofoten archipelago

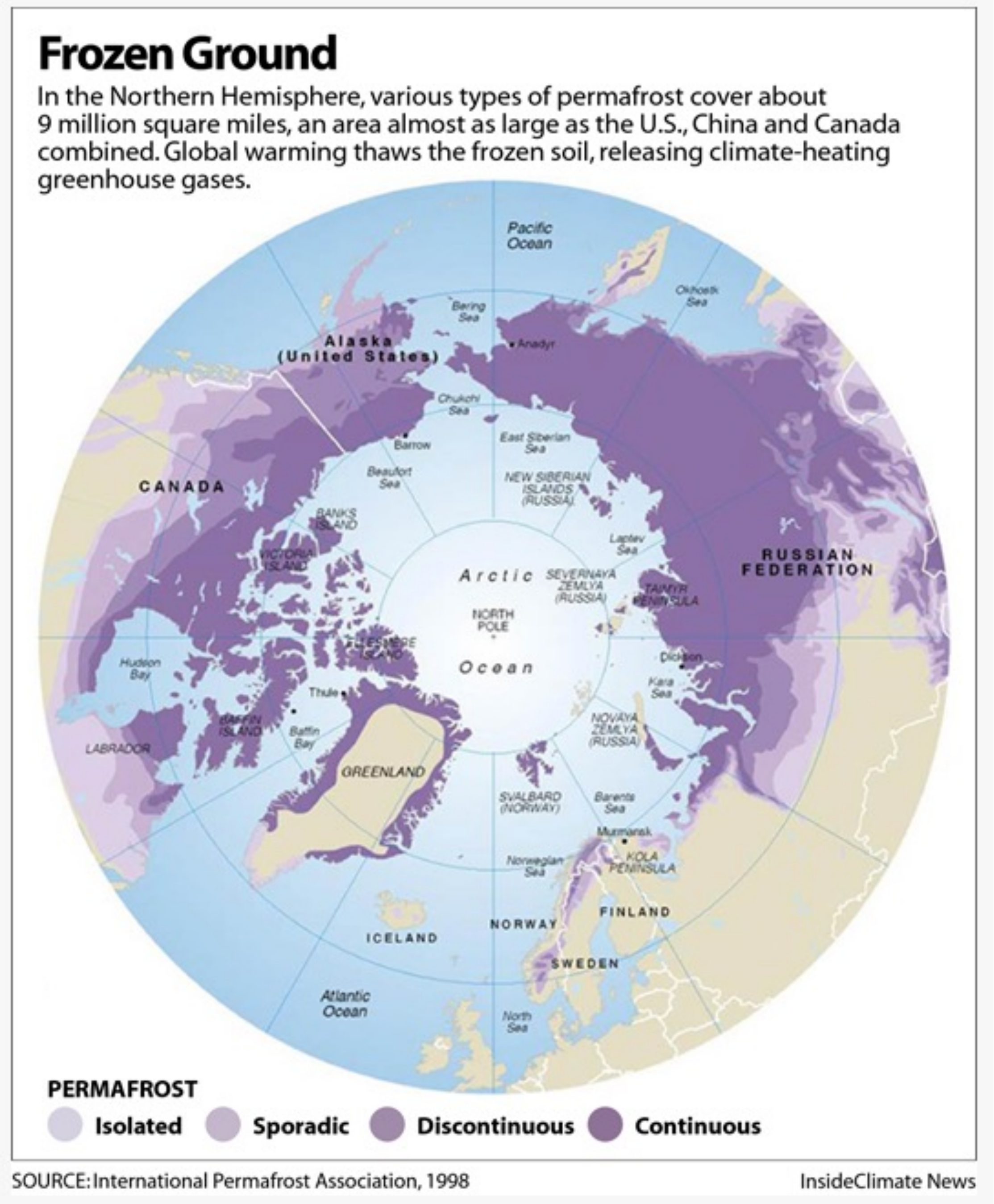


- Spatial connectivity between processes on land and in coastal waters
- Propagated through streams and rivers
- Ecosystems are connected into meta-ecosystem through the flow of energy and matter
- From ecosystem processes to population dynamics

Permafrost melt and river biogeochemistry

Check the scale in the photo →

Permafrost melt and river biogeochemistry



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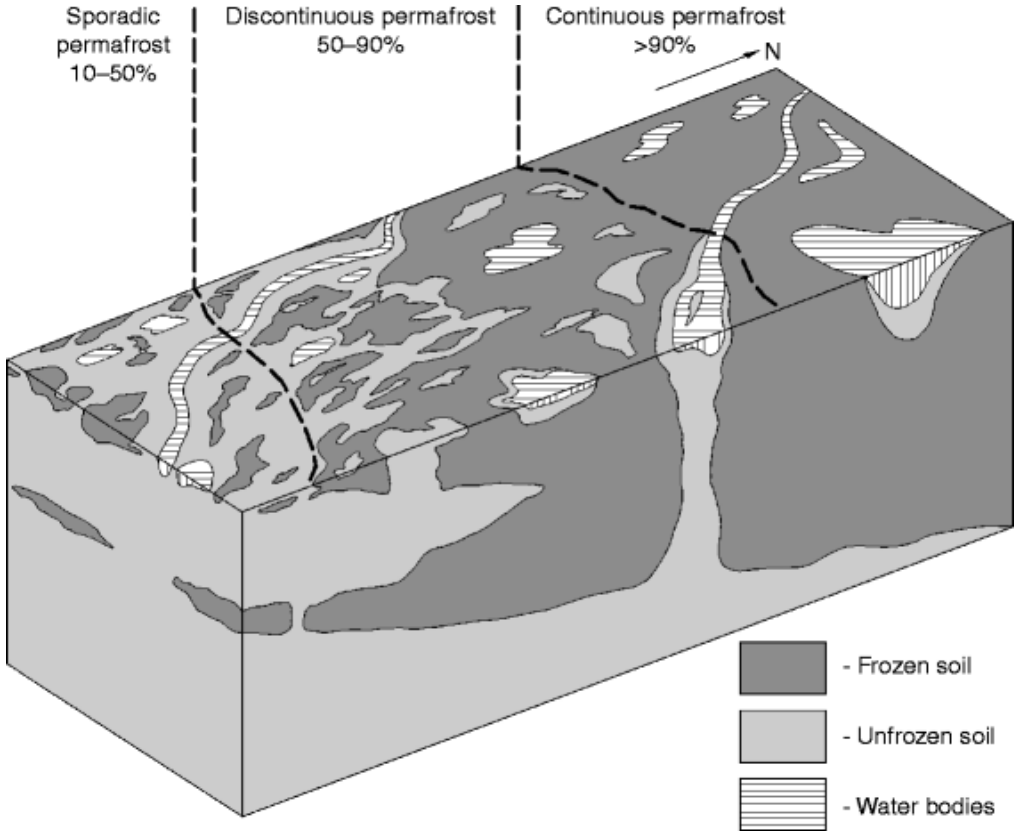
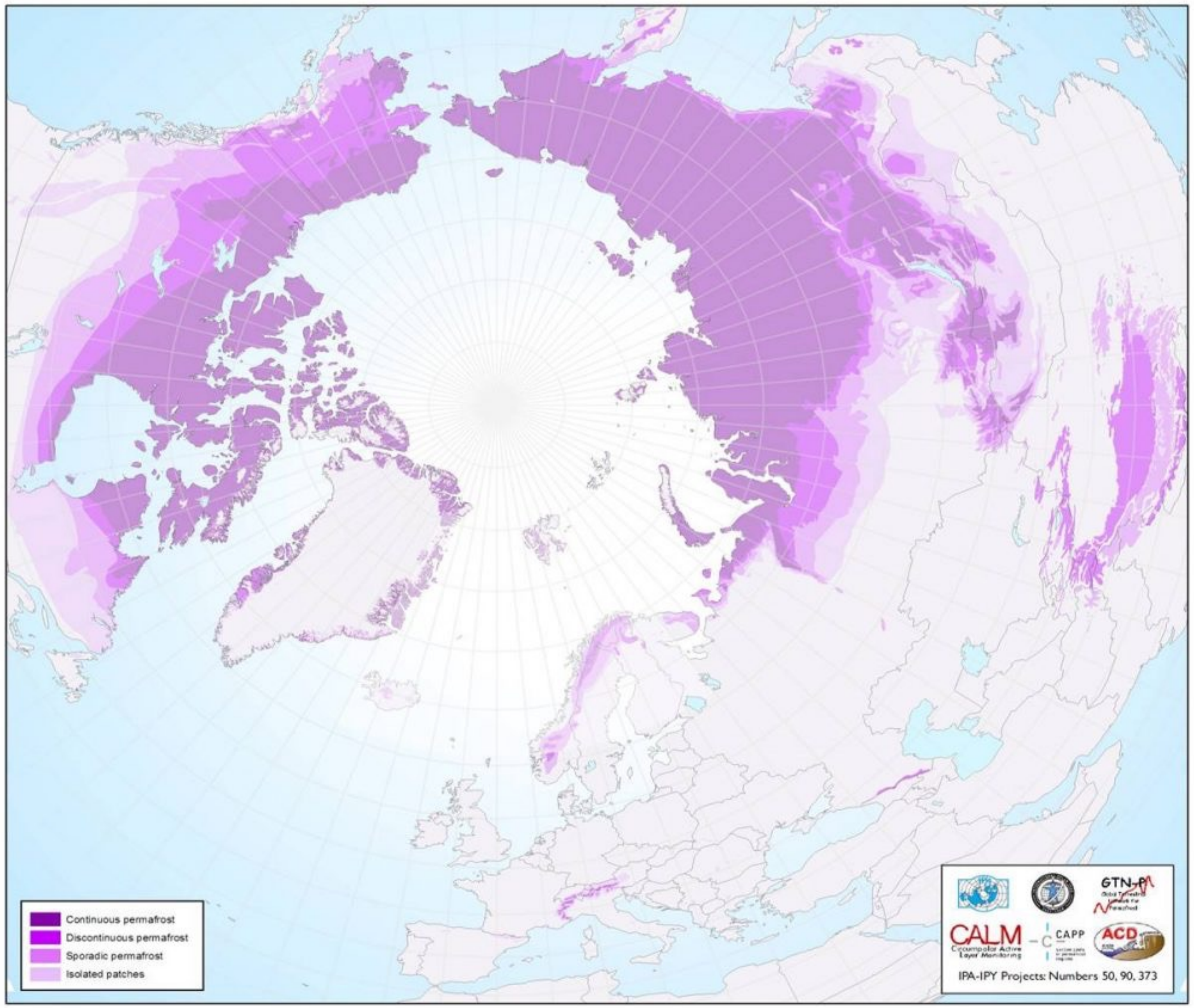
Permafrost melt and river biogeochemistry





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Permafrost organic carbon: old but highly bioavailable

High biolability of ancient permafrost carbon upon thaw

Jorien E. Vonk,[1,2,3] Paul J. Mann,[4] Sergey Davydov,[5] Anna Davydova,[5] Robert G. M. Spencer,[4] John Schade,[6] William V. Sobczak,[7] Nikita Zimov,[5] Sergei Zimov,[5] Ekaterina Bulygina,[4] Timothy I. Eglinton,[3] and Robert M. Holmes[5]

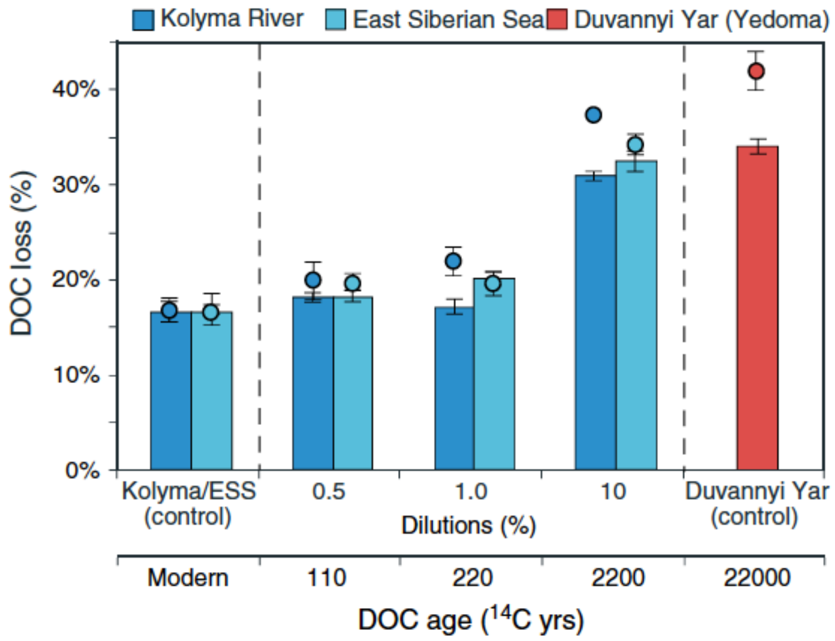


Figure 3. Dissolved organic carbon loss (%) after 14 days (bars) and 28 days (points) dark incubations at 20°C for Kolyma River (light blue), East Siberian Sea (dark blue), Yedoma streams (red), and three dilutions of Yedoma water with Kolyma River or East Siberian Sea water. The ^{14}C age of DOC (years) (*x*-axis) represents the proportion of Duvannyi Yar (Yedoma) stream water added to Kolyma River or East Siberian Sea water. Standard deviations represent errors from triplicate experiments.

- Up to 41% of the DOC from Pleistocene Yedoma deposits bioavailable to the microbial metabolism
- High bioavailability when mixed with Kolyma River or East Siberian Sea water

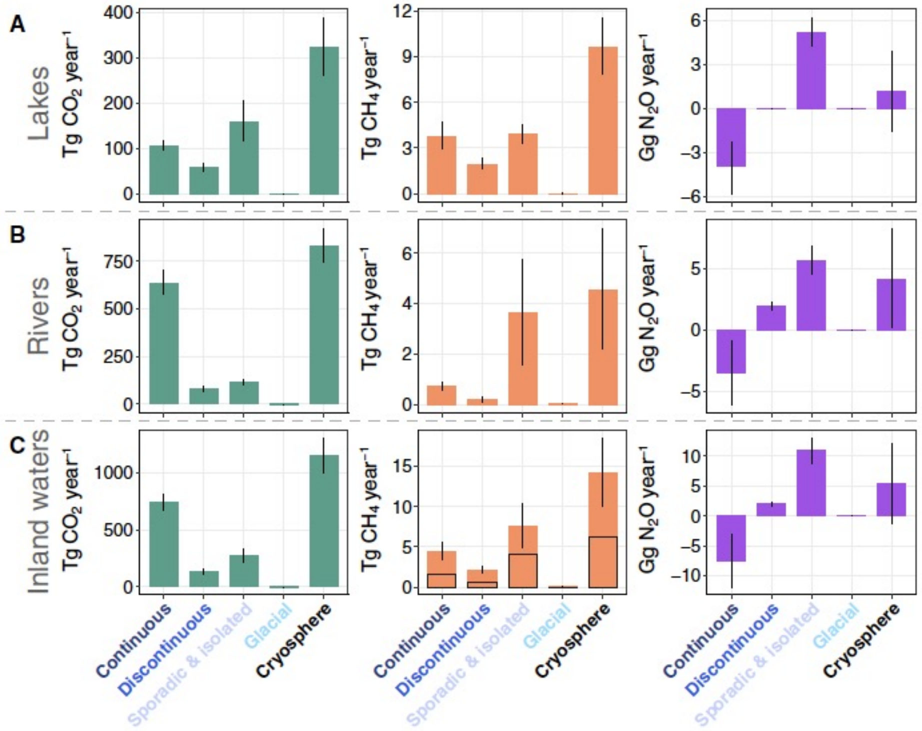
- Permafrost organic carbon highly successible to microbial respiration
- Relevance for greenhouse gas production with climate feedbacks

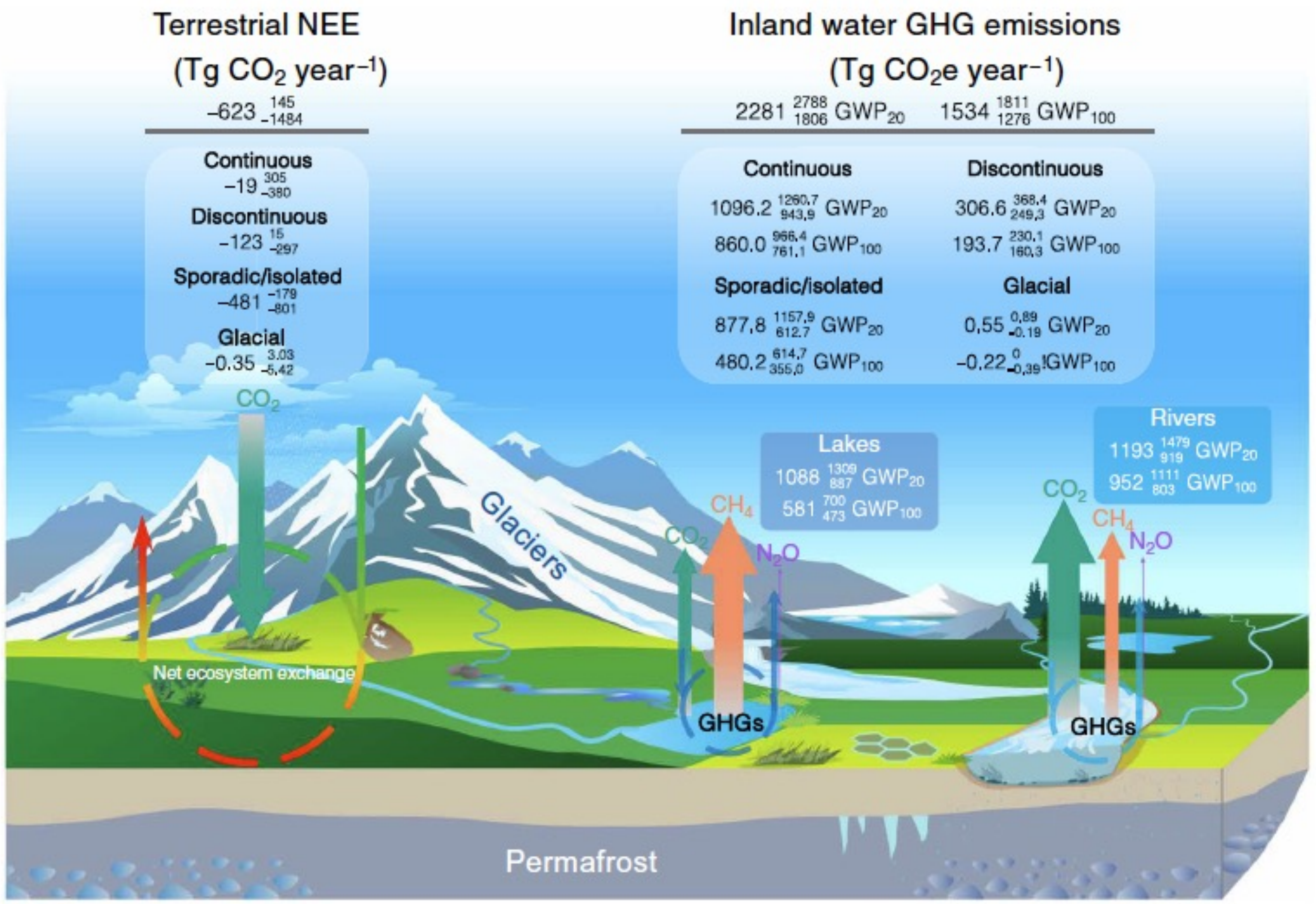
SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Inland water greenhouse gas emissions offset the terrestrial carbon sink in the northern cryosphere

Chunlin Song[1]*†, Shaoda Liu[2]†, Genxu Wang[1]*†, Liwei Zhang[3], Judith A. Rosentreter[4], Gang Zhao[5], Xiangyang Sun[1], Yuanzhi Yao[6], Culcui Mu[7], Shouqin Sun[1], Zhaoyong Hu[1], Shan Lin[1], Juying Sun[1], Yang Li[1], Ying Wang[1], Yuhao Li[1], Peter A. Raymond[8], Jan Karlsson[9]





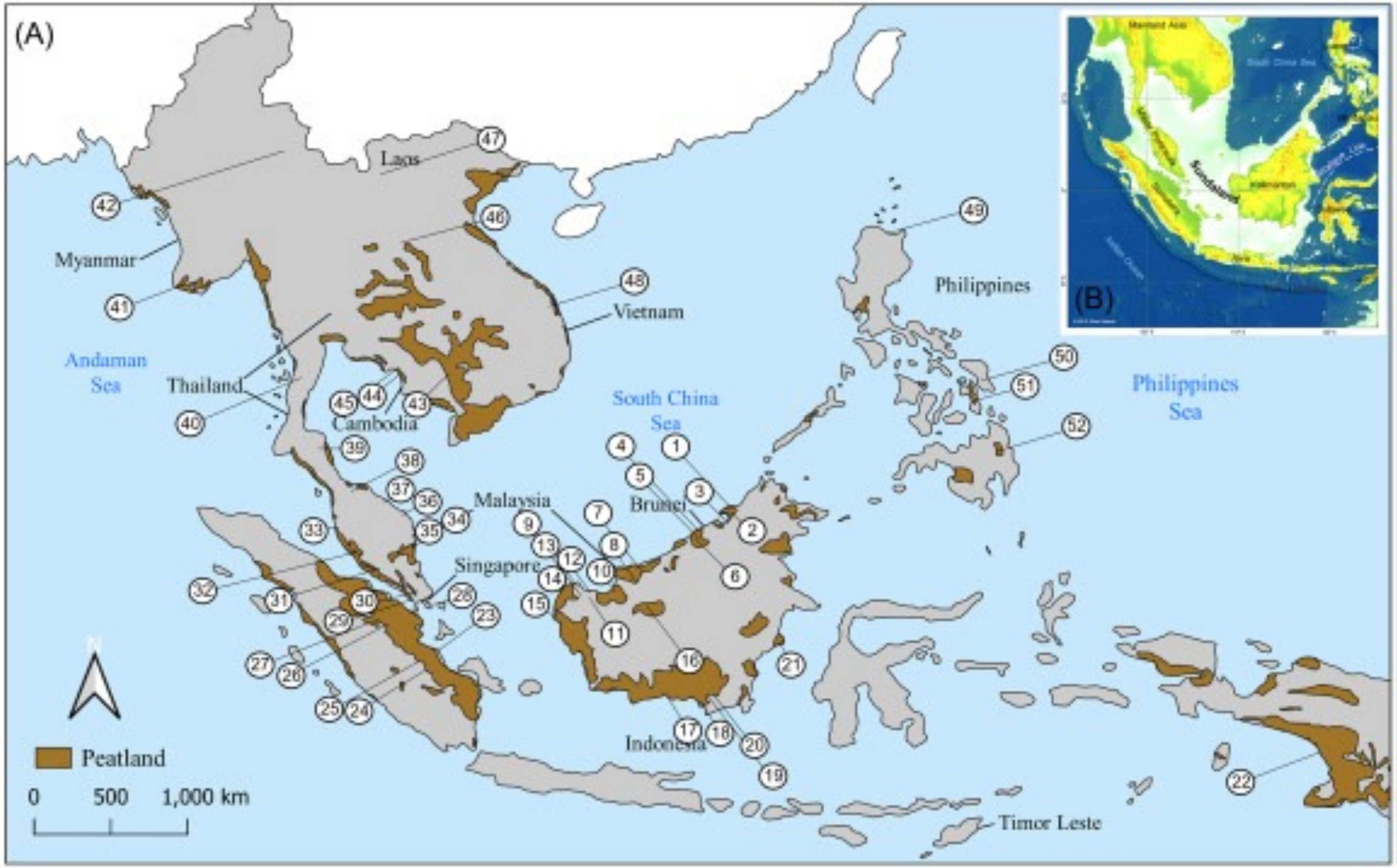
- Larger CO_2 emssions from rivers than lakes
- Similar CH_4 emissions for rivers and lakes

- Greenhouse gas emissions (as CO_2 eqivalents) from rivers and lakes largely outpace terrestrial net ecosystem CO_2 exchange
- Underscores the role of inlandwaters for metabolism of permafrost organic matter and GHG production

Palm oil plantations in Southeast Asia and river and coastal biogeochemistry

Tropical peat in Southeast Asia

Tropical peatlands store around one-sixth of the global peatland carbon pool (that is 105 gigatonnes), equivalent to 30% of the carbon held in rainforest vegetation



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Use of palm oil and plantations

https://greenglobaltravel.com/how-to-avoid-products-with-palm-oil/

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REVIEWS

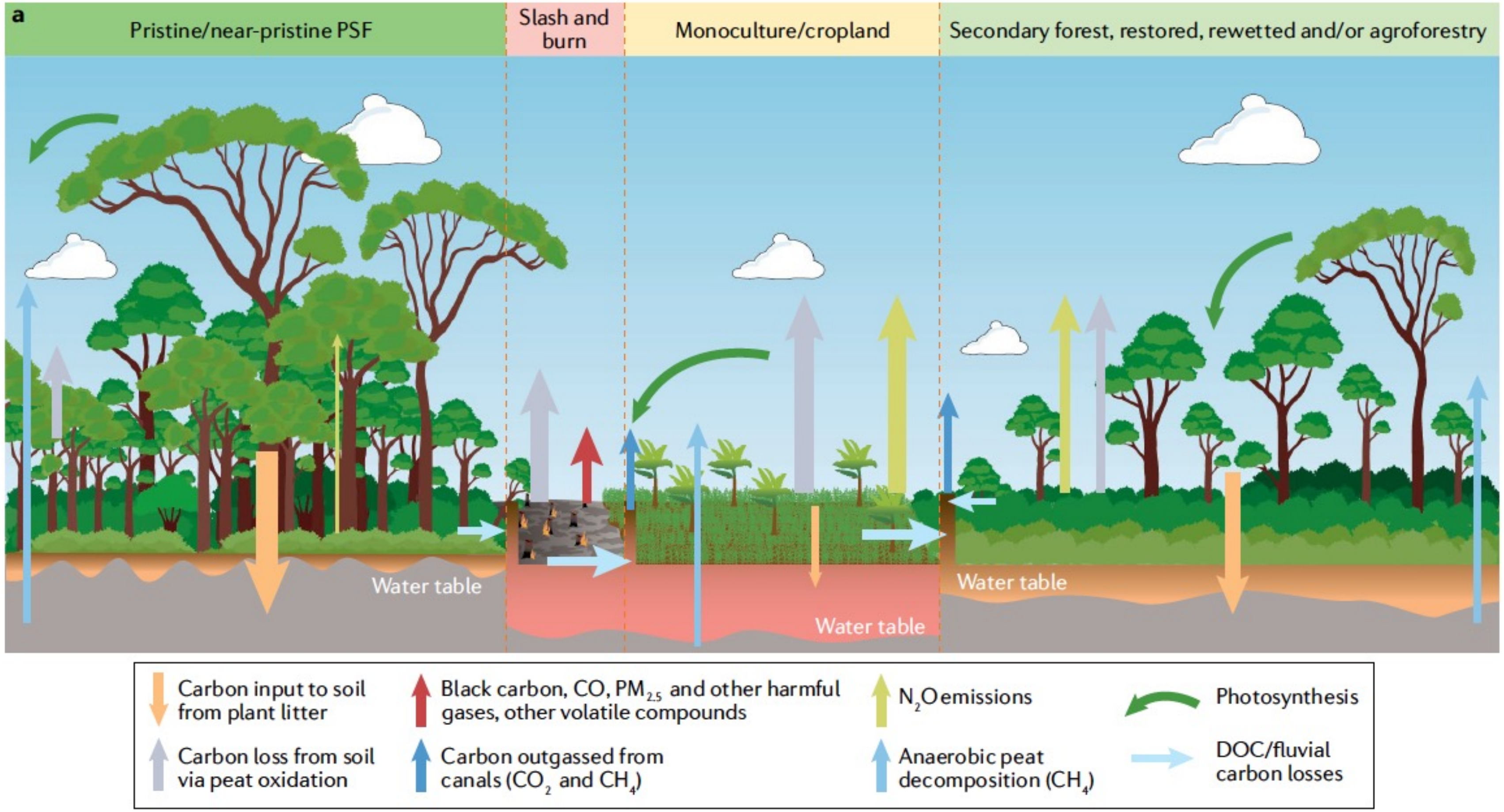
Check for updates

Anthropogenic impacts on lowland tropical peatland biogeochemistry

Susan Page[1]✉, Shailendra Mishra[2], Fahmuddin Agus[3], Gusti Anshari[4,5], Greta Dargie[6], Stephanie Evers[7,8], Jyrki Jauhiainen[9,10], Adi Jaya[11], Antonio Jonay Jovani-Sancho[12,13], Ari Laurén[14], Sofie Sjögersten[13], Ifo Averti Suspense[15], Lahiru S. Wijedasa[16] and Chris D. Evans[12]

Deterioration of tropic peatlands

- Drainage system, groundwater lowering and peat drying
- Prone to (wild)fires — CO_2 emissions
- Clear-cutting
- Loss of biodiversity
- Fundamental alterations of biogeochemical fluxes



REVIEWS

Check for updates

Anthropogenic impacts on lowland tropical peatland biogeochemistry

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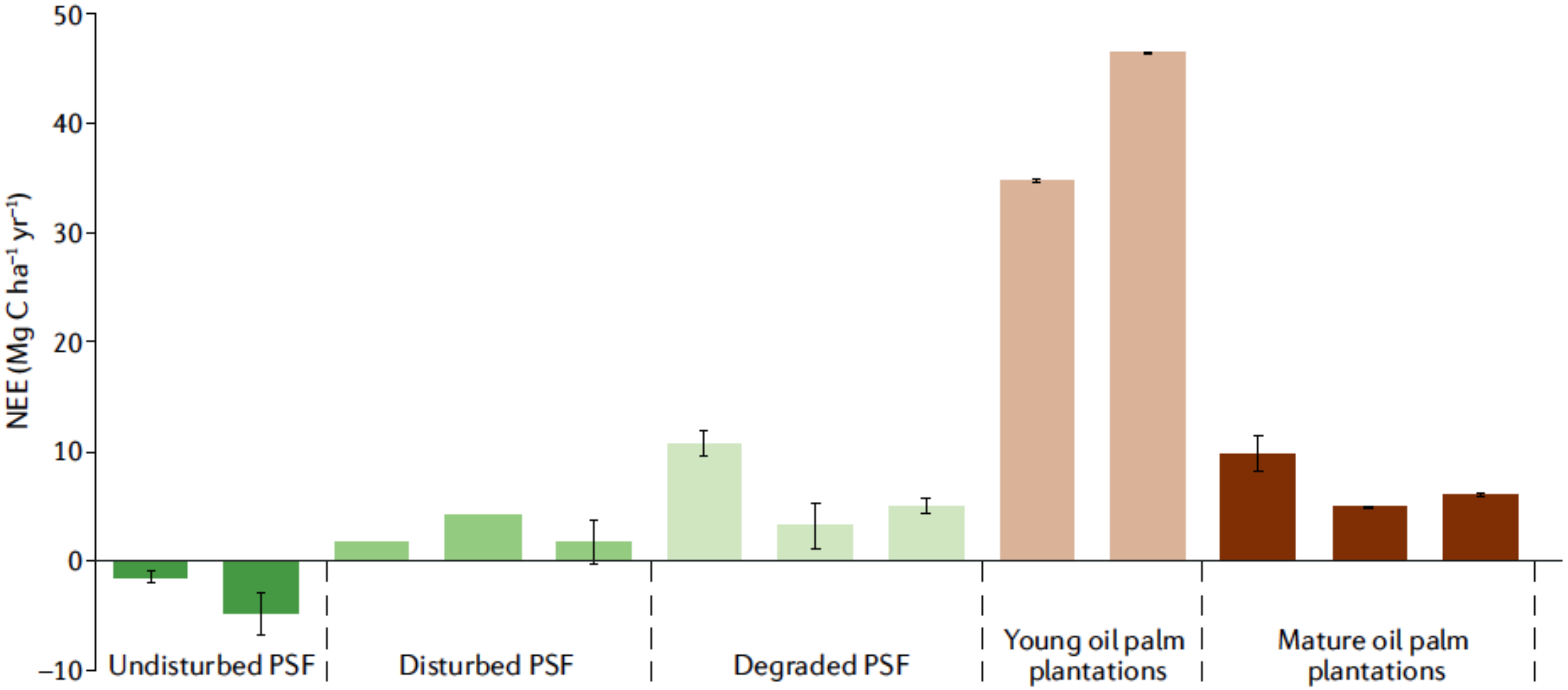
Deterioration of tropic peatlands

- The conversion of native peat land to oil palm plantations inverses the ecosystem CO_2 exchange from a GHG sink to a source to the atmosphere
- Loss of soil organic cyrbon to stream networks….



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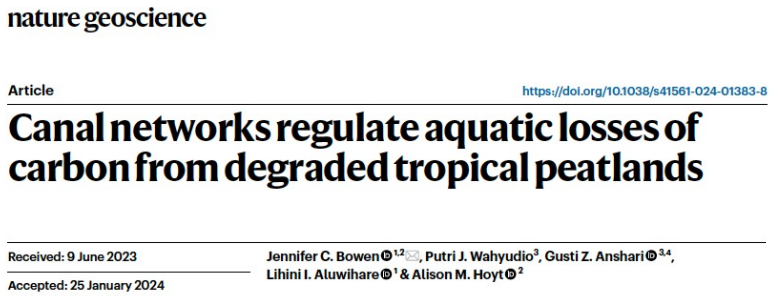

nature geoscience

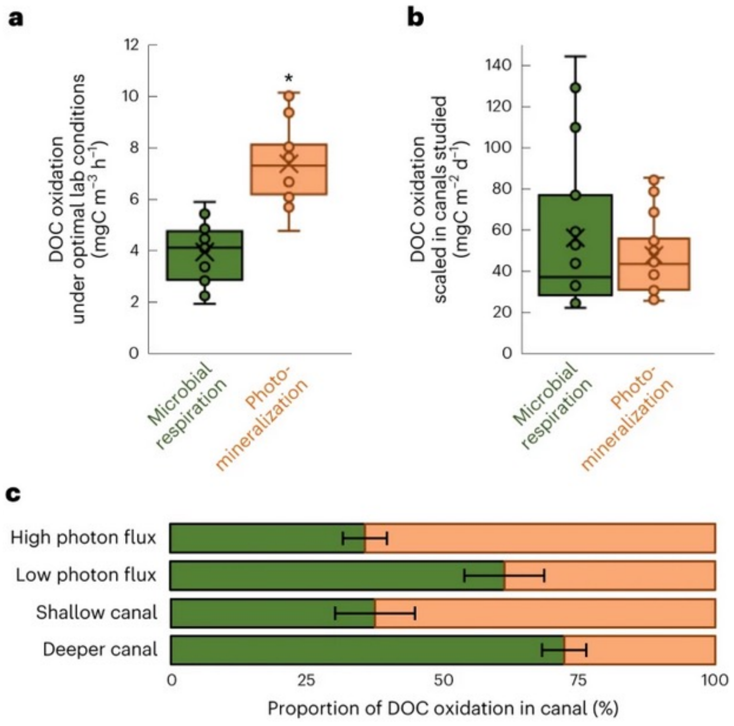
Article https://doi.org/10.1038/s41561-024-01383-8

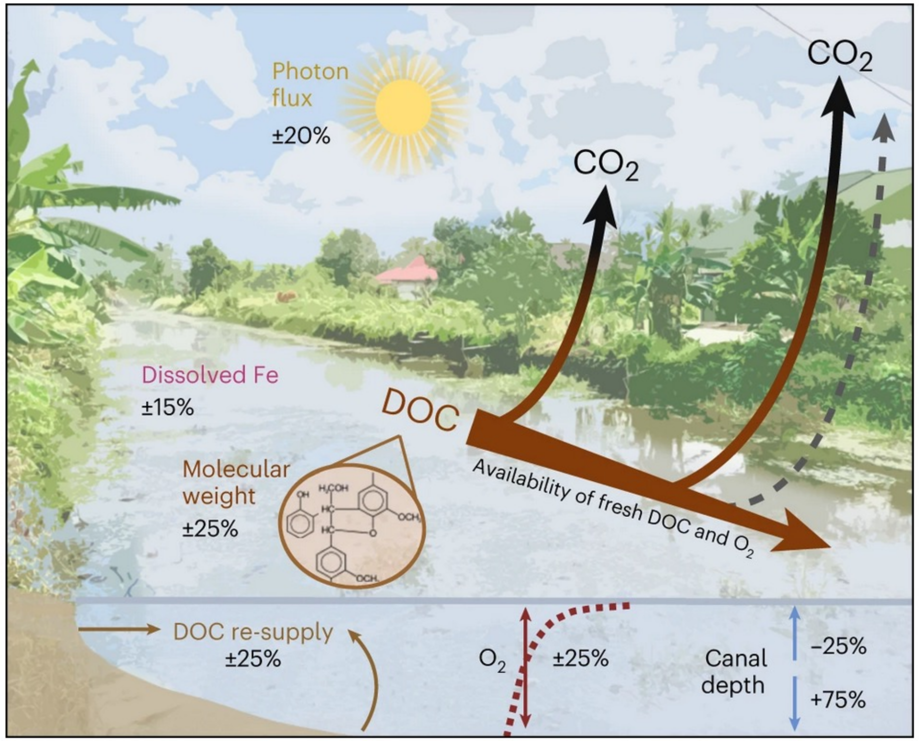
Canal networks regulate aquatic losses of carbon from degraded tropical peatlands

Received: 9 June 2023

Accepted: 25 January 2024

Jennifer C. Bowen[1,2], Putri J. Wahyudio[3], Gusti Z. Anshari[3,4], Lihini I. Aluwihare[1] & Alison M. Hoyt[2]





- The relative importance of microbial respiration and photomineralisation of DOC to CO_2 depend on solar radiation and channel depth (light attenuation)

- The concentration of dissolved iron present, the relative abundance of lower molecular-weight DOC compounds and dissolved O_2 (oxygenation, gas exchange) at deeper water depths, as well as DOC re-supply control DOC oxidation rates

- DOC/DOM that is not oxidized may be transported to the coastal waters

OCEANOGRAPHY

Rising dissolved organic carbon concentrations in coastal waters of northwestern Borneo related to tropical peatland conversion

Nivedita Sanwlani[1]*†, Chris D. Evans[2,3,4], Moritz Müller[5], Nagur Cherukuru[6], Patrick Martin[1]*

Time series of satellite ocean color data from northwestern Borneo show that DOC concentrations in coastal waters have increased between 2002 and 2021 by 0.31 μmol liter^{-1} year^{-1}.

This was caused by a ≥30% increase in the concentration of terrigenous DOC and coincided with the conversion of 69% of regional peatland area to non-forest land cover, suggesting that peatland conversion has substantially increased DOC fluxes to the sea.

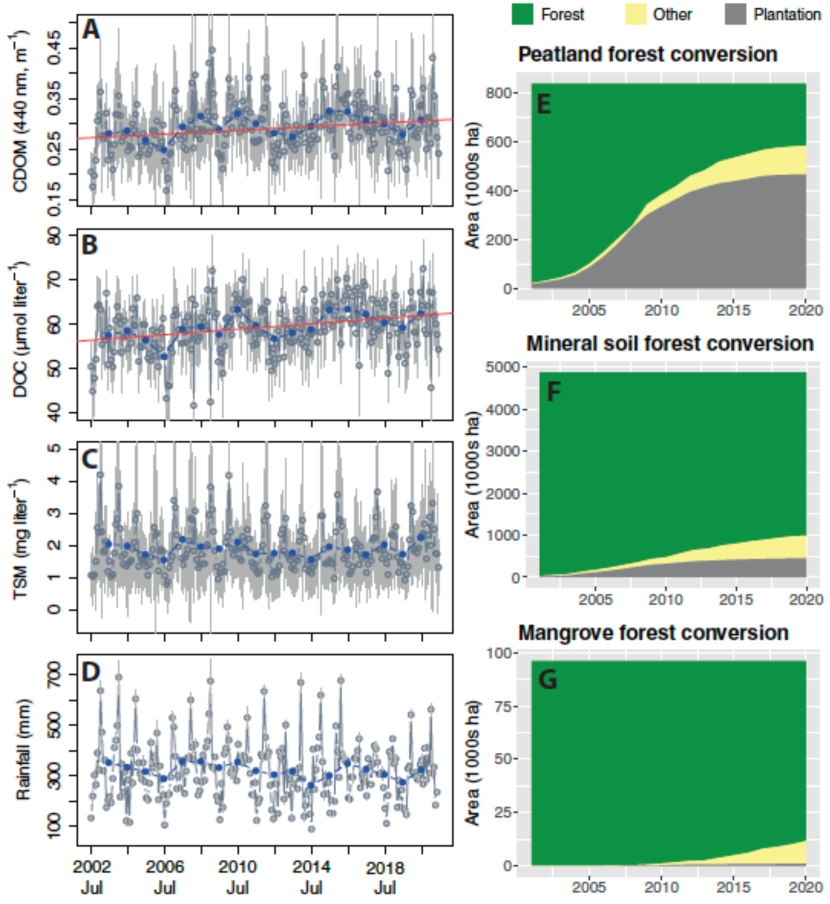


Fig. 3. Time series showing increased dissolved organic matter concentrations in coastal waters and land conversion of peatlands. Mean monthly (gray circles) and annual (blue dots) values of (**A**) CDOM absorption, (**B**) DOC concentration, (**C**) TSM concentration across the coastal waters, and (**D**) monthly precipitation on land. Solid red lines in (A) and (B) show statistically significant Theil-Sen trends ($P < 0.05$). The time series of TSM and rainfall showed no statistically significant trend. Gray error bars show 1 SD across the coastal water region (A to C) or across the land area (D). Land cover changes over time are shown for (**E**) peatlands, (**F**) mineral soil forest, and (**G**) mangrove forest.

SCIENCE ADVANCES | RESEARCH ARTICLE

OCEANOGRAPHY

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This rise in DOC concentration has also increased the underwater light absorption by dissolved organic matter, which may affect marine productivity by altering underwater light availability.

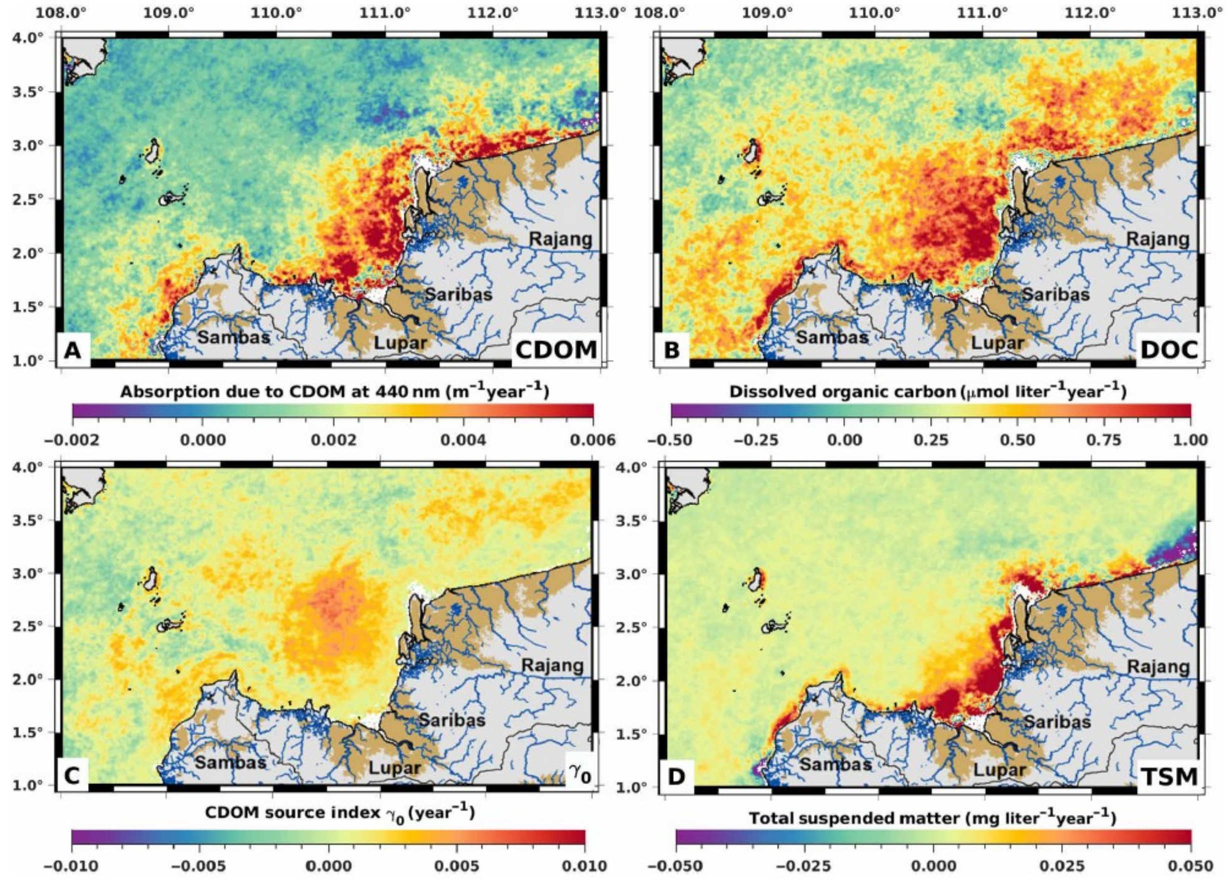

Fig. 4. Spatial distribution of trends in dissolved organic matter and TSM over the period 2002–2021. Theil-Sen trends were calculated for each 1-km^2 pixel across the time series for (**A**) CDOM, (**B**) DOC, (**C**) the CDOM source index γ_0, and (**D**) TSM. The largest increasing trends in CDOM and DOC occurred in coastal waters adjacent to the main peatland areas (A and B), while for TSM, only small and inconsistent (positive and negative) trends were seen across the region (D). Trends in γ_0 are greater somewhat further from shore, reflecting the fact that γ_0 close to shore is already high due to the dominance of terrigenous DOC in these waters throughout the time series (cf. Fig. 1) and the fact that spectral slopes show nonlinear concentration-dependent changes (see Methods).

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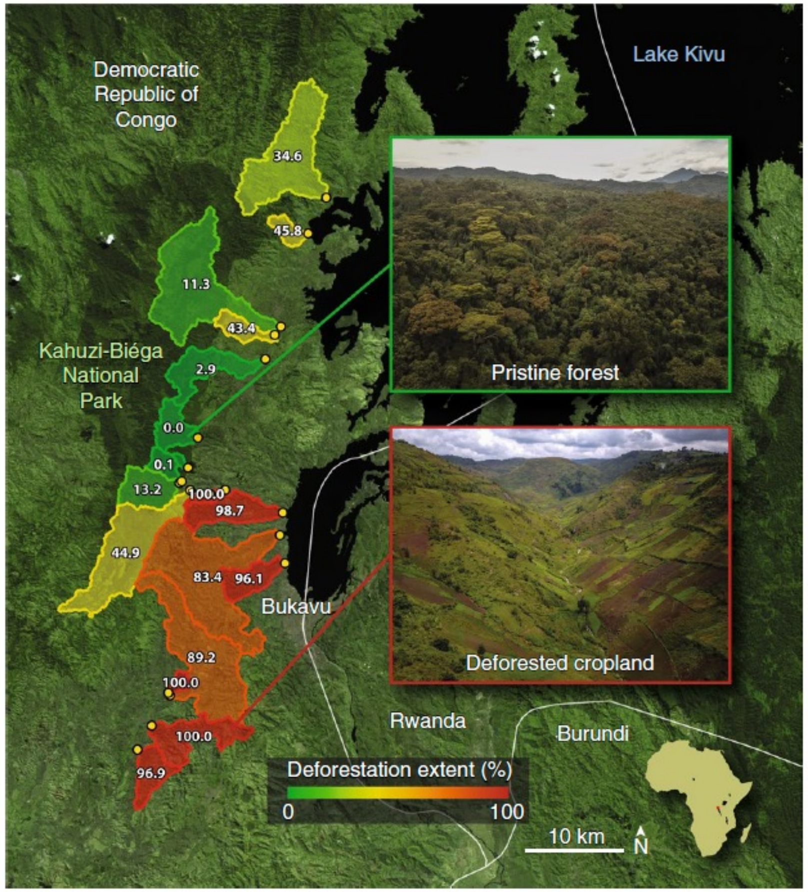
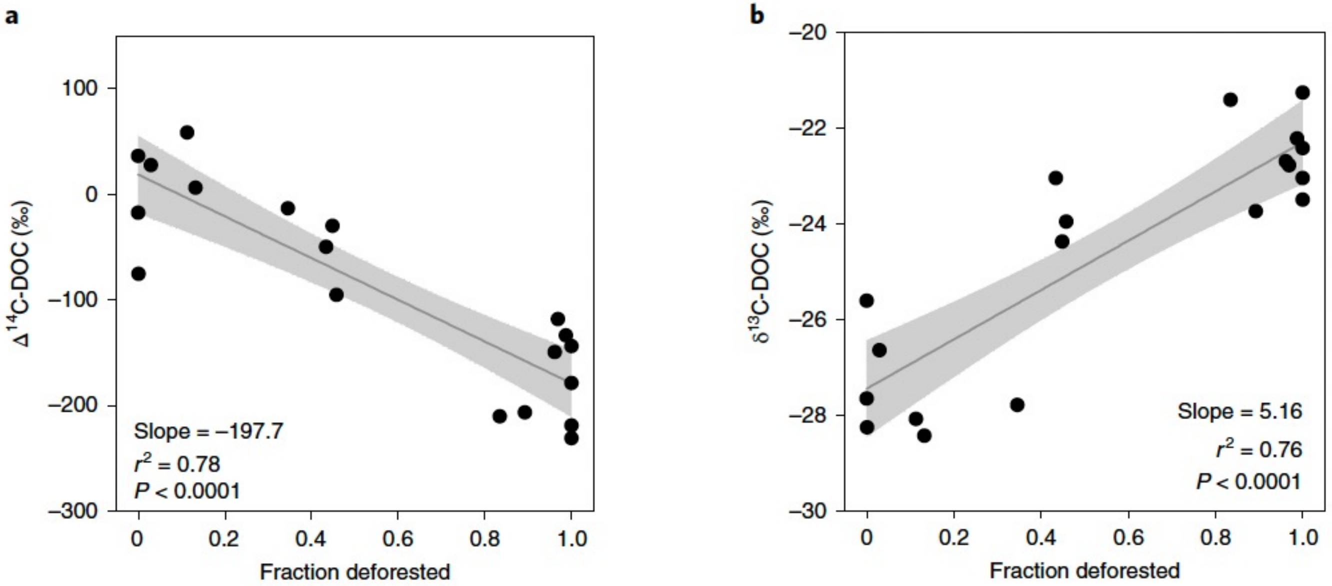
Deforestation in Africa

nature geoscience
ARTICLES
https://doi.org/10.1038/s41561-019-0384-9

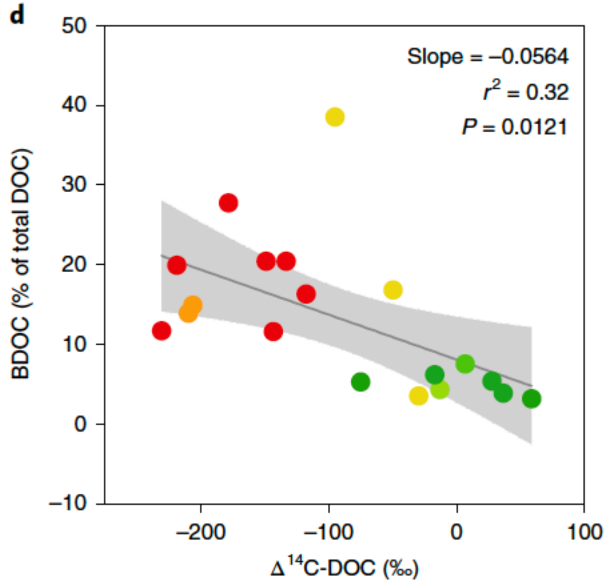
Mobilization of aged and biolabile soil carbon by tropical deforestation

Travis W. Drake[1,2,11]*, Kristof Van Oost[3], Matti Barthel[4], Marijn Bauters[5,6], Alison M. Hoyt[7,8], David C. Podgorski[1,2,12], Johan Six[4], Pascal Boeckx[5], Susan E. Trumbore[7,9], Landry Cizungu Ntaboba[10] and Robert G. M. Spencer[1,2]





- Deforestation mobilized old and soil-derived DOC to the streams
- Old terrigenous DOC is highly bioavailable to the microbial metabolism



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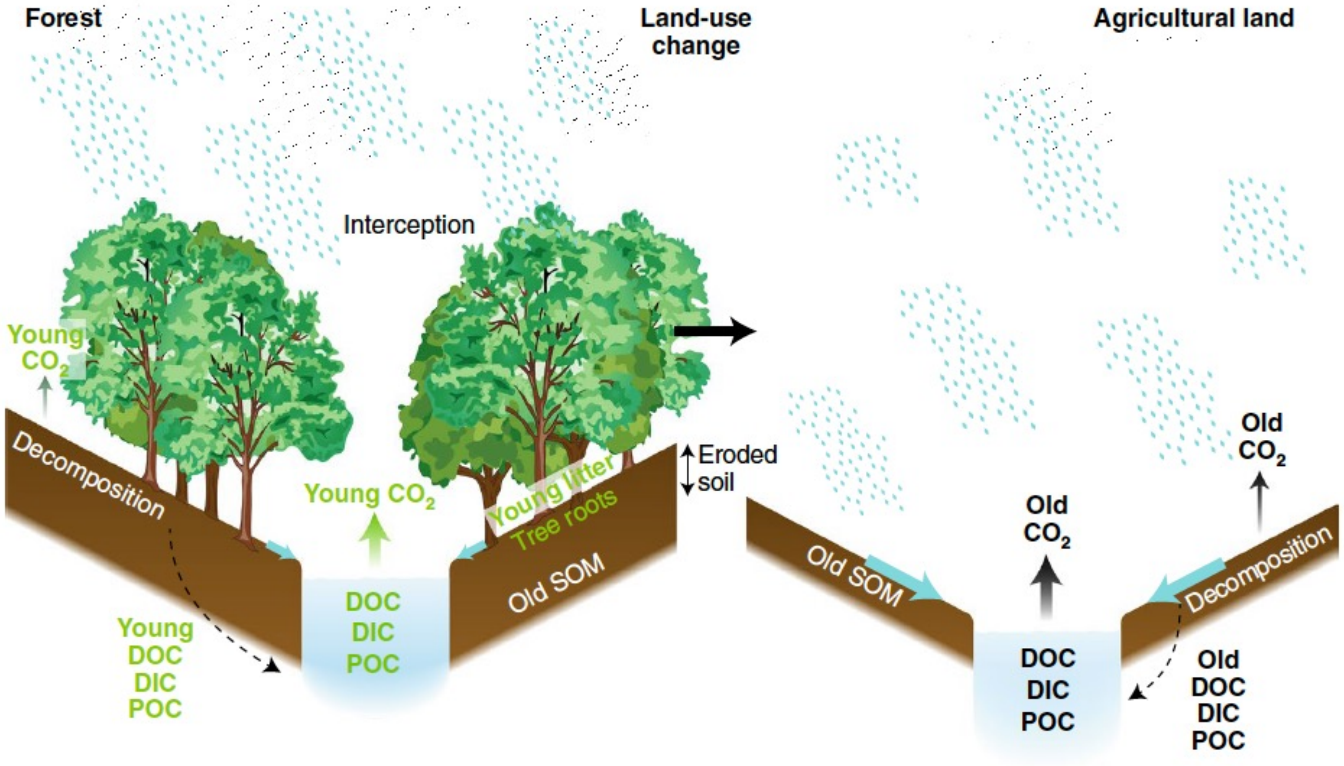
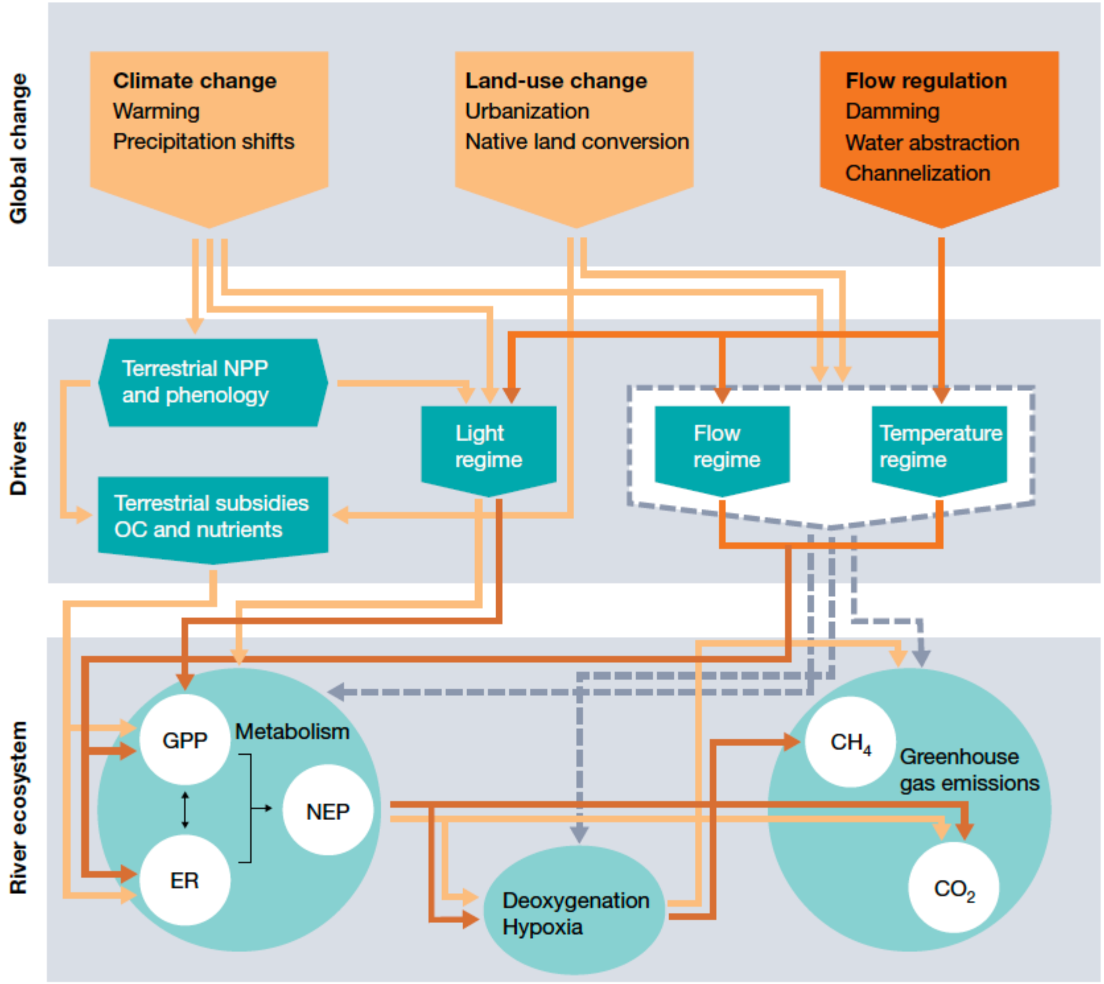
Pristine forests protect deeper and old SOM from erosion. OM from young primary production is metabolised on land or transported via surface and shallow runoff to streams. In streams, this OM is slowly decomposed with the production of young CO_2.

Removal of trees exposes soils to heavy rain (tropics!), which increases the rate of surface run-off and soil erosion. SOM from those soils increasingly flows into rivers where it is rapidly degraded with the production of old CO_2.





Land use change

- Climate change (temperature, CO_2 fertilization, precipitation)
- Native land conversion

Changes in flow regimes

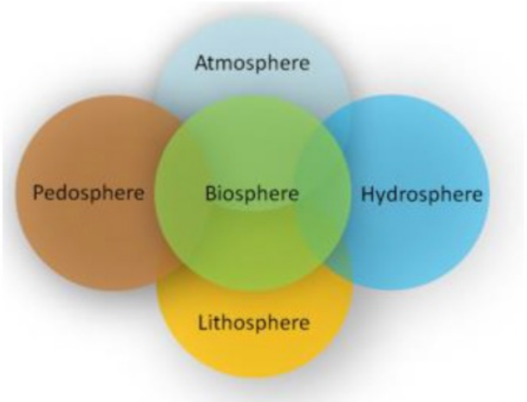
- Increased hydrological connectivity (land-river-coastal waters)

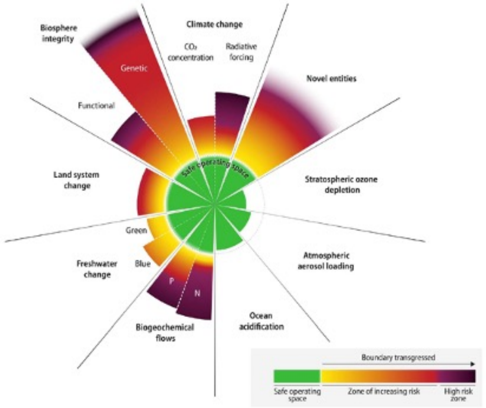
Terrestrial primary production

- Terrestrial subsidies of organic matter (and nutrients…)

- Stores of old organic matter become mobilized
- Fuel contemporary aquatic metabolism
- Contribution to GHG emissions with potential climate feedbacks

A better appreciation of biogeochemistry





What is biogeochemistry?

Biogeochemistry is the scientific discipline that explores the interactions between living organisms and the physical and chemical components of the environment.

It combines principles from biology, geology, chemistry, and environmental science to study the processes that govern the cycling of elements in ecosystems.

In biogeochemical cycles, elements and compounds move through the atmosphere, hydrosphere, lithosphere, and biosphere in a series of complex processes.

These ecosystem processes include primary production, respiration, decomposition, weathering, erosion, and sedimentation.

Human activities deeply impact biogeochemical cycles – with feedbacks to the climate.