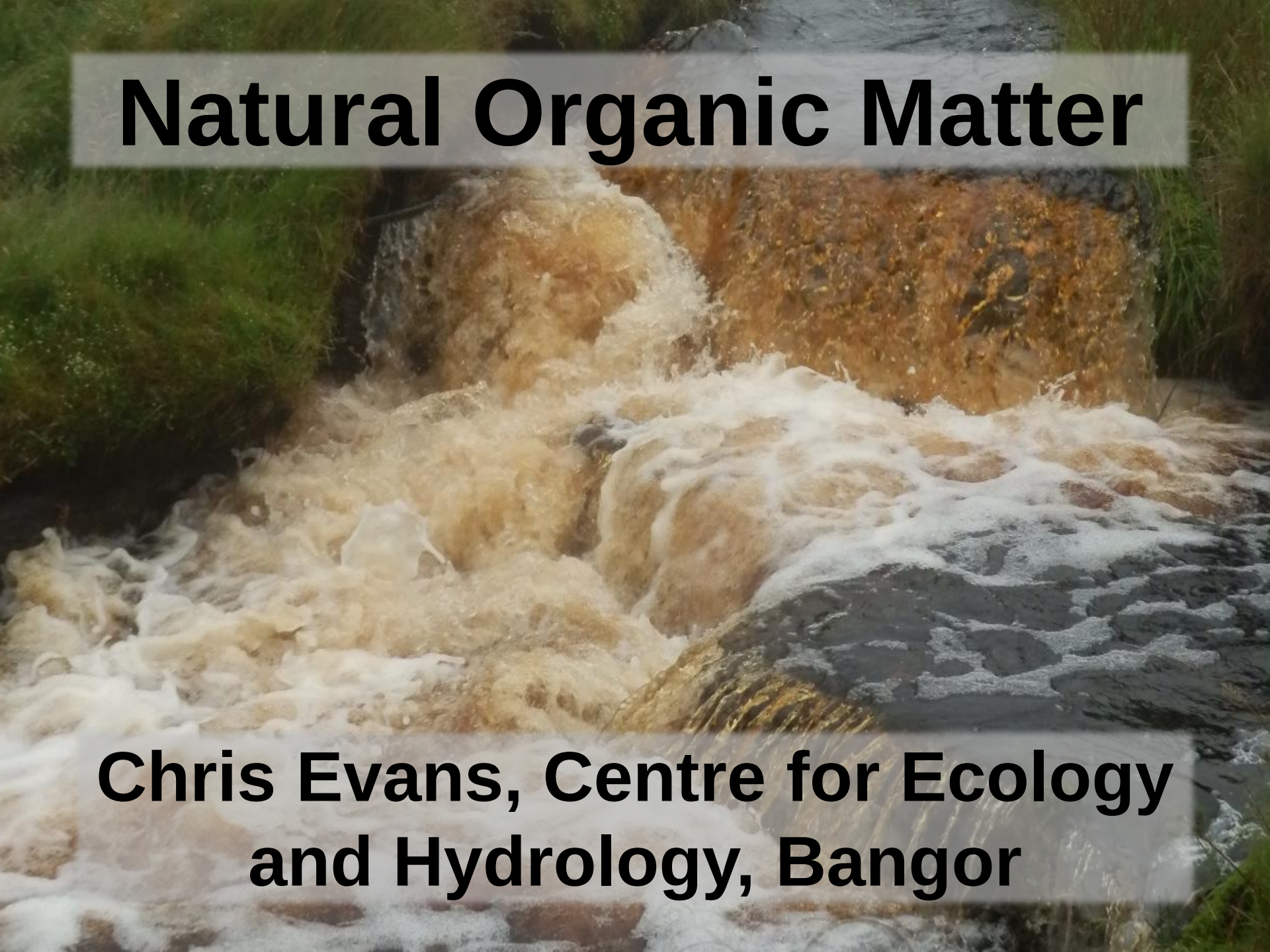


Natural Organic Matter

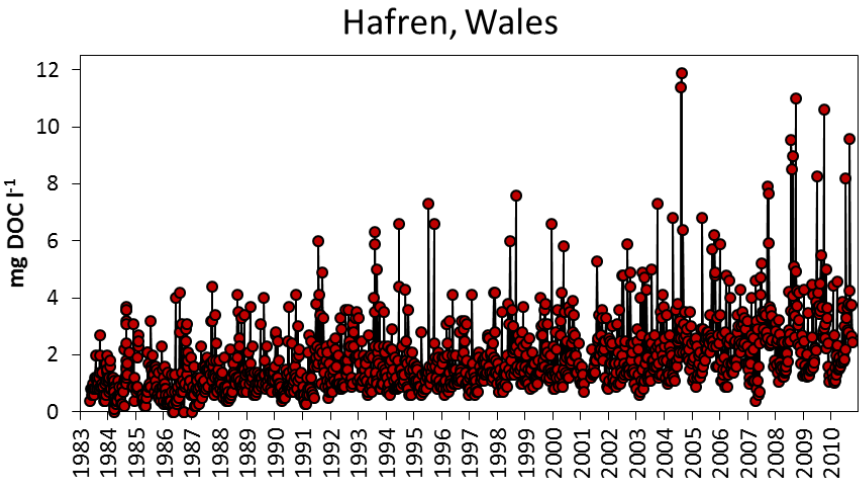
Chris Evans, Centre for Ecology and Hydrology, Bangor

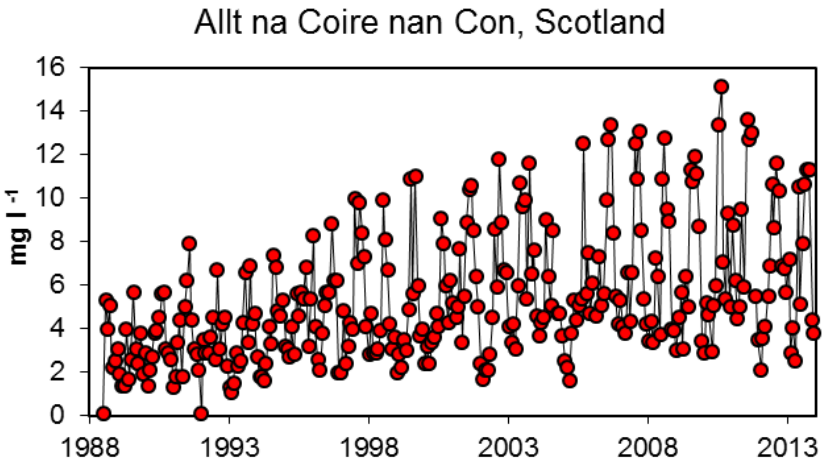
Welsh Water 2050

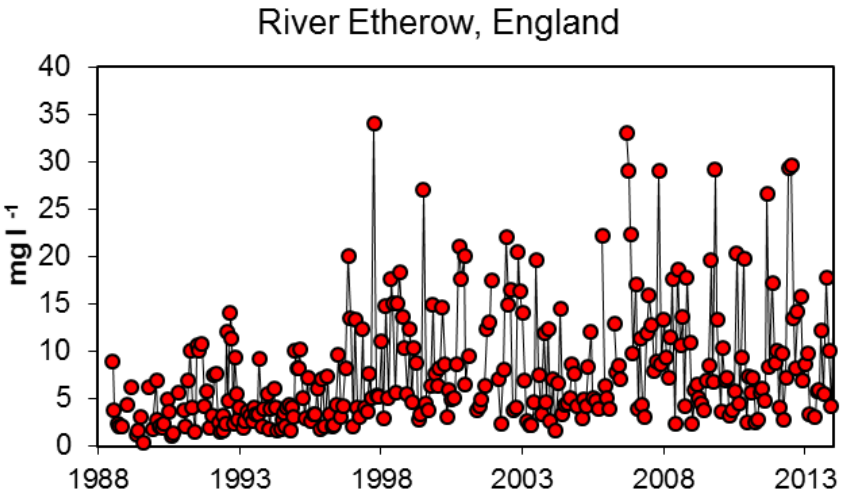
Strategic response 1. Safeguarding clean drinking water through **catchment management**

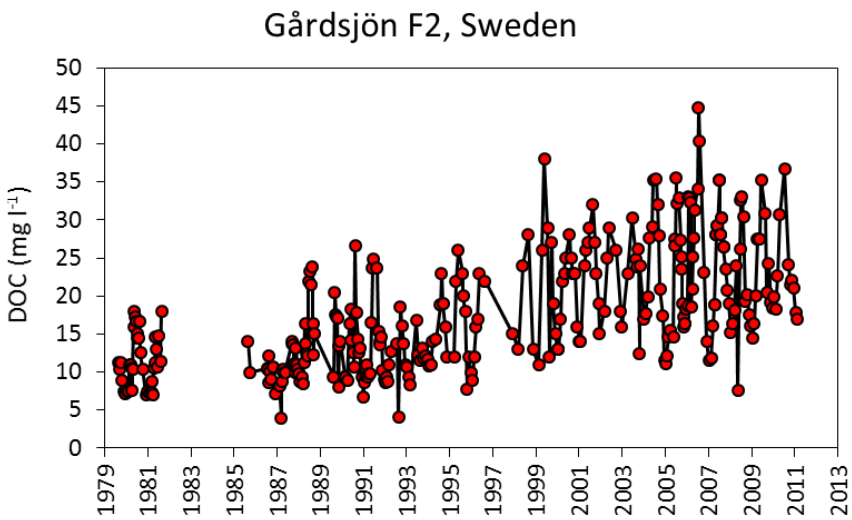
Increased control of the quality of our raw product in the face of increased turbidity and run-off due to extreme weather events caused by climate change; ensuring raw water entering our treatment works is of a consistent and manageable quality (including managing cryptosporidium, **natural organic matter** causing disinfection by products and algal growth causing taste and odour complaints)

The challenge of rising DOC

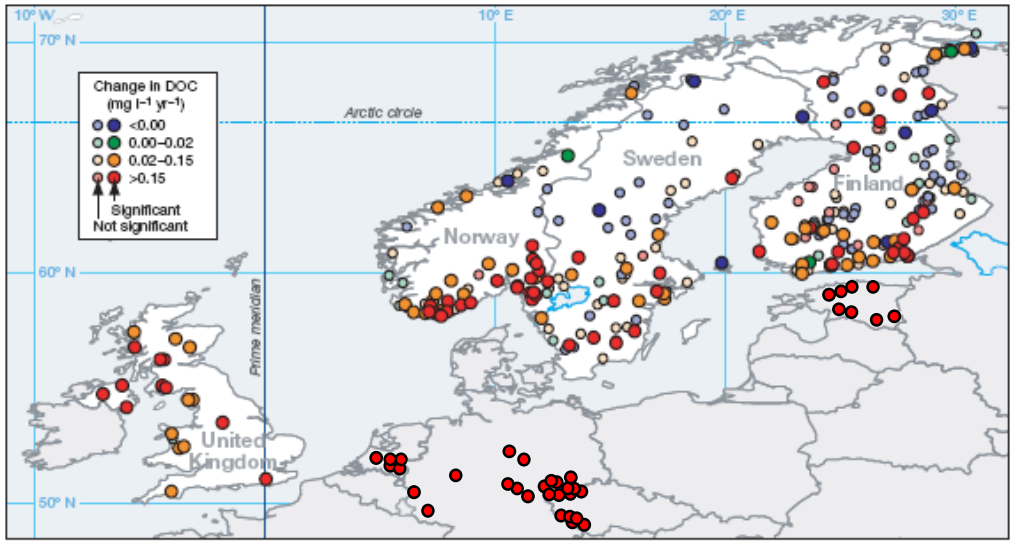


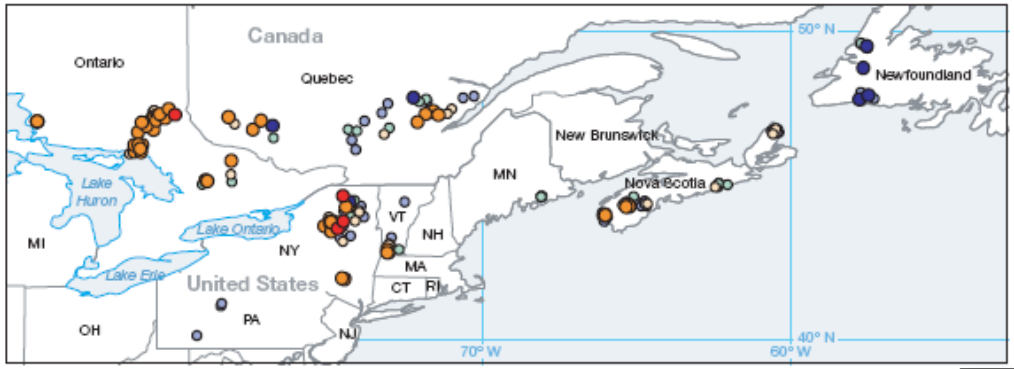






DOC increases in Europe and North America





- DOC increases have occurred across large areas of Northern Europe and NE North America
- Increases have been observed in catchments draining forests, peatlands, upland grasslands and heathlands
- However, peatlands are in general the largest sources of freshwater DOC

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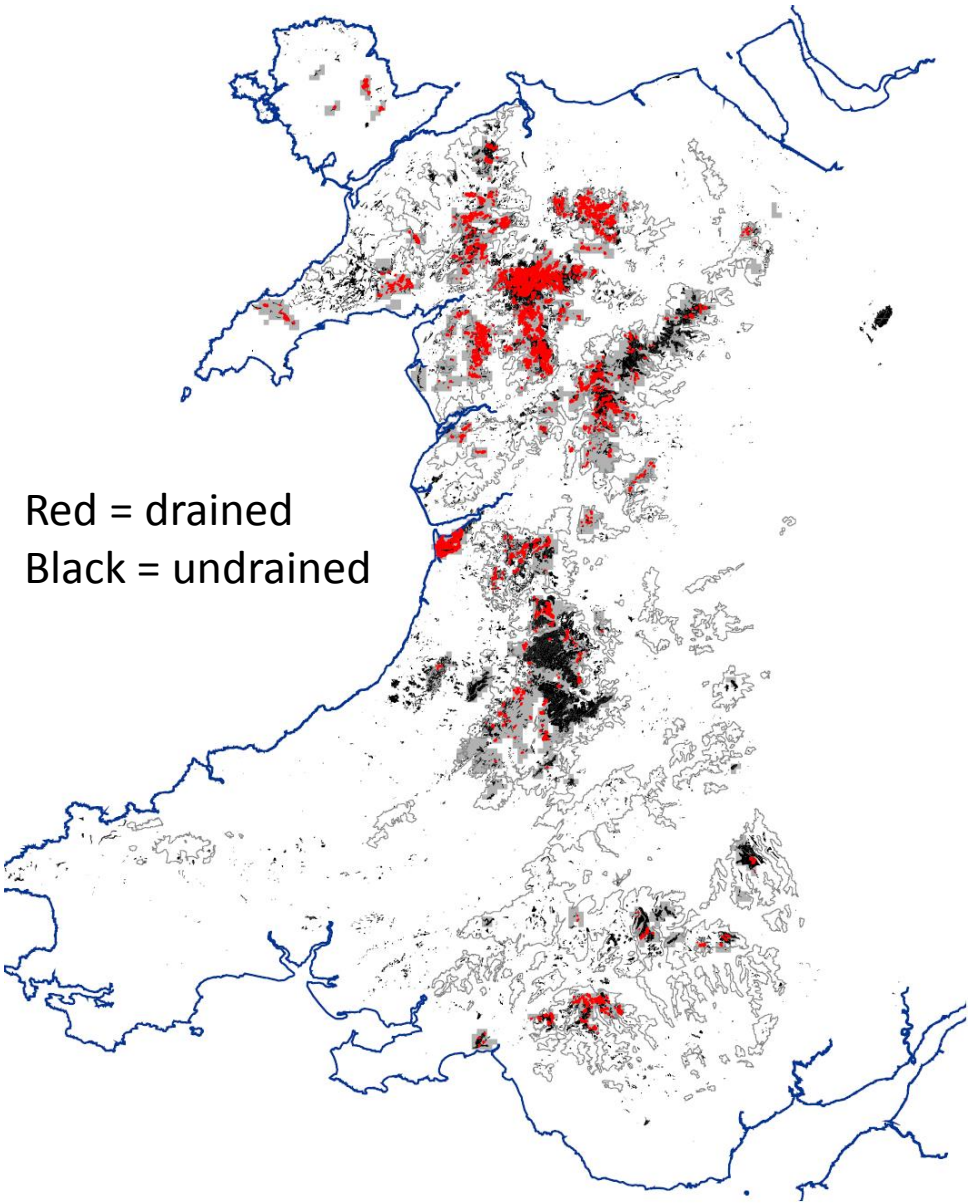
LETTERS

Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry

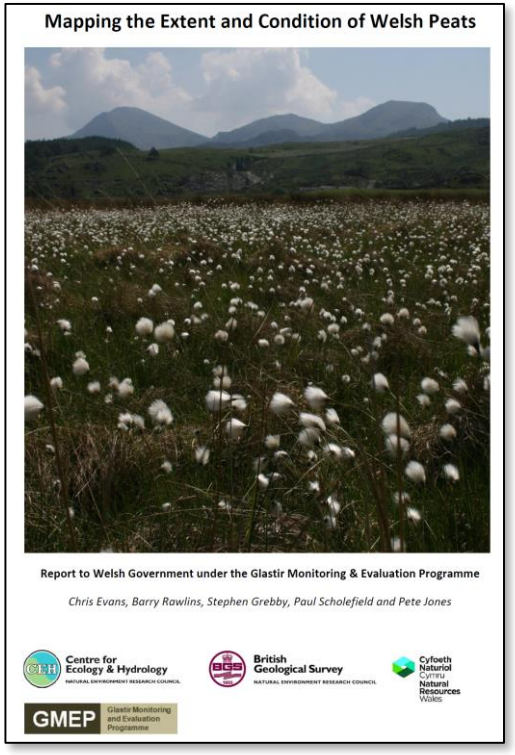
Donald T. Monteith[1]*, John L. Stoddard[2]*, Christopher D. Evans[3], Heleen A. de Wit[4], Martin Forsius[5], Tore Høgåsen[4], Anders Wilander[6], Brit Lisa Skjelkvåle[4], Dean S. Jeffries[7], Jussi Vuorenmaa[5], Bill Keller[8], Jiri Kopácek[9] & Josef Vesely[10]‡

Land-use impacts on Welsh peatlands

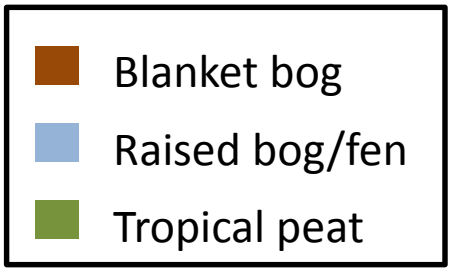


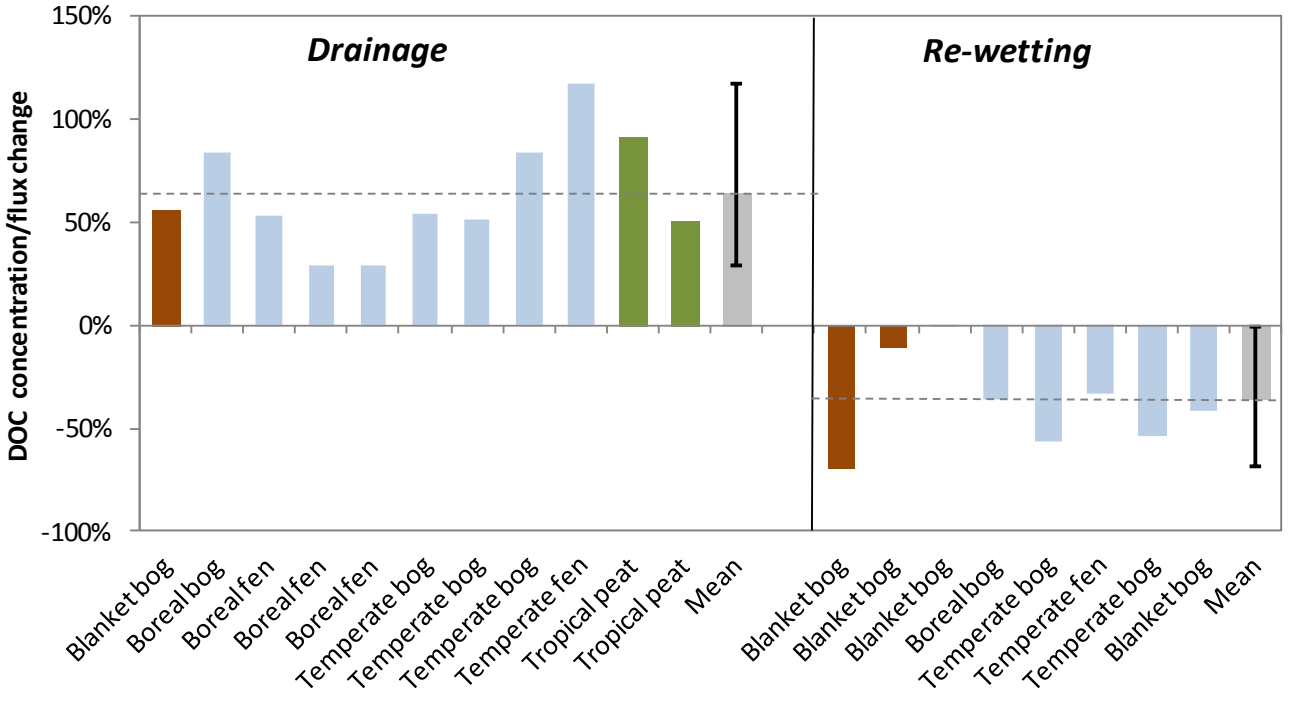
Red = drained
Black = undrained

- Around 10% of Welsh peatlands have been afforested
- At least 3000 km of drainage ditches
- Extensive areas of heavily modified bog and agricultural grassland on peat



Effects of drainage?

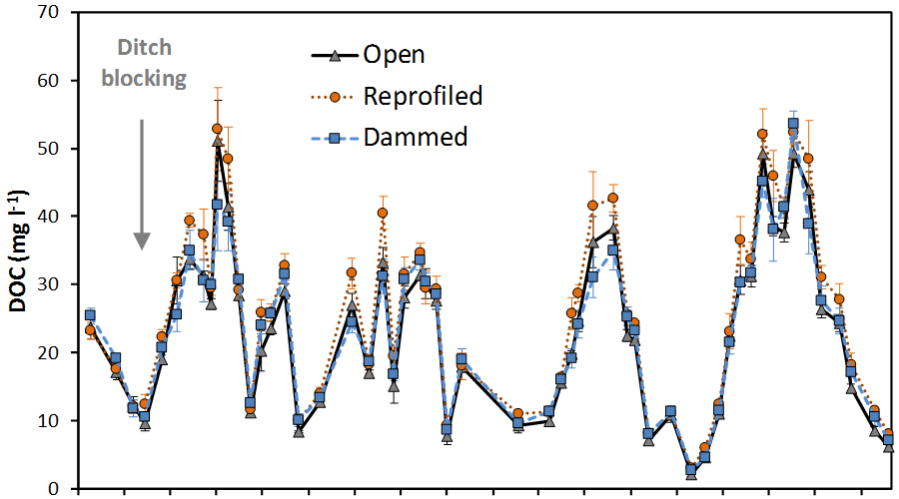




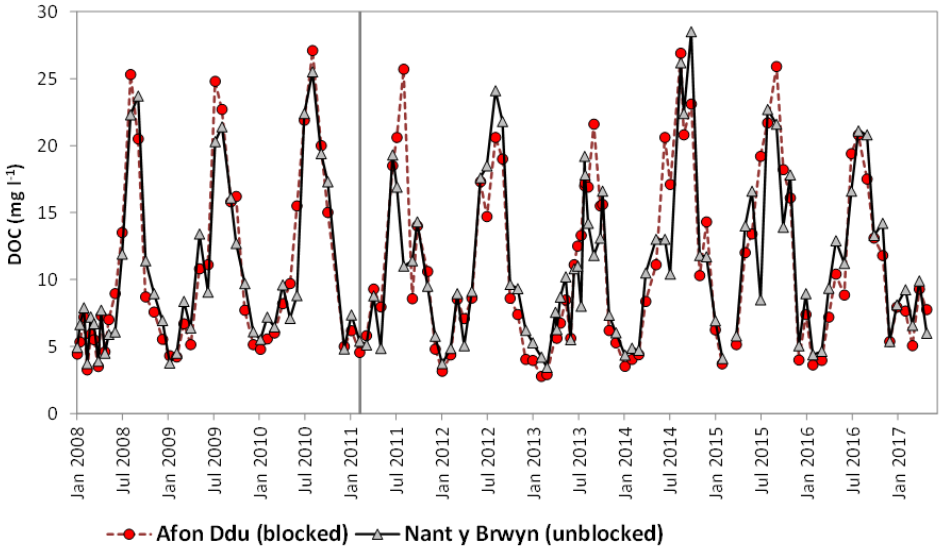
Evans et al. (2016), IPCC (2013)

DOC responses to ditch-blocking, N Wales

Hillslope Scale



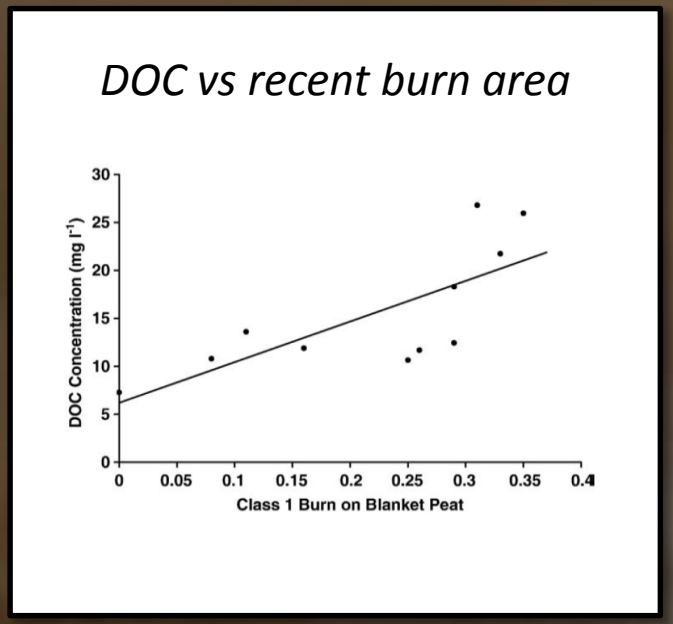
Paired Catchment Scale



Evans et al. (in review)

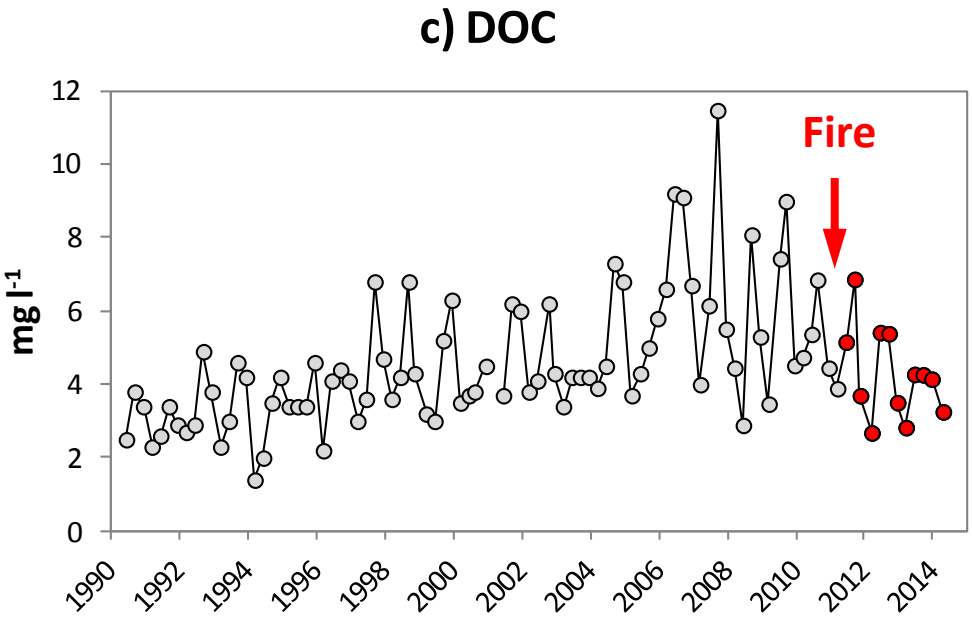
defra
Department for Environment Food and Rural Affairs

Effects of managed burning?



Yallop and Clutterbuck (2009)

Effects of a wildfire in Northern Ireland



- Fire caused DOC to decrease, not increase
- This has also been observed elsewhere (and makes some sense)
- Overall, fire seems likely to affect DOC export (e.g. via plant species changes) but evidence base is fairly weak

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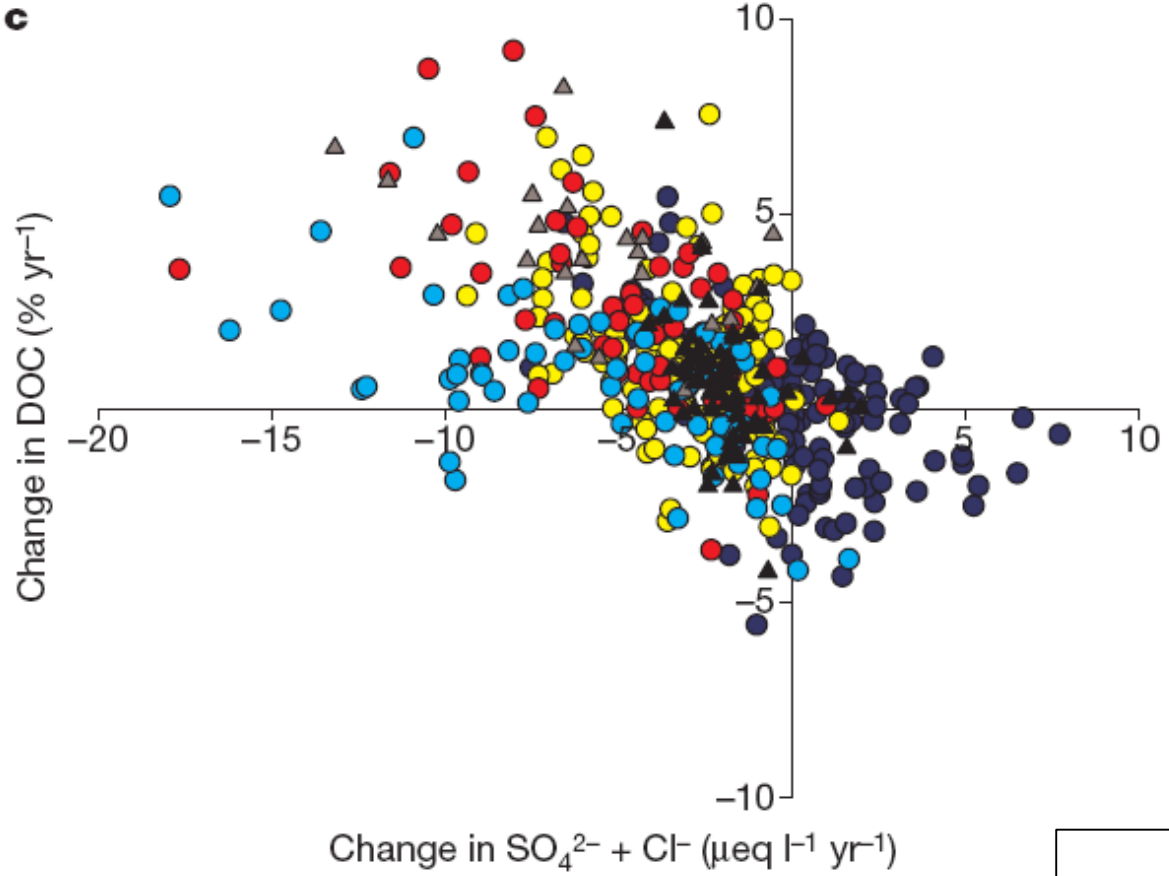
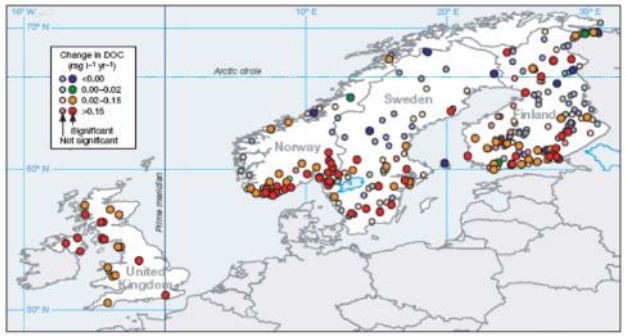
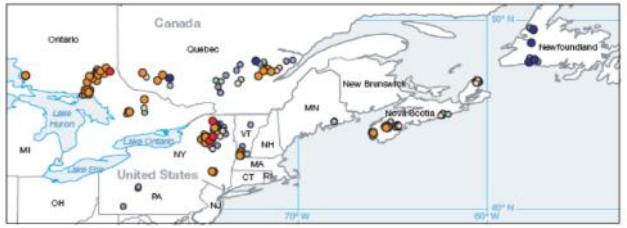
Effects of recovery from acidification?







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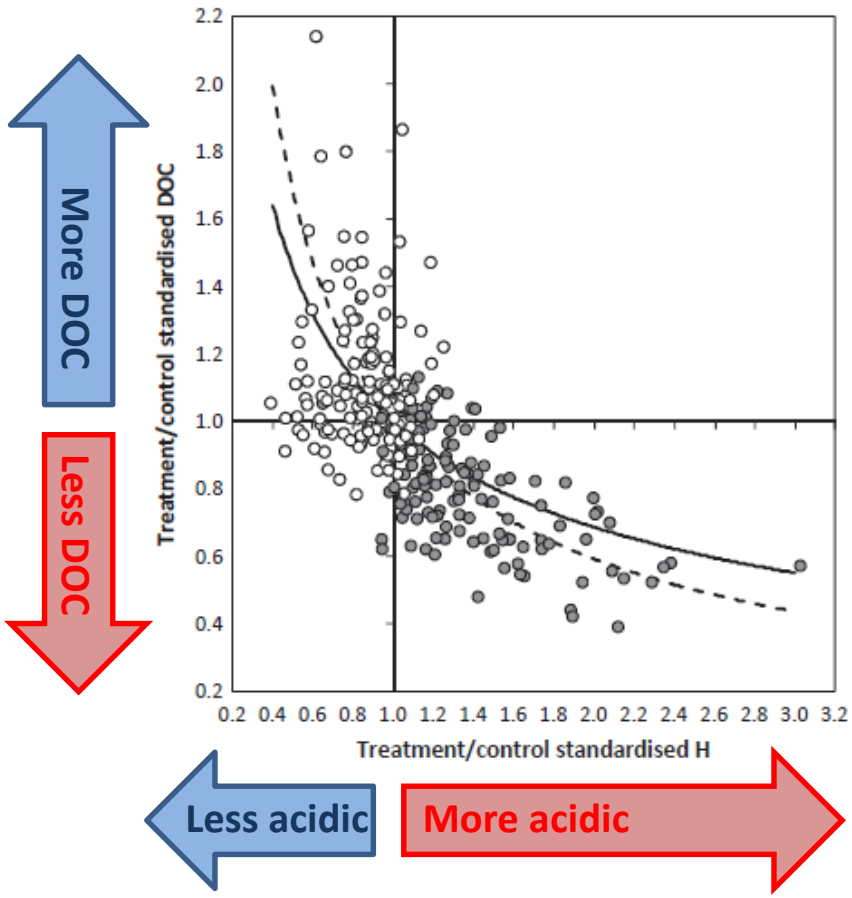

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Global Change Biology

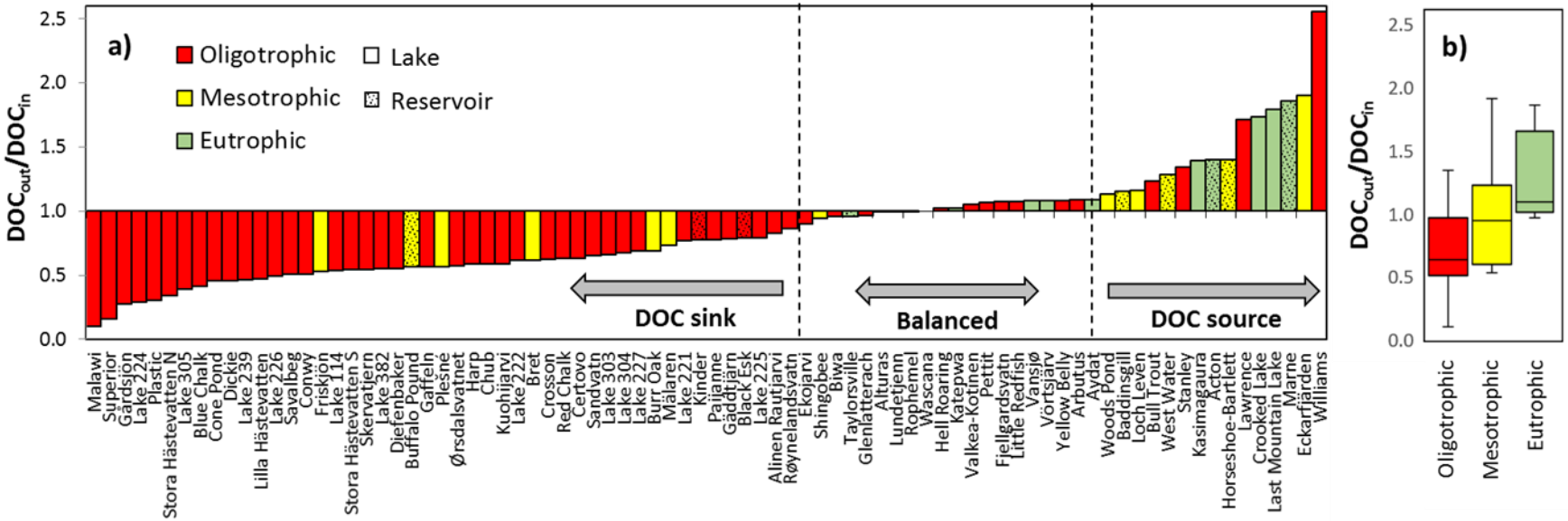
Global Change Biology (2012) 18, 3317–3331, doi: 10.1111/j.1365-2486.2012.02794.x

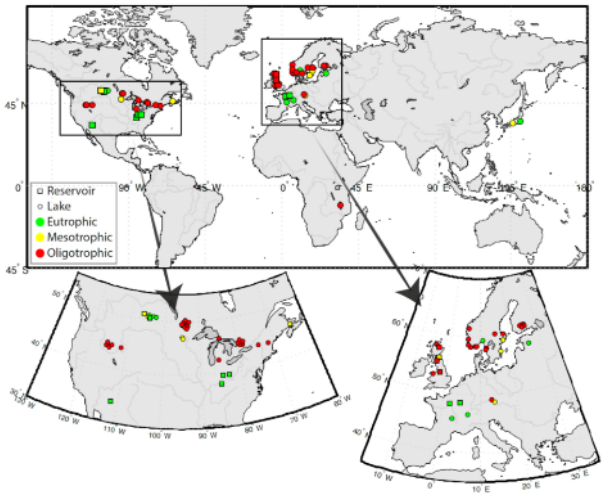
Acidity controls on dissolved organic carbon mobility in organic soils

CHRIS D. EVANS*, TIM G. JONES†, ANNETTE BURDEN*, NICK OSTLE‡, PIOTR ZIELIŃSKI†,§, MARK D. A. COOPER*†, MIKE PEACOCK†, JOANNA M. CLARK¶, FILIP OULEHLE*‖, DAVID COOPER* and CHRIS FREEMAN†

Reservoirs as carbon reactors

Lake/reservoir DOC input-output balances



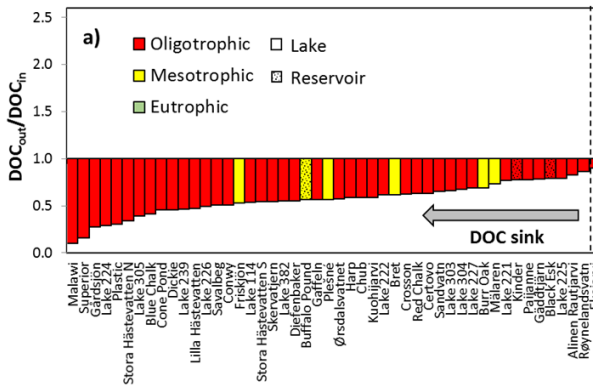


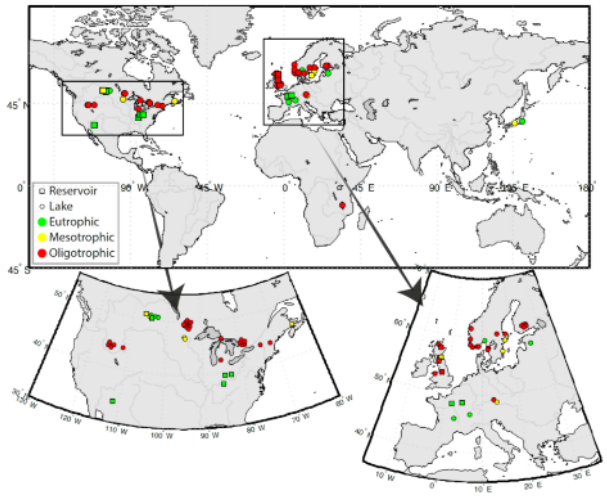
ARTICLES
PUBLISHED ONLINE: 16 OCTOBER 2017 | DOI: 10.1038/NGEO3051
nature geoscience

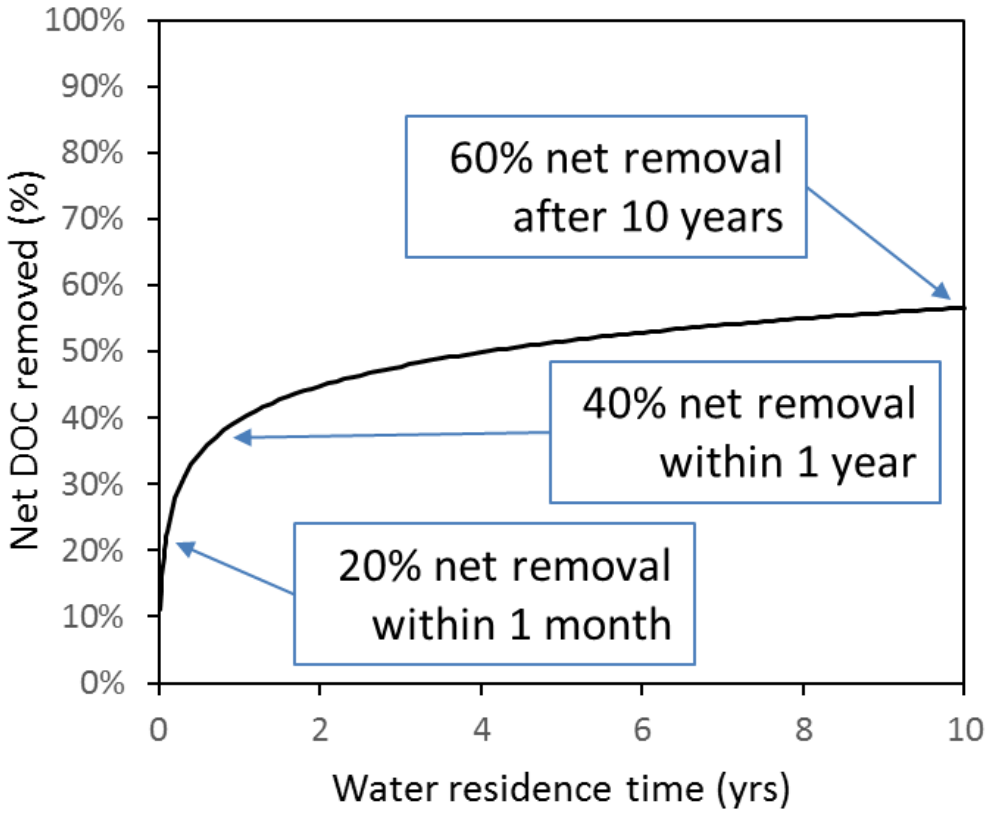
Variability in organic carbon reactivity across lake residence time and trophic gradients

Chris D. Evans[1,2*], Martyn N. Futter[2], Filip Moldan[3], Salar Valinia[4†], Zoe Frogbrook[5] and Dolly N. Kothawala[6]

DOM removal slows down over time:







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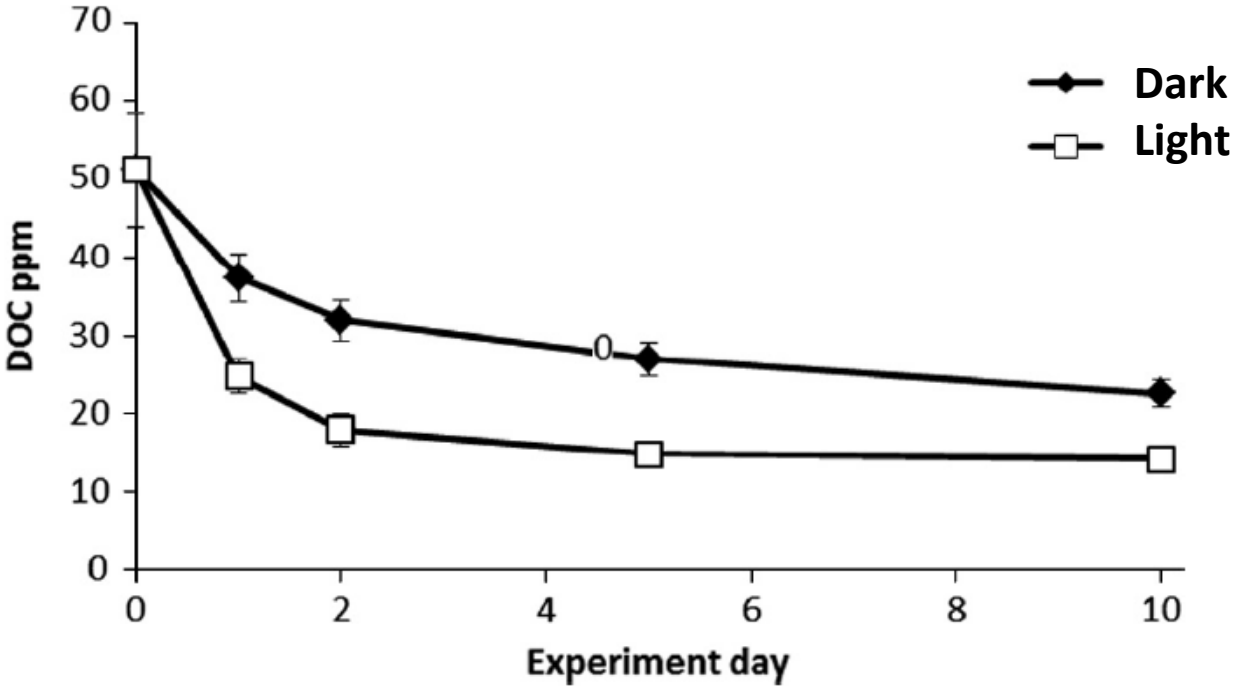
Rapid light-driven removal of ‘fresh’ DOM



Contents lists available at SciVerse ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

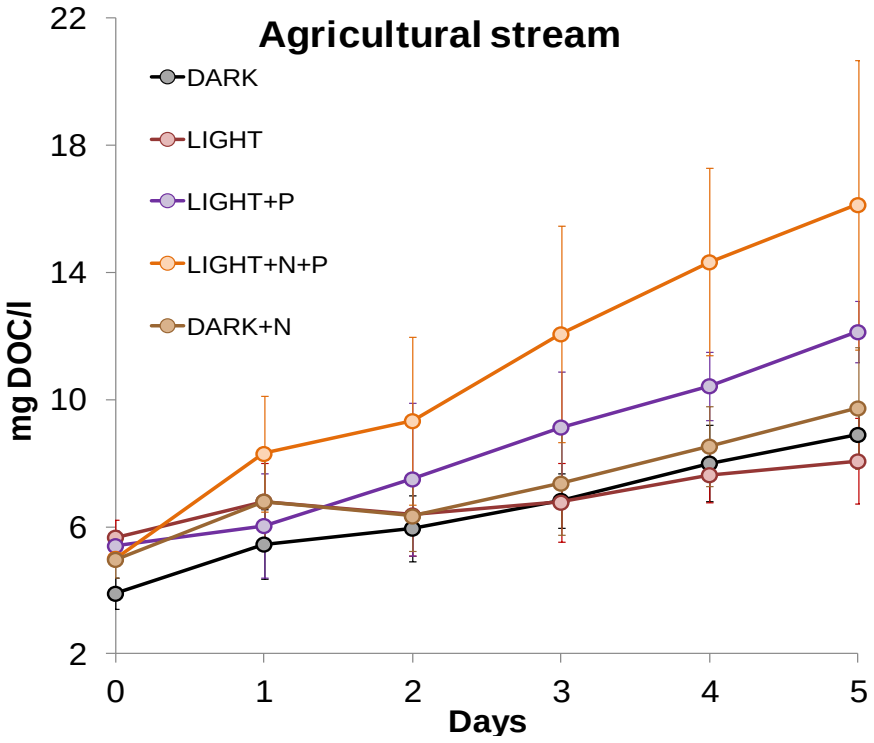
The rate of loss of dissolved organic carbon (DOC) through a catchment

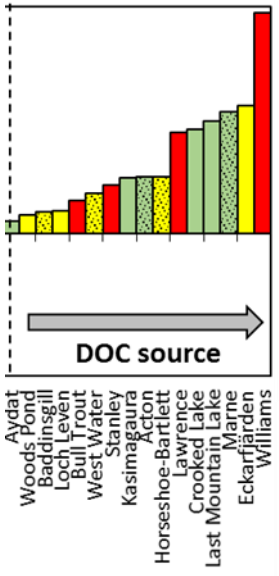
C.S. Moody [a,*], F. Worrall [a], C.D. Evans [b], T.G. Jones [c]

Nutrient pollution causes DOC production:

Farmland Stream:

Adding N& P accelerates DOC production





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Fovet et al. (in prep.)

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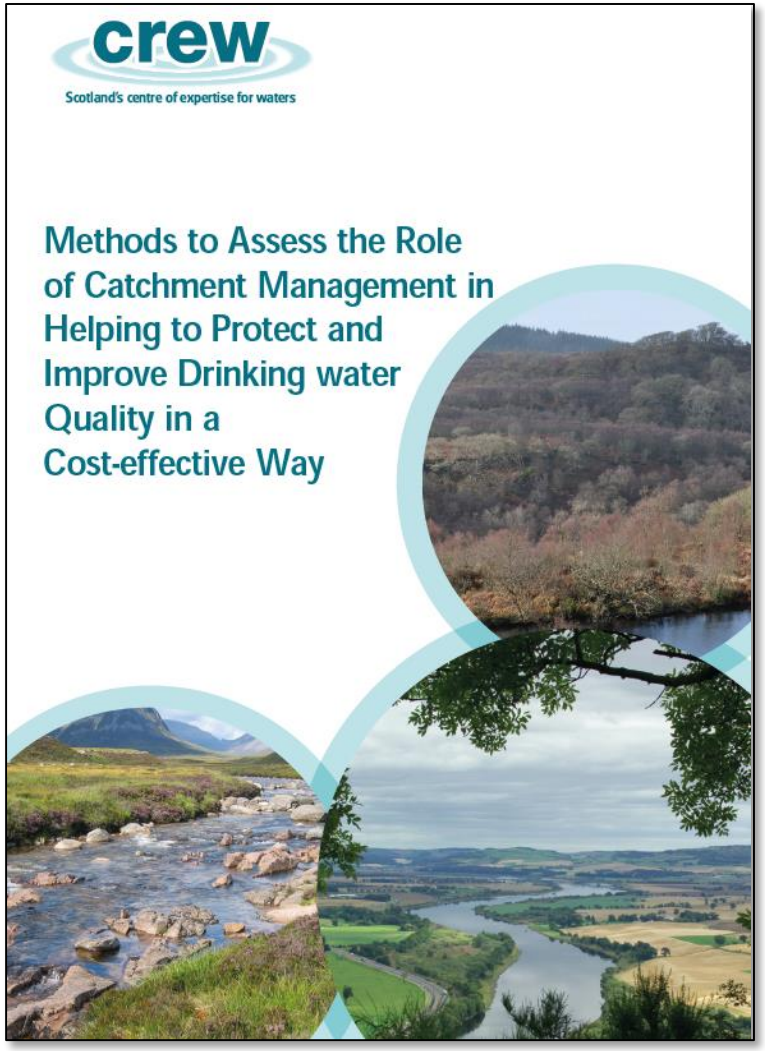
CREW Project



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Scottish Water

The James Hutton Institute

Scottish Government
gov.scot

‘CREW’ Reservoir DOM model

Eq 1) Catchment DOC production:

$$DOC_{catchment} = DOC_{baseline} \times RDOC_{acidity} \times RDOC_{drainage} \times RDOC_{burning} \times RDOC_{forest} \times RDOC_{felling}$$

Eq 2) Effects of acid deposition:

$$RDOC_{acidity} = \{\exp(-\alpha * (\Delta \ln(xSO_{4)}) + \beta)\}/100$$

Eq 3) In-reservoir DOC removal:

Water residence time

$$DOC_{outflow} = \{(DOC_{inflow} - (DOC_{inflow} \times f_{inert})\} * 0.5^{(\frac{RT}{T_{½}})} + (DOC_{inflow} \times f_{inert})$$

DOC half-life

Inert fraction

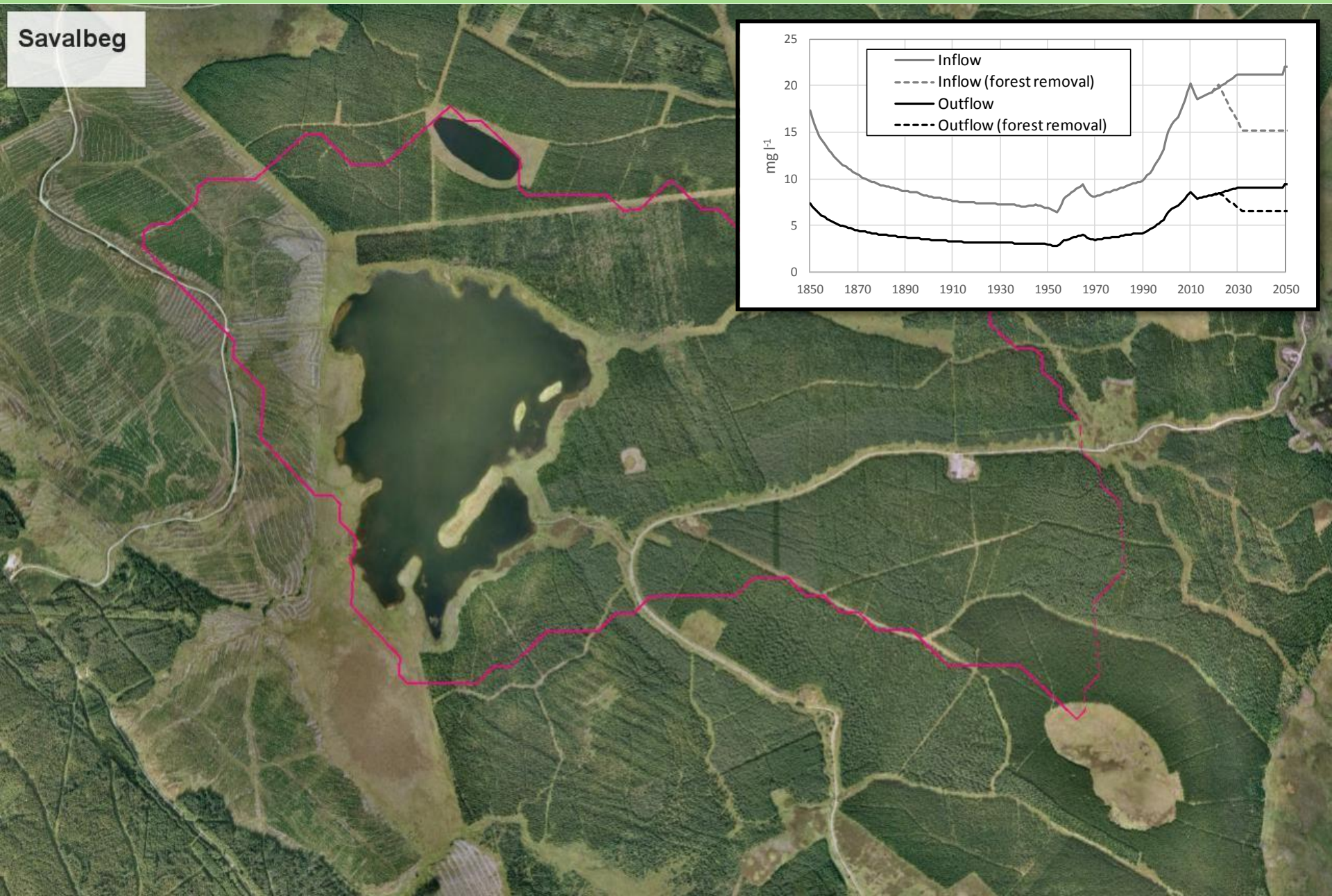
Eq 4) In-reservoir DOC production:

Internal P production

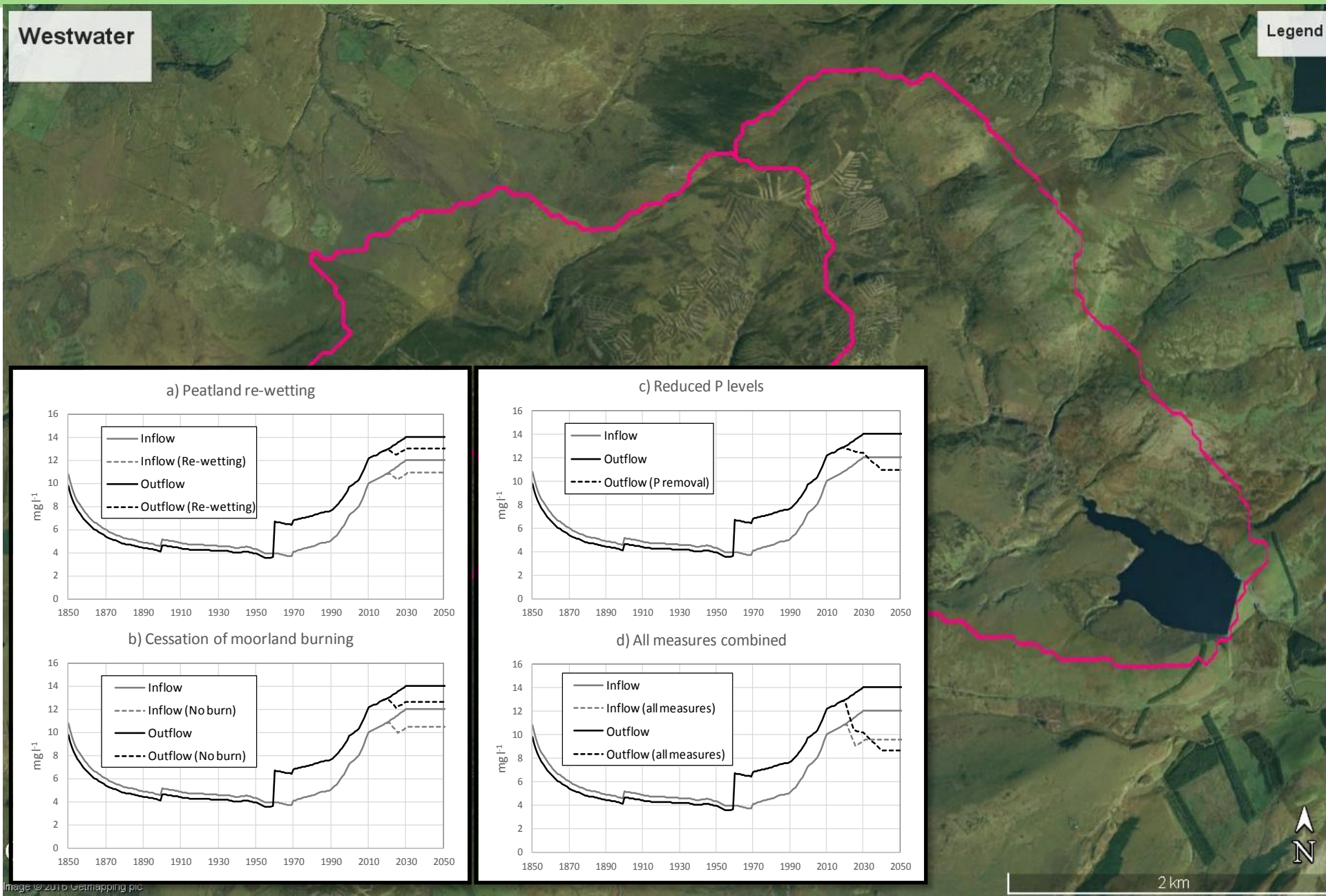
$$DOC_{aquatic} = (P_{external} + P_{internal}) \times \{DOC:DOP\}_{aquatic}$$

Catchment P input

Model simulations, Savalbeg WTW



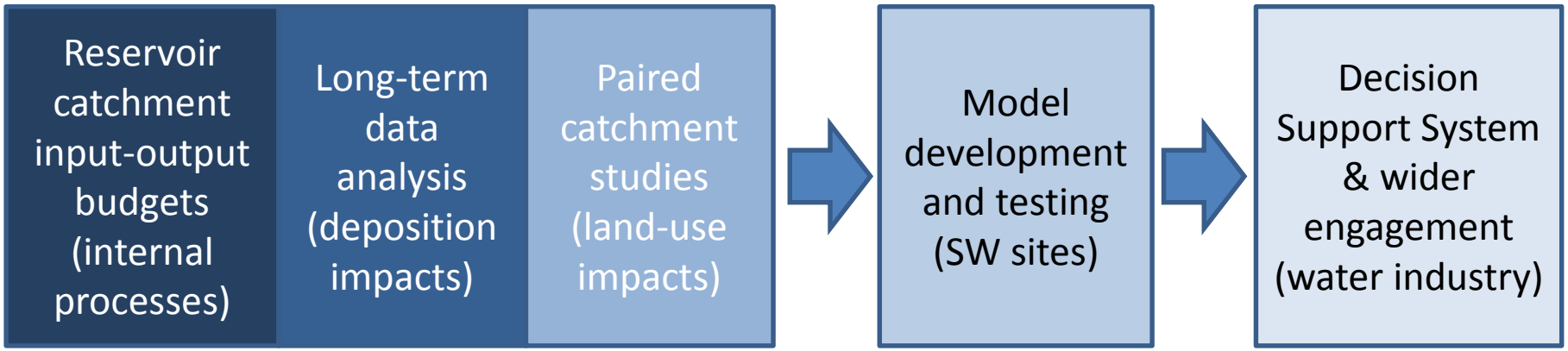
Model simulations, West Water WTW



FREEDOM Project

Forecasting **R**isk to upland water treatment assets from the **E**nvironmental **E**xacerbation of **D**issolved **O**rganic **M**atter levels

*Aims: "to equip Scottish Water, and ultimately the water industry as a whole, with scientifically robust knowledge and tools to enable the threats posed by rising DOM levels in water supplies to be addressed via a sustainable, resilient and cost-efficient combination of **mitigative** and **adaptive** solutions."*



CEH Centre for Ecology & Hydrology
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Dŵr Cymru Welsh Water

United Utilities

UISCE ÉIREANN : IRISH WATER

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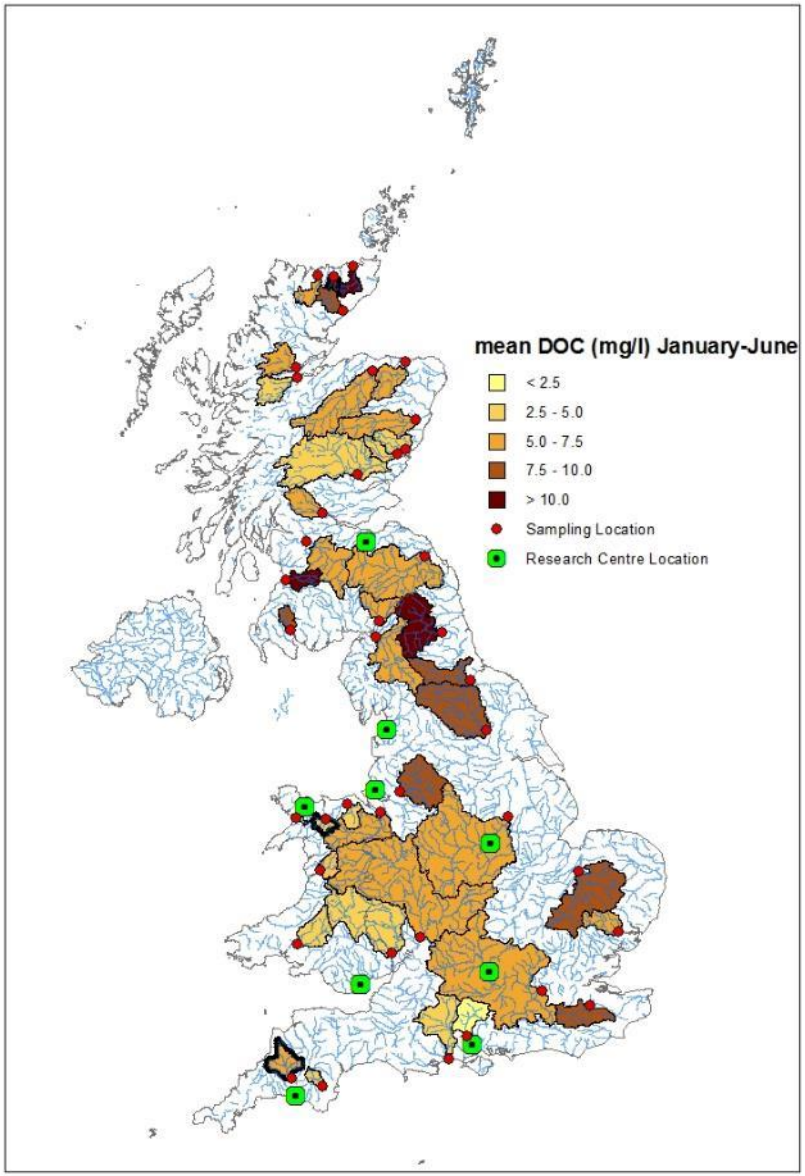
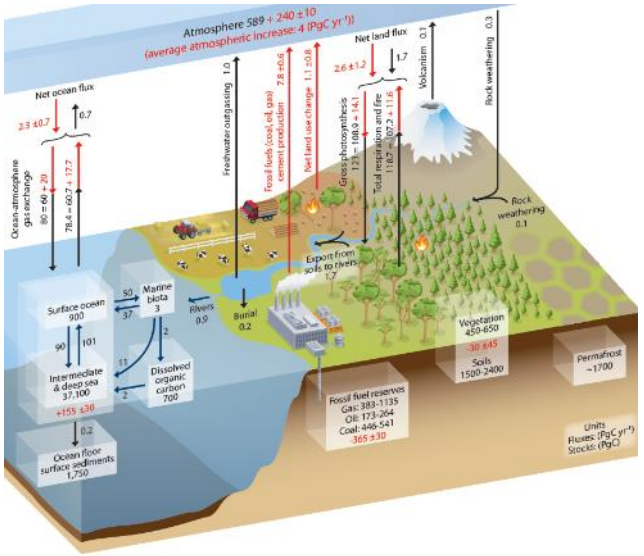
NERC LOCATE project



The role of aquatic C in the earth system



- New data on fluxes, character and processing of organic matter in UK rivers
- Conwy one of three focal study catchments
- New catchment models being developed

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Centre for Ecology & Hydrology
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PML Plymouth Marine Laboratory

Conwy Observatory: Spectrolysers

Hiraethlyn (Improved grassland)

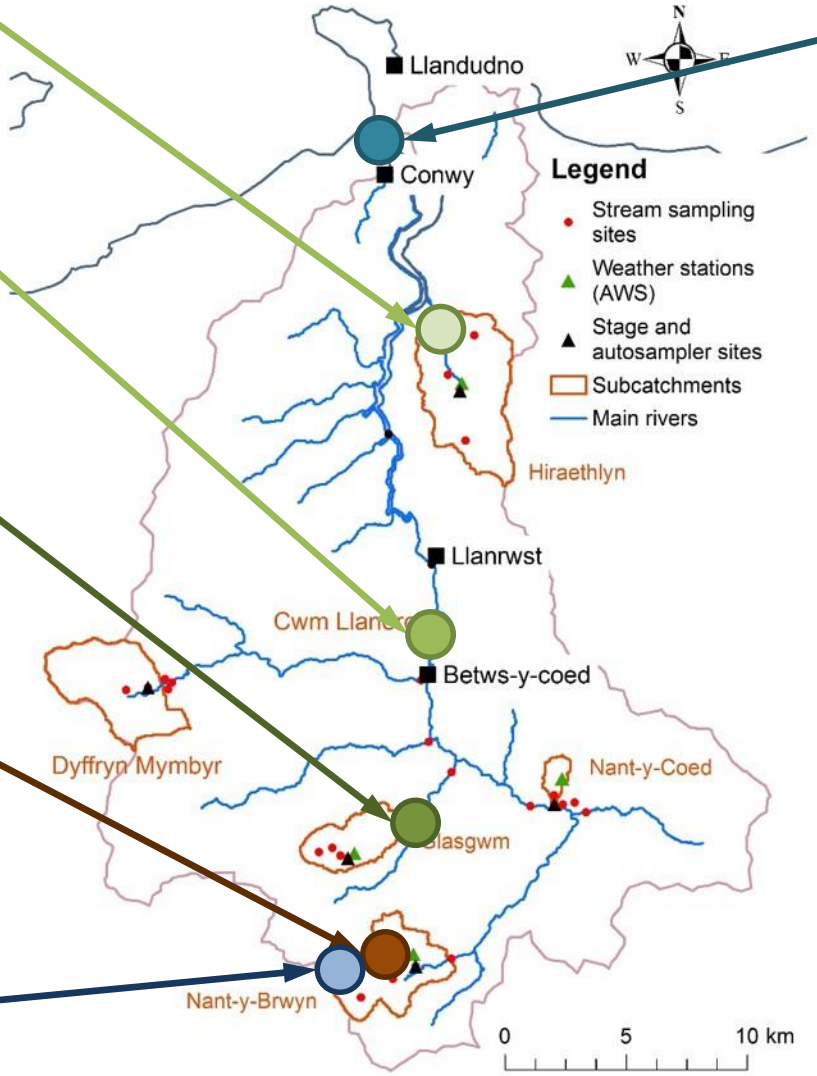
Cwm Llanerch (Tidal limit)

Glasgwm (Forest)

Nant y Brwyn (Blanket bog)

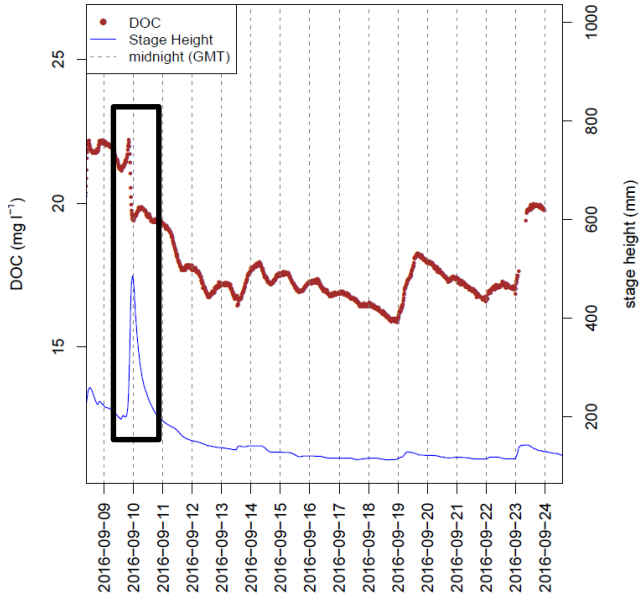
Llyn Conwy (lake)

Conwy Marina (estuary mouth)

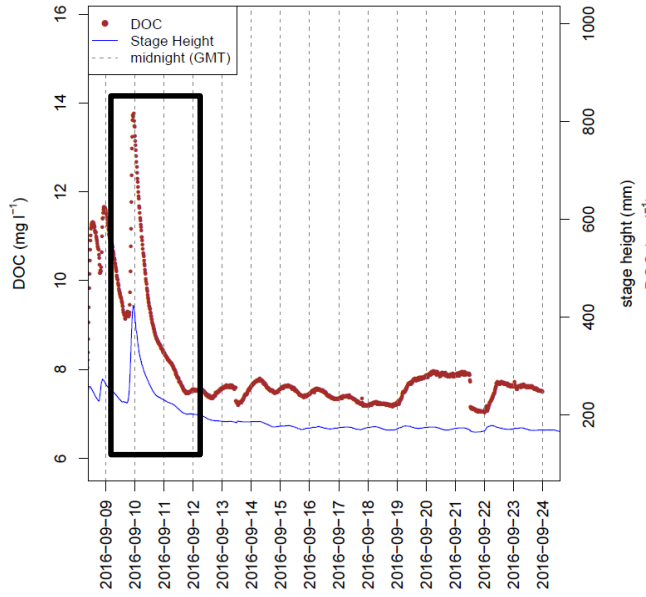


Spectrolyser data, Sep 2016

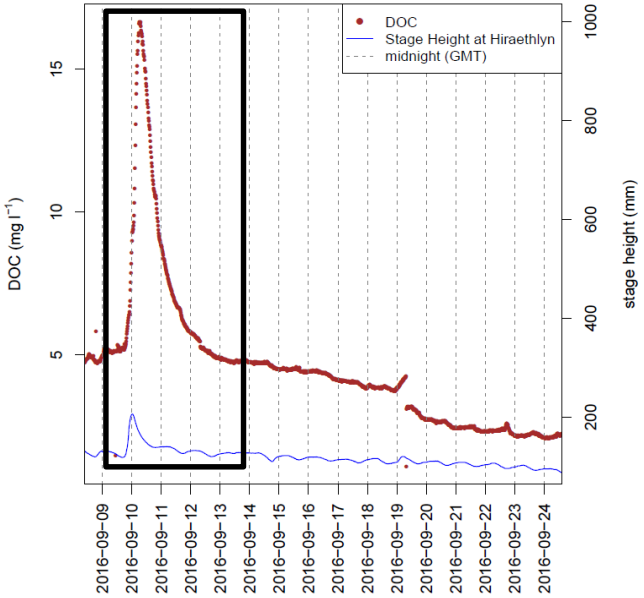
Nant y Brwyn
(blanket bog)



Glascwm
(forest on mineral soil)



Hiraethlyn
(Improved grassland)



- DOC response to rainfall was highly variable between sites, depending on soil type
- Despite a smaller flow peak, by far the largest DOC spike occurred in the farmland catchment

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‘Concluding Questions’

- Can catchment management reduce DOC export from the catchment, and if so how much?
- Are some future DOC increases unavoidable due to ongoing recovery from acidification or climate change?
- Could controlling P (or N) supply in catchments or reservoirs reduce both DOC production and taste & odour problems?
- Can we predict future water colour levels and therefore target catchment mitigation and/or capital investment in infrastructure?
- What controls DOC/water colour peaks, and can we develop real-time prediction systems to avoid high-DOC (or high-sediment) water entering treatment systems?


Thanks for listening