An aerial photograph of a lake showing various sediment patterns and colors. The water is a mix of brown, green, and grey, with some areas appearing more turbid than others. There are some small, dark spots scattered across the surface, possibly rocks or debris. The overall texture is somewhat mottled and uneven.

**How the Holocene sediment
geochemical record can help with
identifying targets for lake water total
phosphorus**

**Madeleine Moyle
John Boyle**

Department of Geography and Planning,
University of Liverpool,

How animal waste is helping turn China's lakes green

Animal husbandry is contaminating China's water and has been linked to turning lakes bright green, a phenomenon known as eutrophication



Hundreds of thousands of native fish dead in second Murray-Darling incident

An estimated 10,000 were killed just weeks ago, and locals fear native stocks could be all but wiped out this time



Fertilizers, a Boon to Agriculture, Pose Growing Threat to U.S. Waterways

BBC NEWS navigation menu with categories like Home, UK, World, Business, Politics, Tech, Science, Health, Family & Education, and a sub-menu for Suffolk.

Reservoir near Ipswich shuts Aqua Park due to algae health risks

SPECIAL REPORT: WATER

Rivers and lakes

Poisoned and over-exploited, many rivers are in a parlous state

Three different approaches are trying to improve that



Print edition | Special report > Feb 28th 2019



Why should we care?

SPECIAL REPORT: WATER

Water conflicts

Disputes over water will be an increasing source of international tension

Violence over water access is on the rise

Twitter post from Lakes Rangers (@LakesRangers) about blue green algae found near Woodend.

100% Pure? New Zealand's deteriorating water raises a stink

Praveen Menon

6 MIN READ



Our lakes are dying, city sinking with them

DECCAN CHRONICLE | LAKSHEEV THAKUR

Updated Jun 20, 2019, 7:40 am IST



n, Mysuru etc, the lakes were found to have been classified categories.

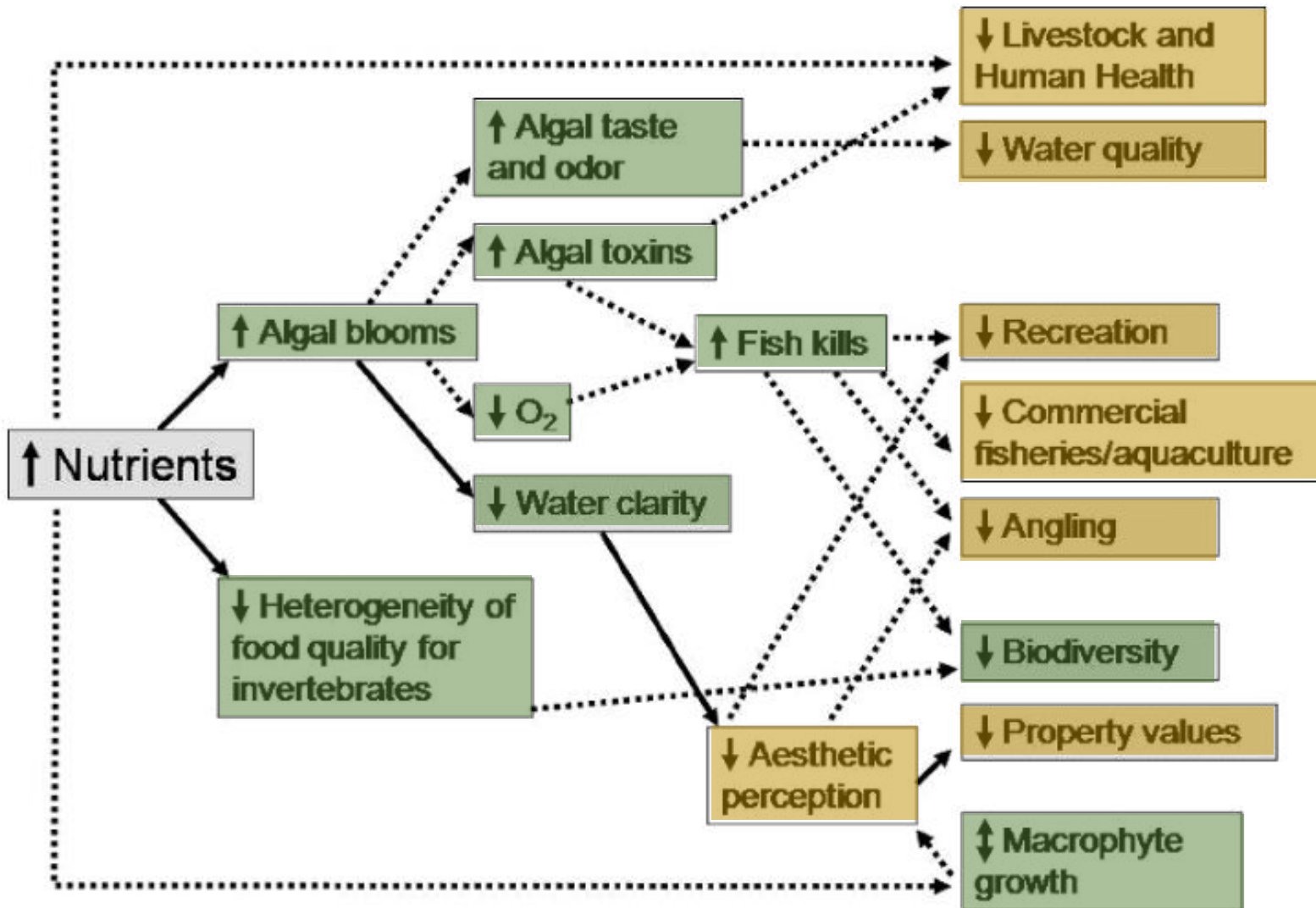


New commission aims to restore river Wye and Lugg water quality

3 Oct



Survey reveals increased pollutants at Windermere

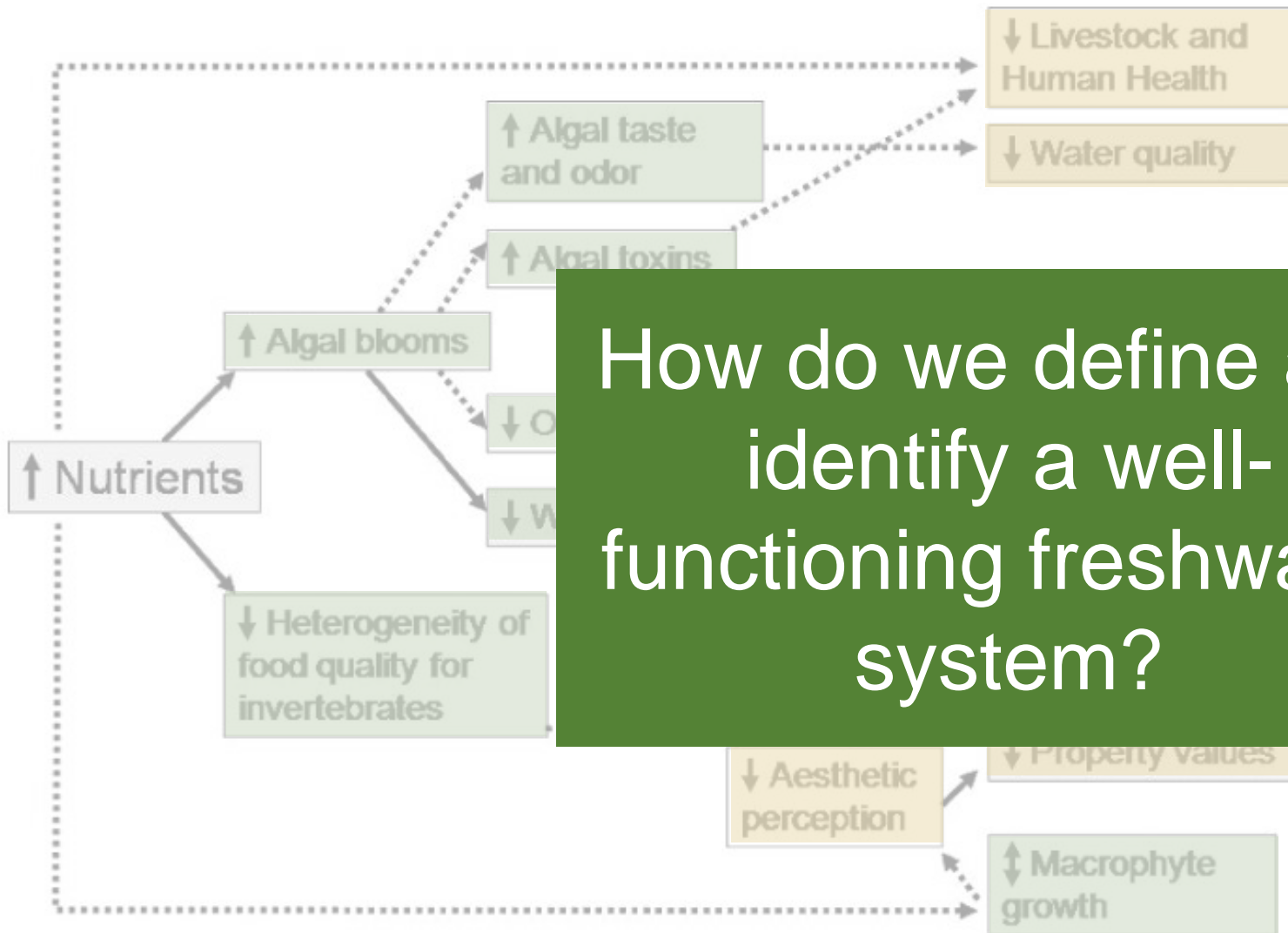


Biological/
ecological

Socio-
economic

After Dodds et al. 2009

Human systems are reliant on well-functioning natural systems



How do we define and identify a well-functioning freshwater system?

Biological/
ecological

Socio-
economic

After Dodds et al. 2009

Human systems are reliant on **well-functioning** natural systems

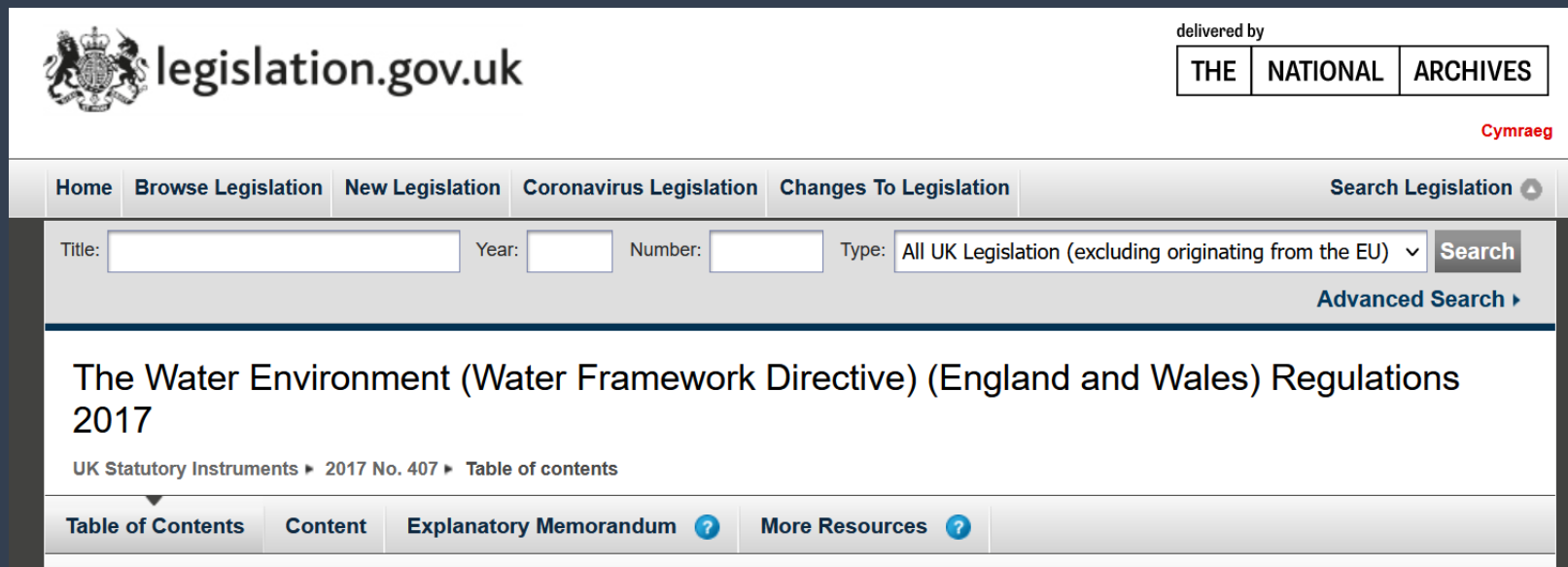
Managing our environment

WFD good ecological status:

“The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.”

— Annex V, Water Framework Directive

Essentially lakes should show minimal (or no) signs of human impact



The screenshot shows the UK legislation.gov.uk website. At the top left is the Royal Coat of Arms and the text 'legislation.gov.uk'. To the right, it says 'delivered by THE NATIONAL ARCHIVES' and 'Cymraeg'. Below this is a navigation bar with links for Home, Browse Legislation, New Legislation, Coronavirus Legislation, and Changes To Legislation, along with a Search Legislation button. A search bar contains fields for Title, Year, Number, and Type (set to 'All UK Legislation (excluding originating from the EU)'), with a Search button and an Advanced Search link. The main content area displays the title 'The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017' and a link to the Table of contents. At the bottom, there are tabs for Table of Contents, Content, Explanatory Memorandum, and More Resources.

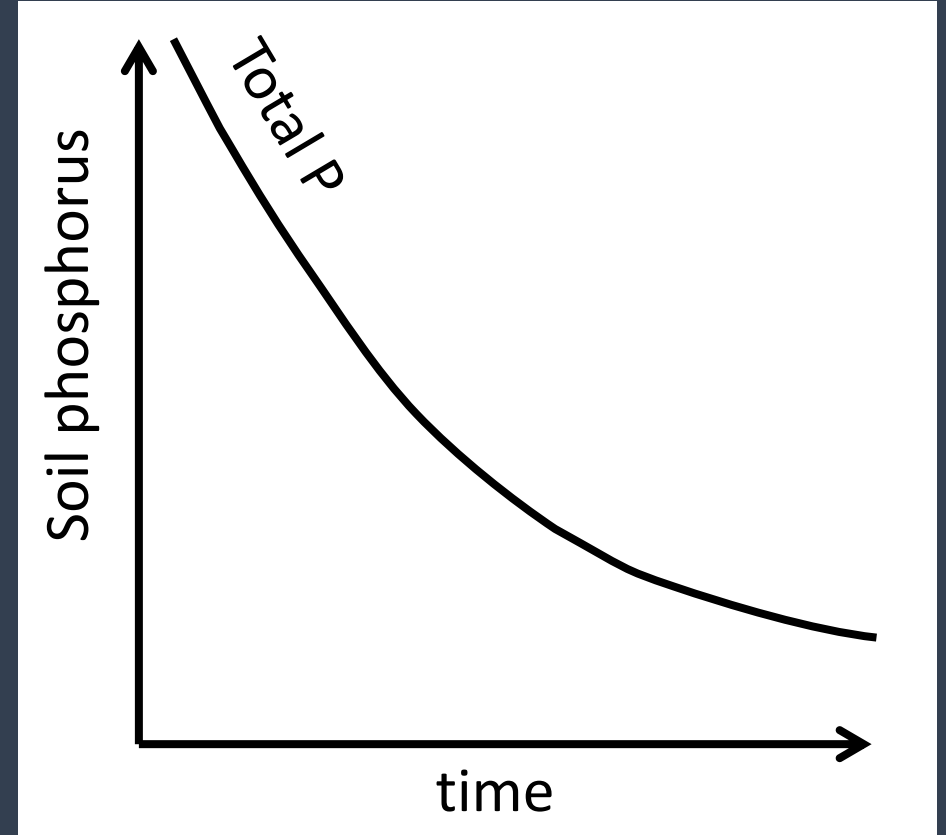


What is 'natural'?

How can we tell if lakes have been impacted by humans?

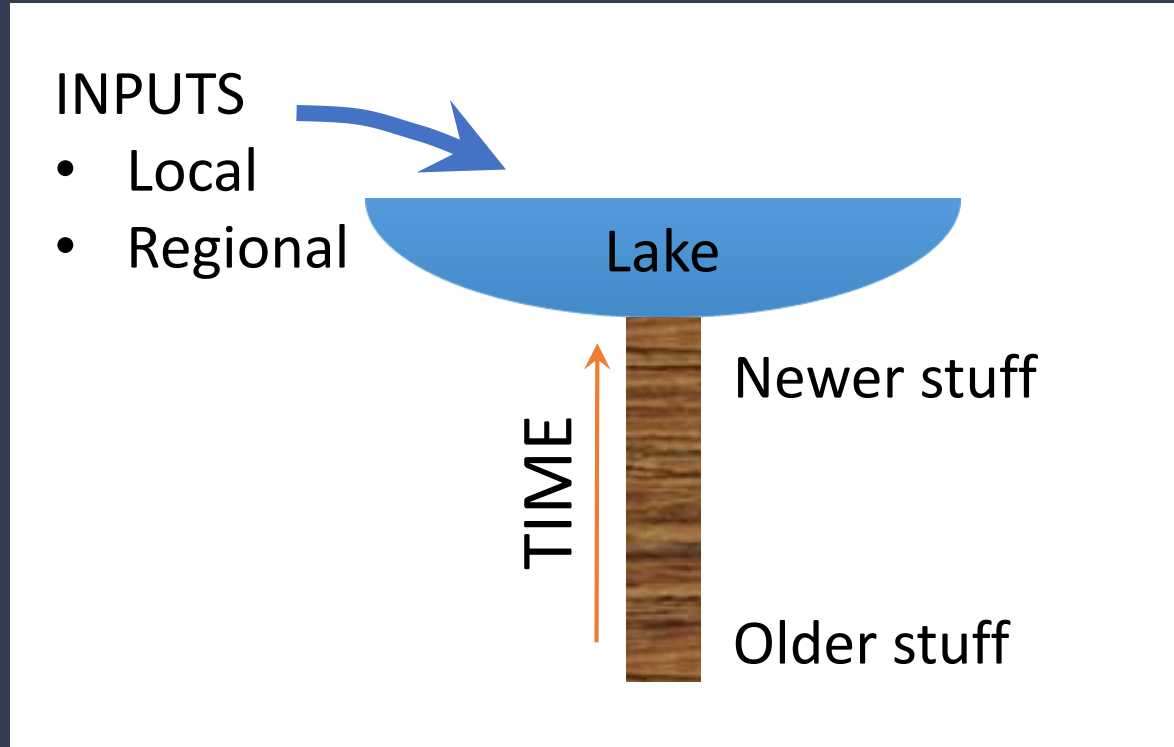
We need to understand how the natural system behaves to identify our reference condition / "natural" state

The theory says: phosphorus should decline naturally throughout time without (human) disturbance

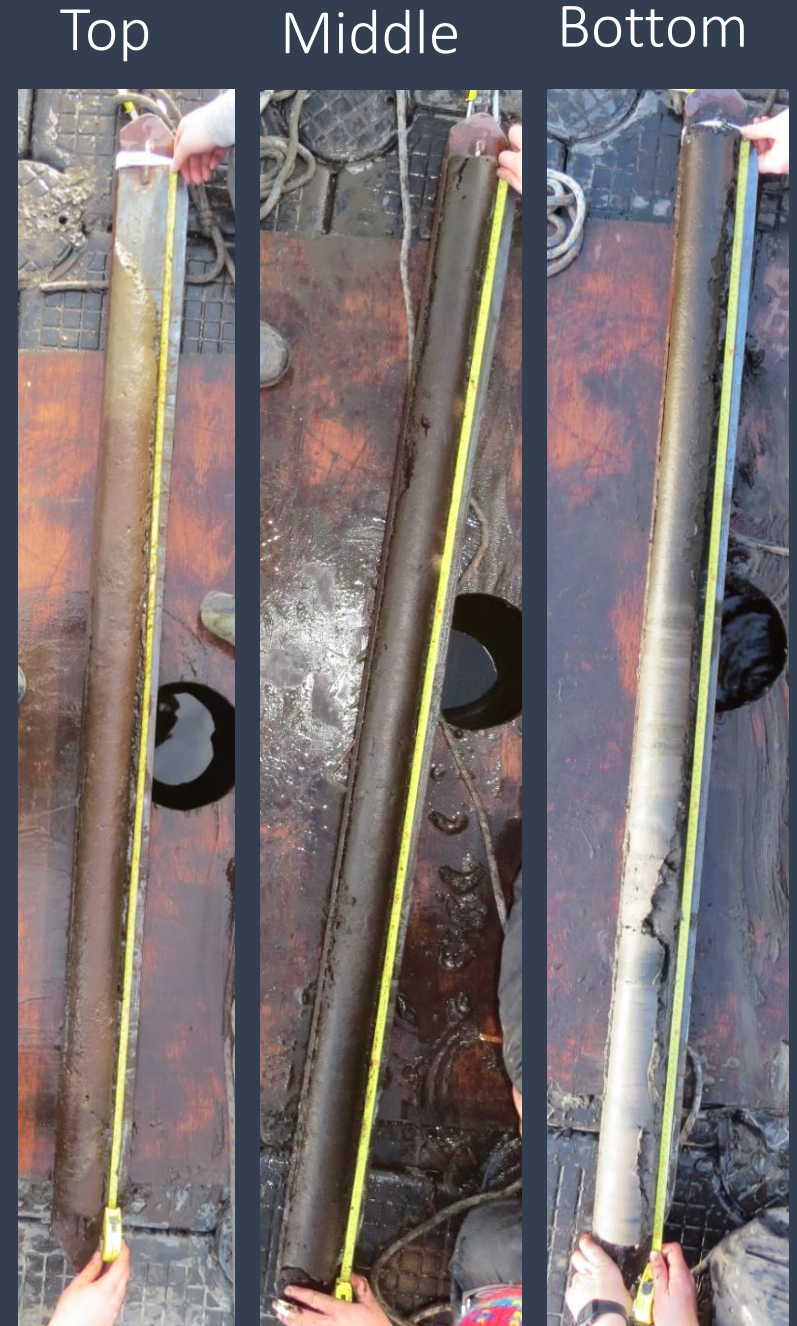


Walker & Syers 1976 (redrawn)

Using the palaeo record



Lake sediments provide a record of change through time



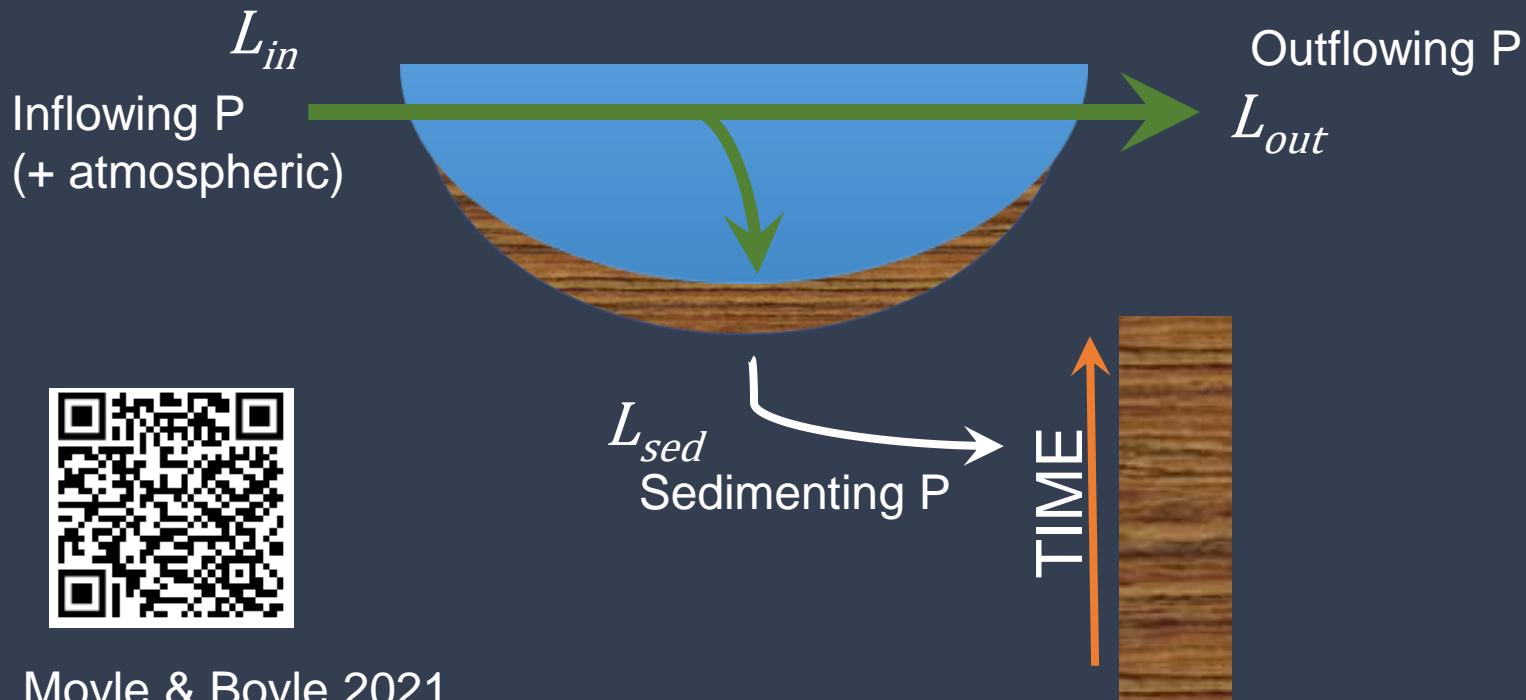
Historic lake P records from sediment cores

If we consider the P in the lake as a mass balance then:

$$L_{in} = L_{sed} + L_{out}$$

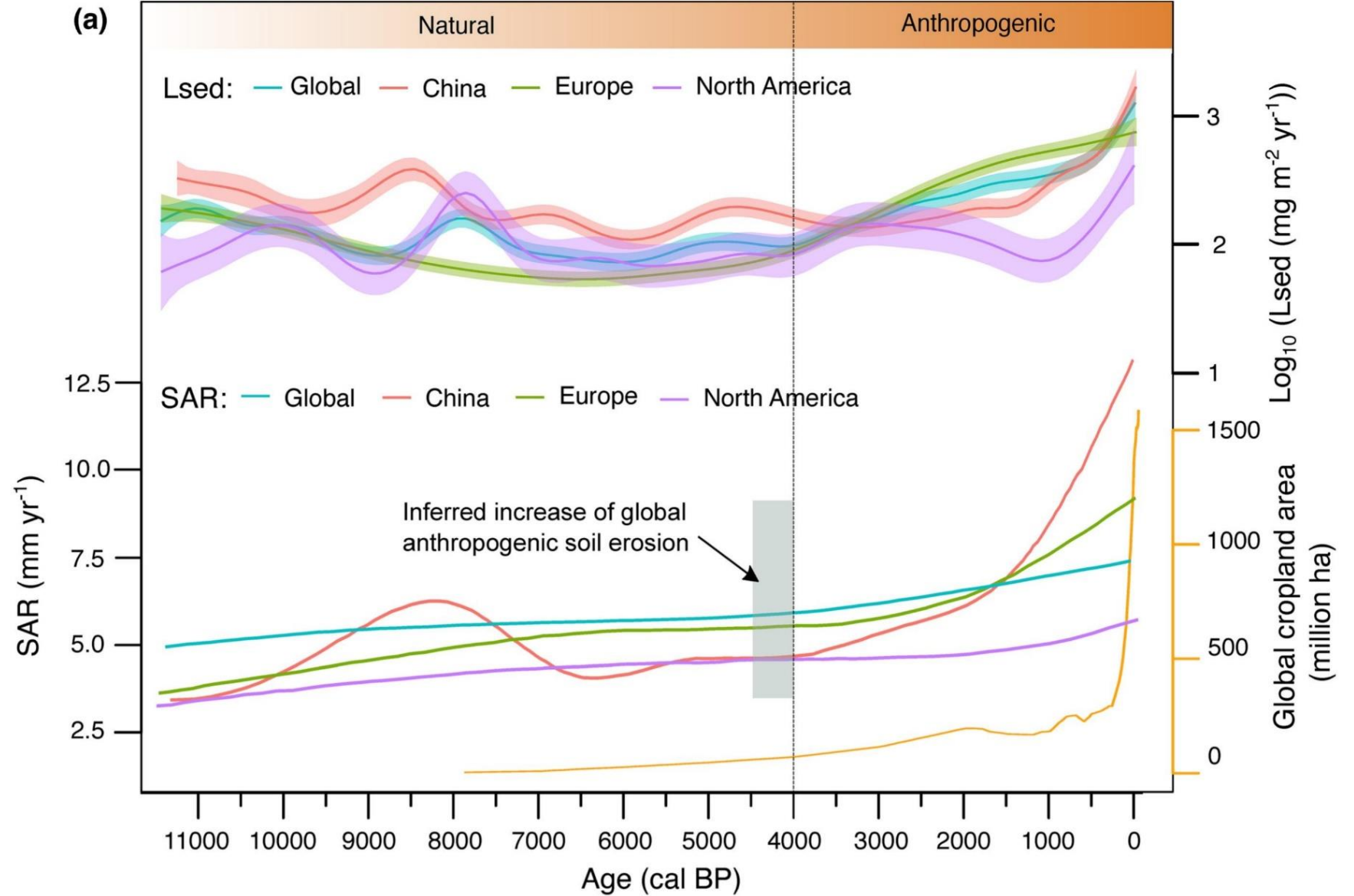
We can calculate sediment-inferred lake water TP (SI-TP) using:

$$SI-TP = \frac{L_{sed}}{R_P q_s} (1 - R_P)$$



L	P loading (area normalised P flux)	mg/m ² LA/yr
q _s	Areal water load (i.e. Q/LA)	m/yr
R _P	P retention coefficient (how well the sediment retains P)	-
	$R_P = \frac{L_{in} - L_{out}}{L_{in}} = \frac{L_{sed}}{L_{in}}$	

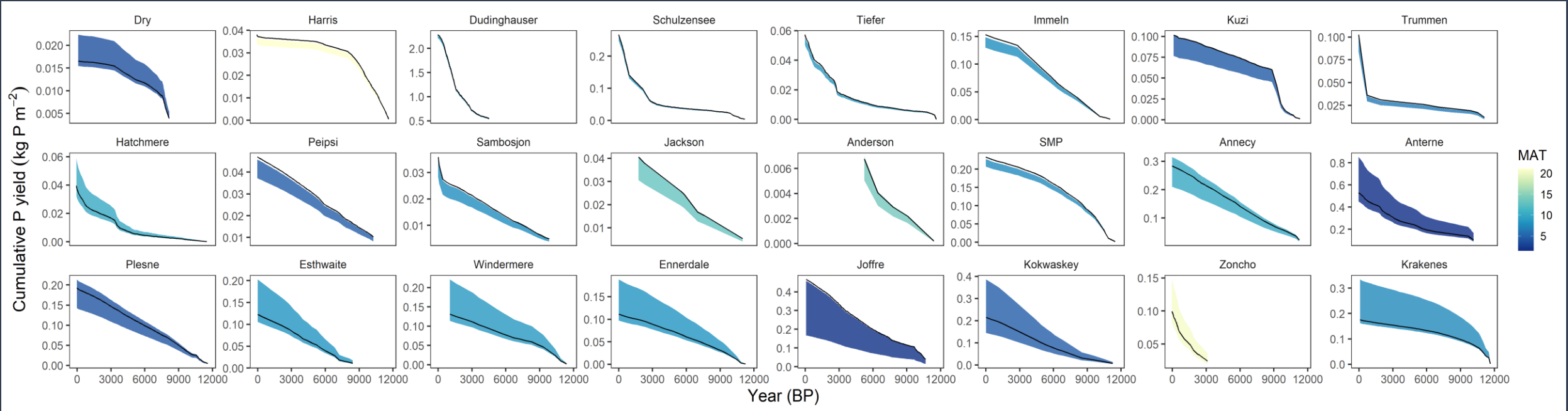
Historic lake P records from sediment cores



Tu et al 2023



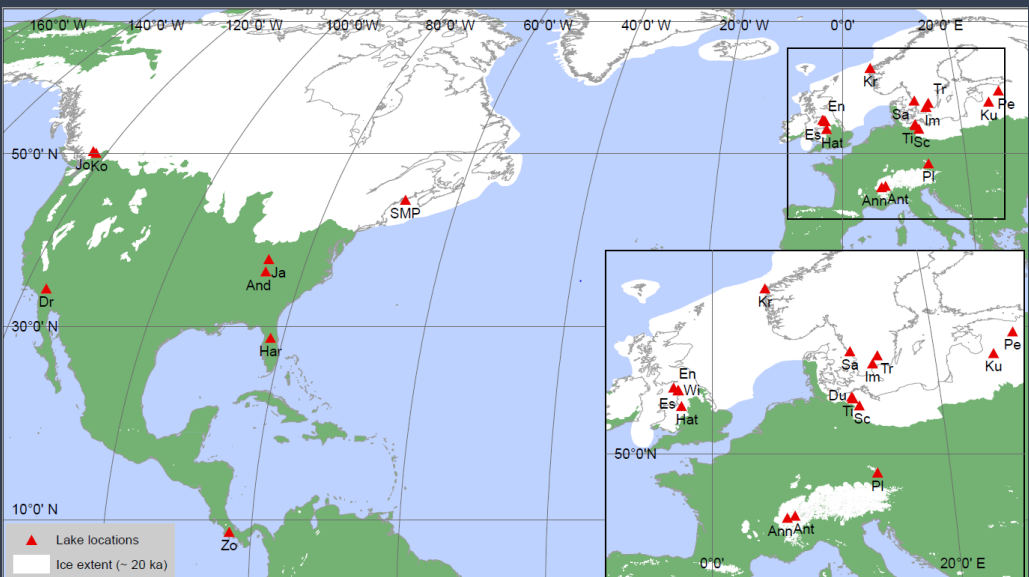
Historic lake P records from sediment cores



← time

Using the sediment record we can look at long term trends, natural baselines and earliest impacts

Moyle et al 2021



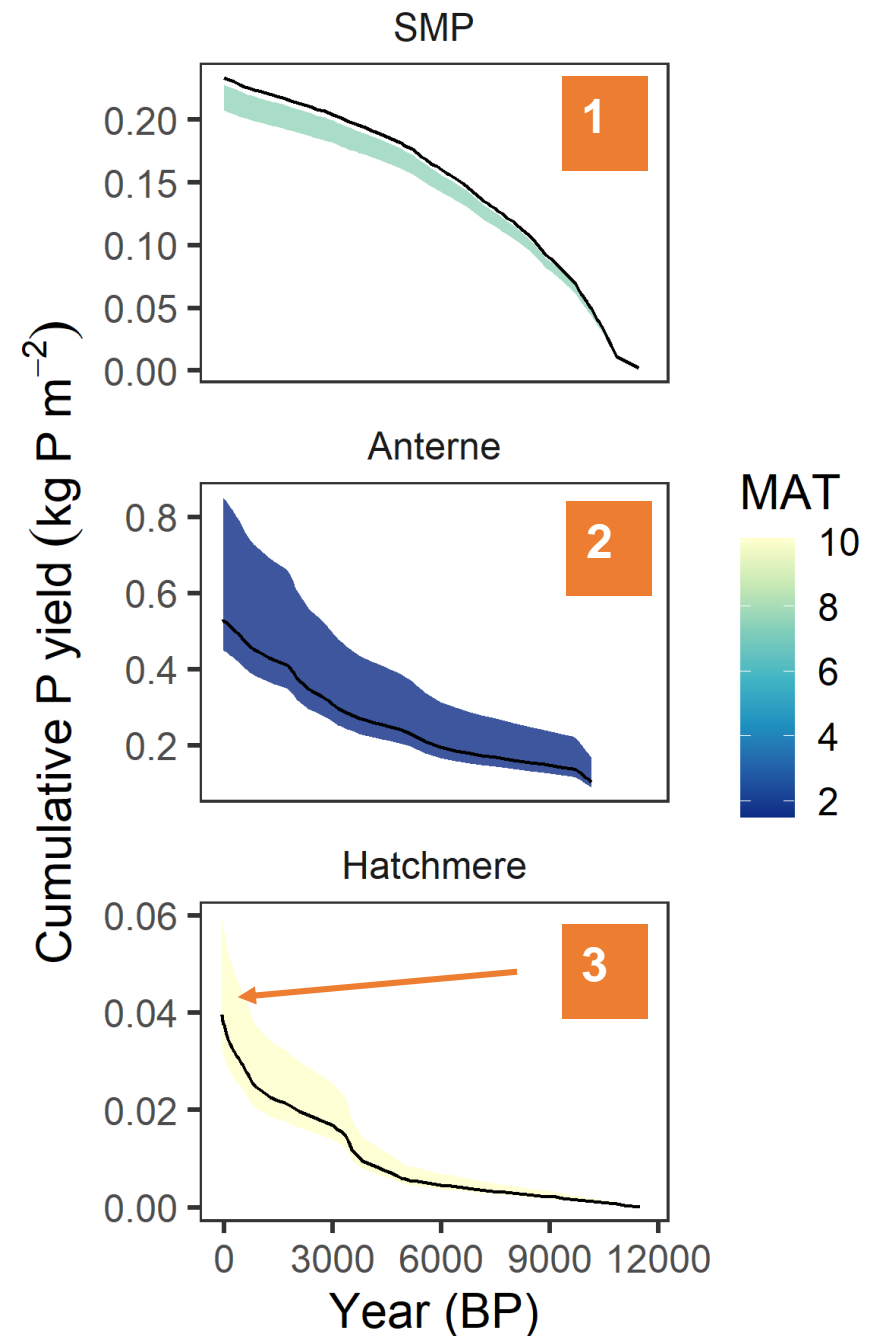
Disentangling human and natural

Trait 1 glacially reset landscapes remote from intense human impact.

Trait 2 landscapes with early farming and/or neoglaciation (mobilising catchment P stocks).

Trait 3 landscapes near modern population centres or in intensive agricultural landscapes.

Can we identify natural baseline TP based on land use history?



Summary

The palaeo record can be used to identify natural baselines and when human activity began to disrupt natural systems

We need to look at millennial timescales to see natural baselines

Landscape types may offer a novel way of defining TP targets

The palaeo record can be used to explore our options for future landscapes, we can test hypotheses and modelled scenarios to choose meaningful and achievable targets

Say hello!

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