Nitrogen in UK Upland Waters

Don Monteith &

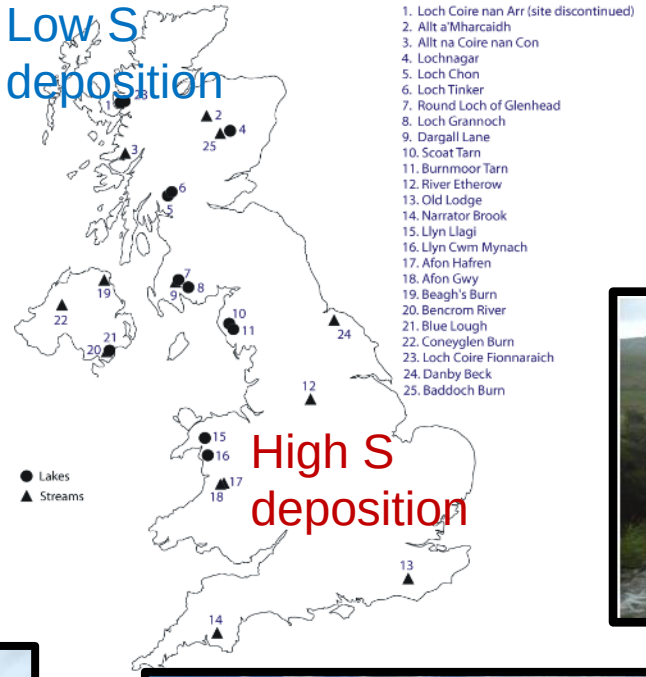
UK Upland Waters Monitoring Network team

UK Centre for Ecology & Hydrology

UK Upland Waters Monitoring Network: Est 1988.

11 streams and 12 lakes

Low S deposition



High S deposition

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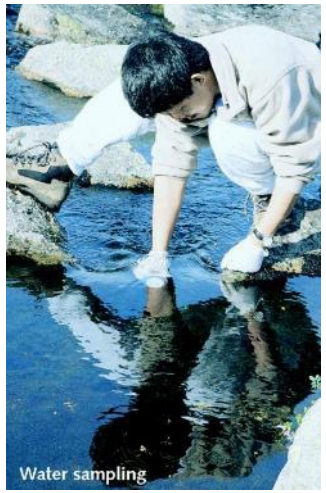
Site photos: Ewan Shilland

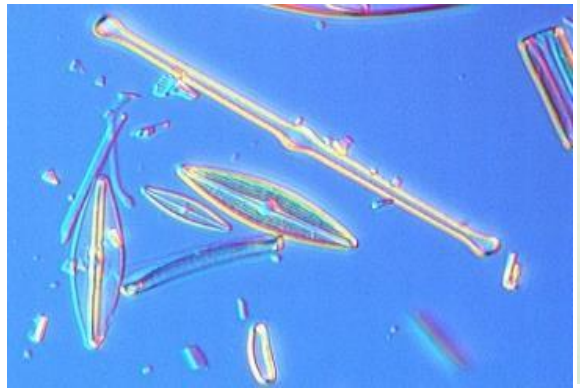
UWMN measurements

annual / biannual biological sampling



Water chemistry

Aquatic macrophytes



epilithic diatoms

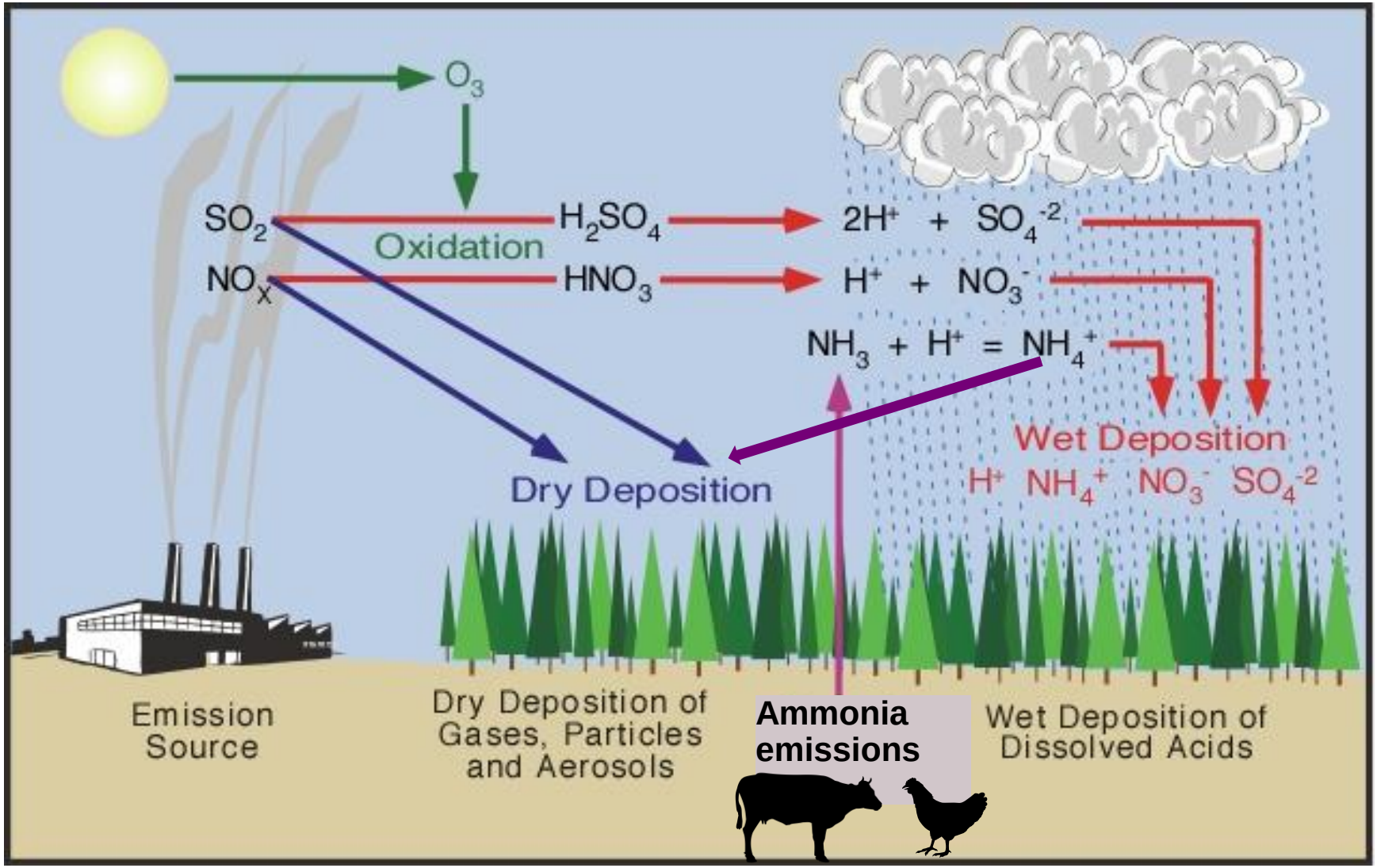
macroinvertebrates

Nitrogen and life

- Component of all living organisms
- Essential component of many biomolecules, including proteins, DNA and chlorophyll
- While N_2 most abundant gas in atmosphere – mostly unavailable to living organisms….
- …therefore, availability often limits the primary productivity of natural ecosystems
- Strategies evolved to secure nitrogen in N-limited systems, e.g. insectivorous plants

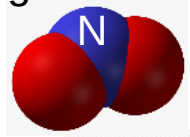
Utricularia intermedia - photo Ben Goldsmith

Nitrogen as an acidifier

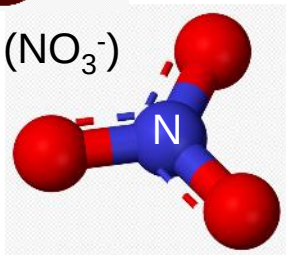


Oxidised nitrogen

Nitrogen dioxide (NO_2)

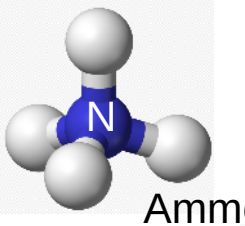


Nitrate (NO_3^-)

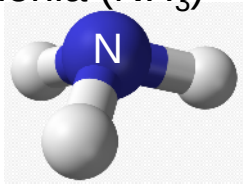


Reduced nitrogen

Ammonium (NH_4^+)



Ammonia (NH_3)



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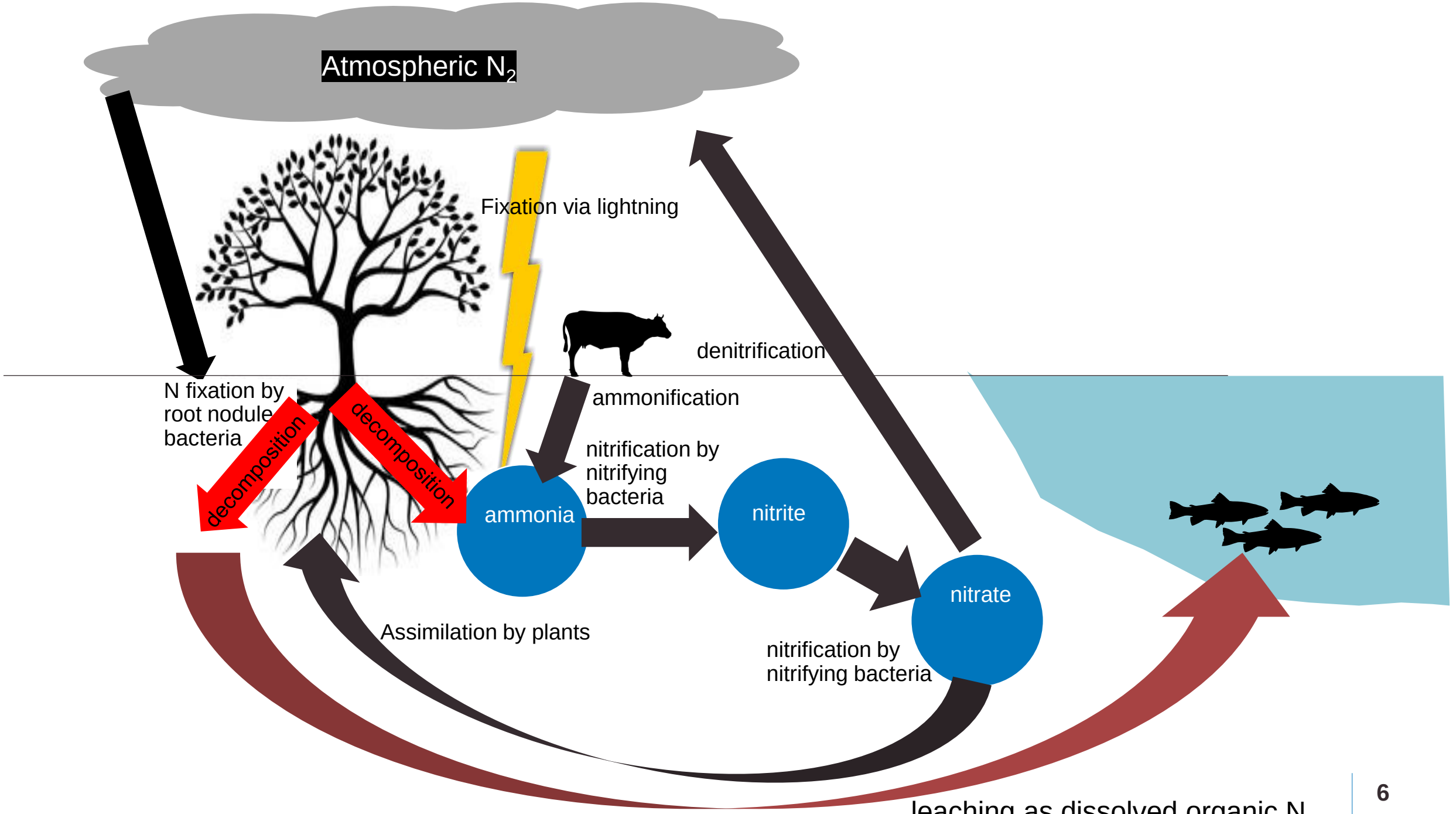
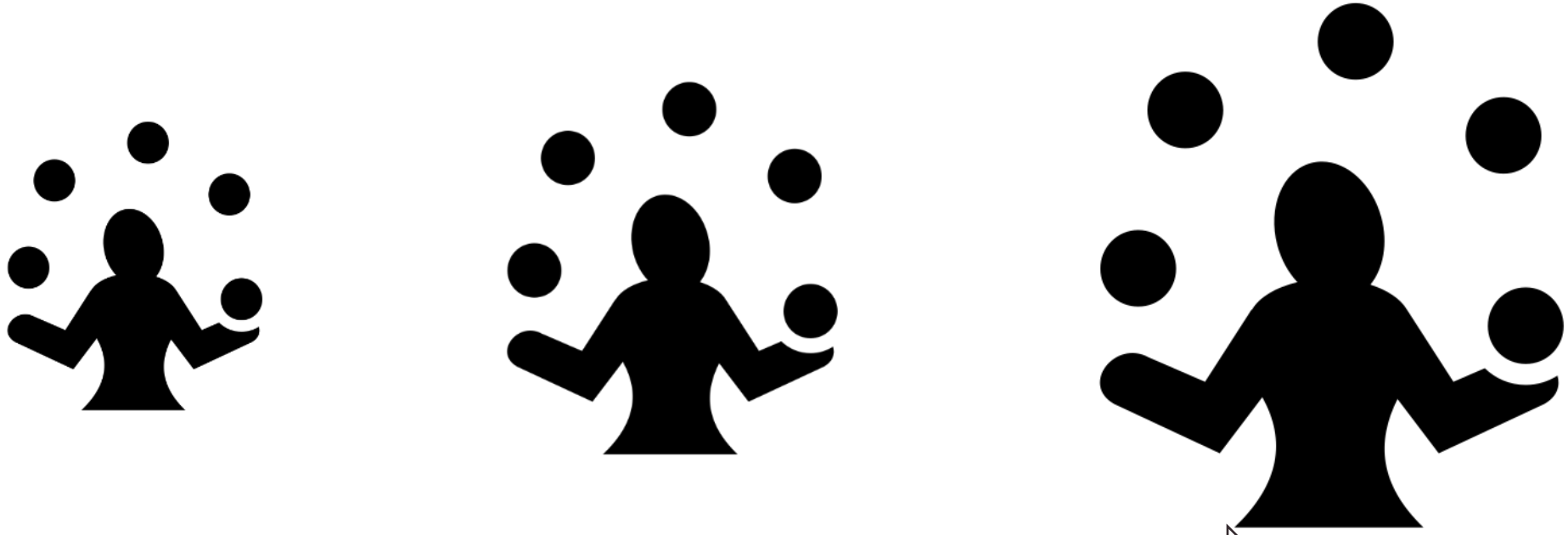
Source:www.physicalgeography.net/fundamentals/8h.html


Atmospheric N_2
Fixation via lightning
denitrification
N fixation by root nodule bacteria
decomposition
decomposition
ammonification
nitrification by nitrifying bacteria
ammonia
nitrite
nitrate
Assimilation by plants
nitrification by nitrifying bacteria
leaching as dissolved organic N

Soil microbial – plant system as a nitrogen juggler

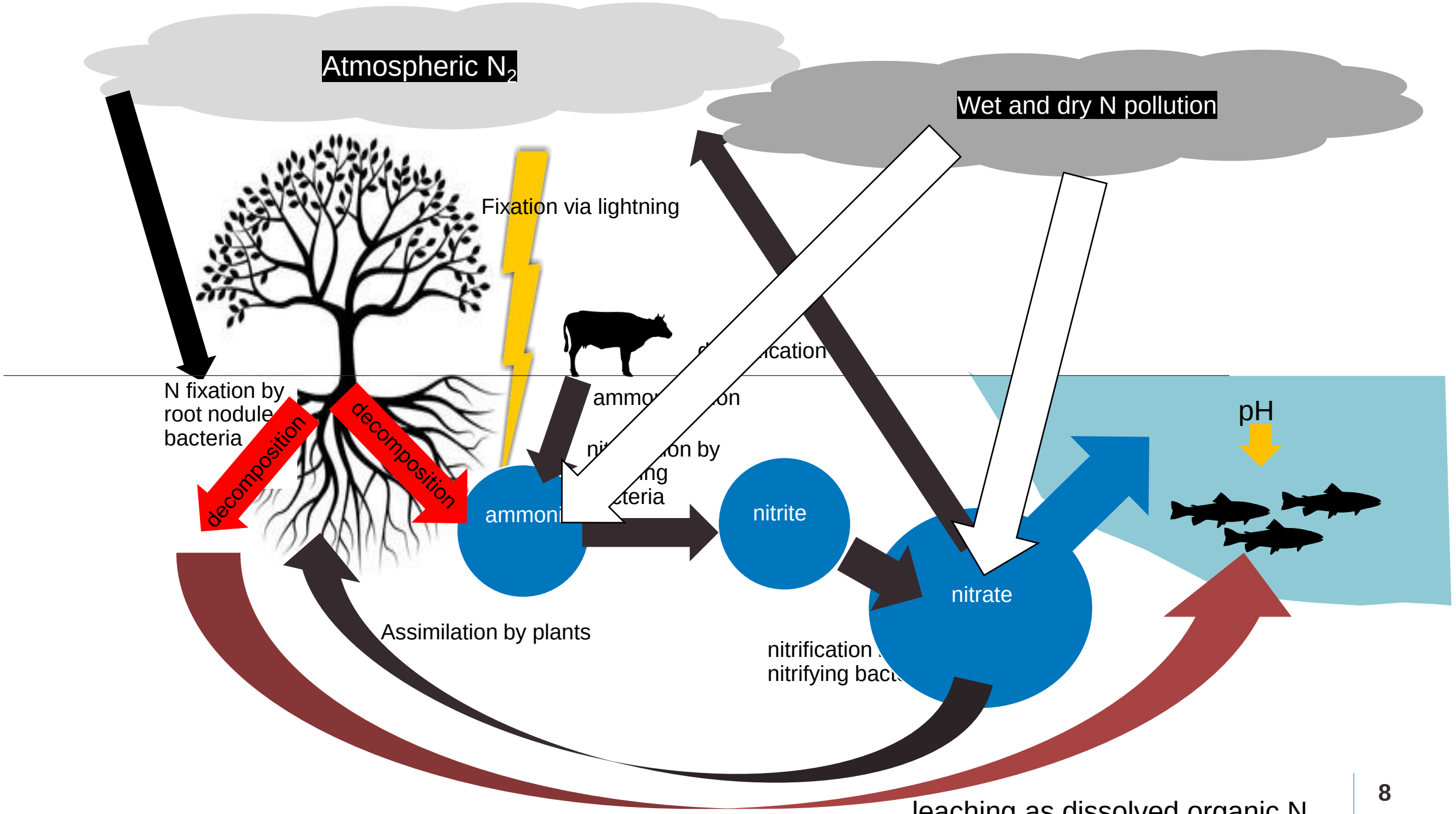


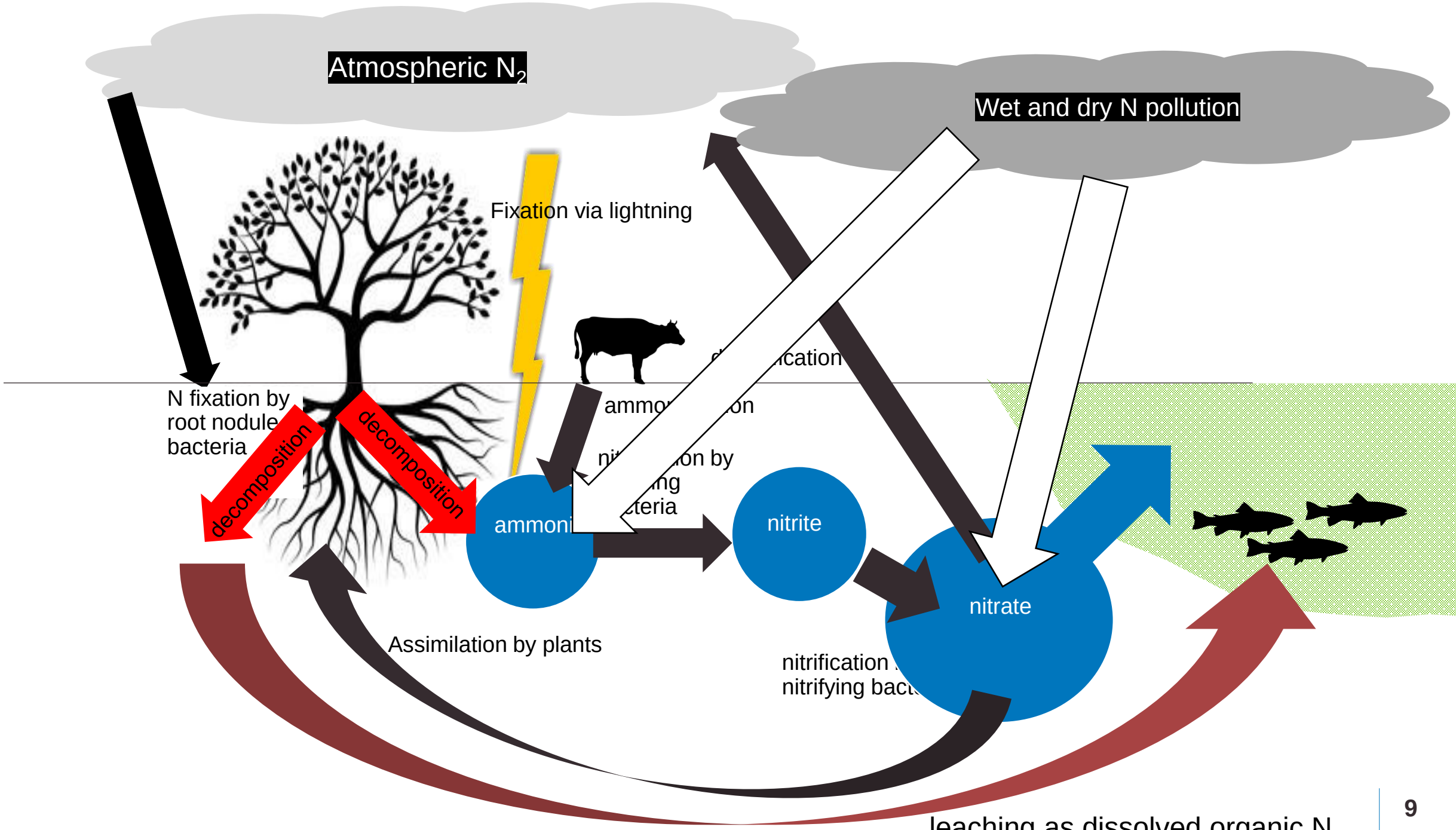
availability of carbon and phosphorus

soil pH

soil moisture

soil temperature


Atmospheric N_2
Wet and dry N pollution
Fixation via lightning
N fixation by root nodule bacteria
decomposition
decomposition
ammoni
nitrite
nitrate
pH
Assimilation by plants
leaching as dissolved organic N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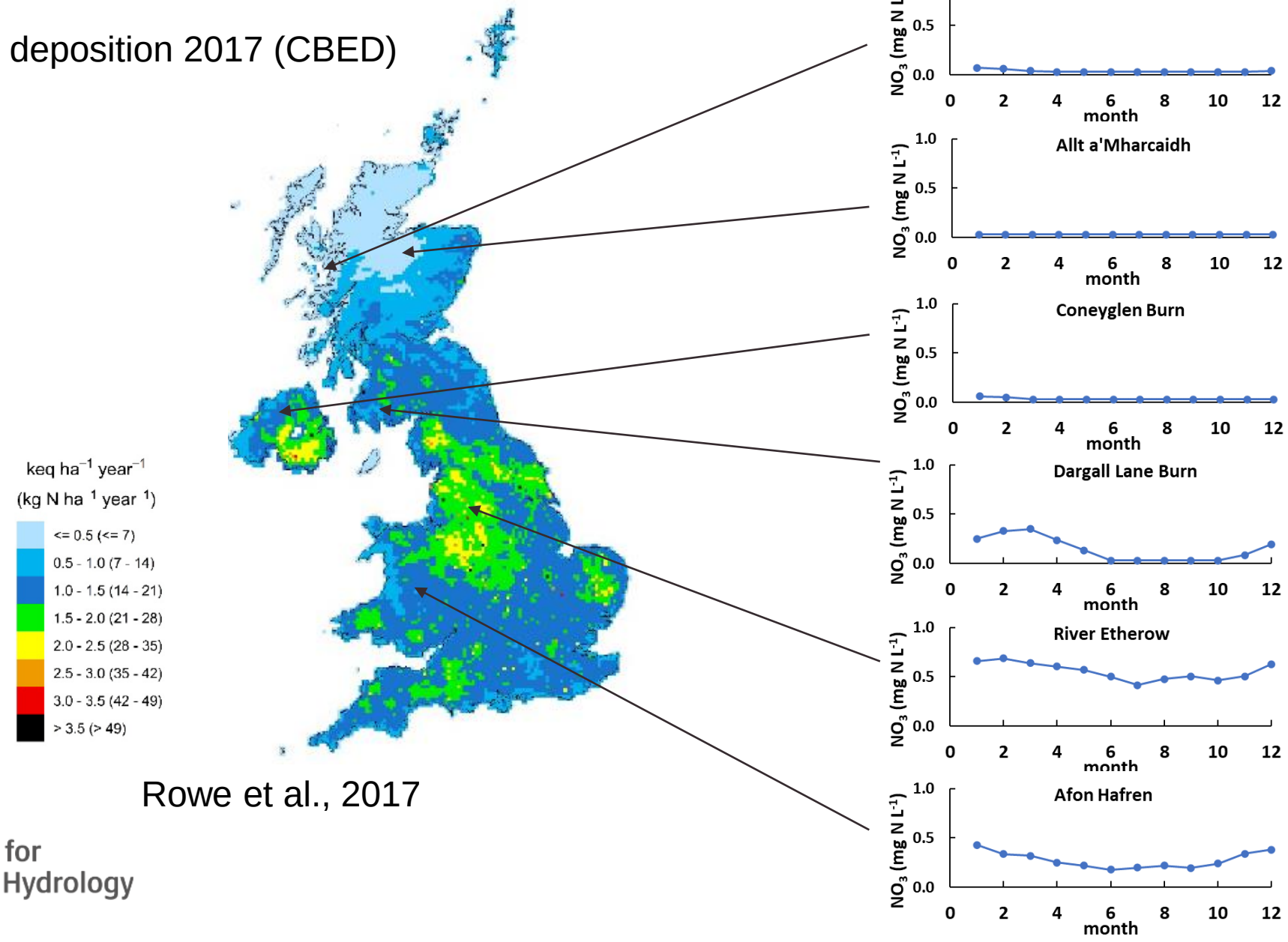
Evidence for UK N saturation gradient: UWMN streams

Modelled total N deposition 2017 (CBED)



Rowe et al., 2017

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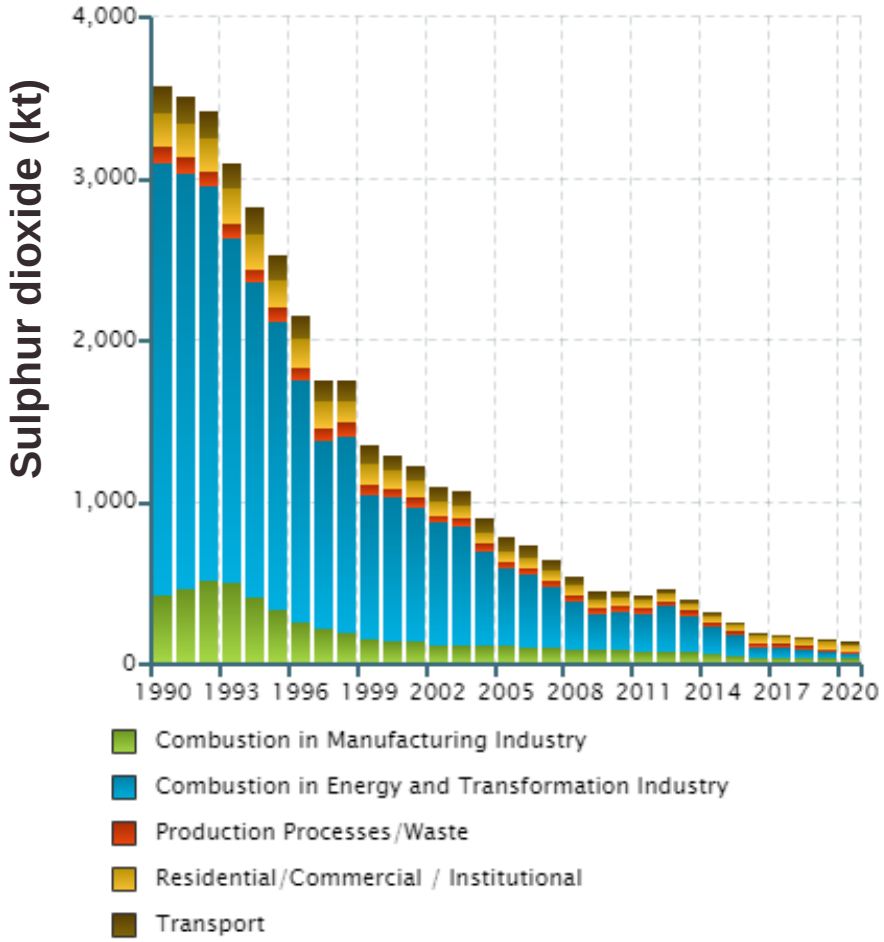
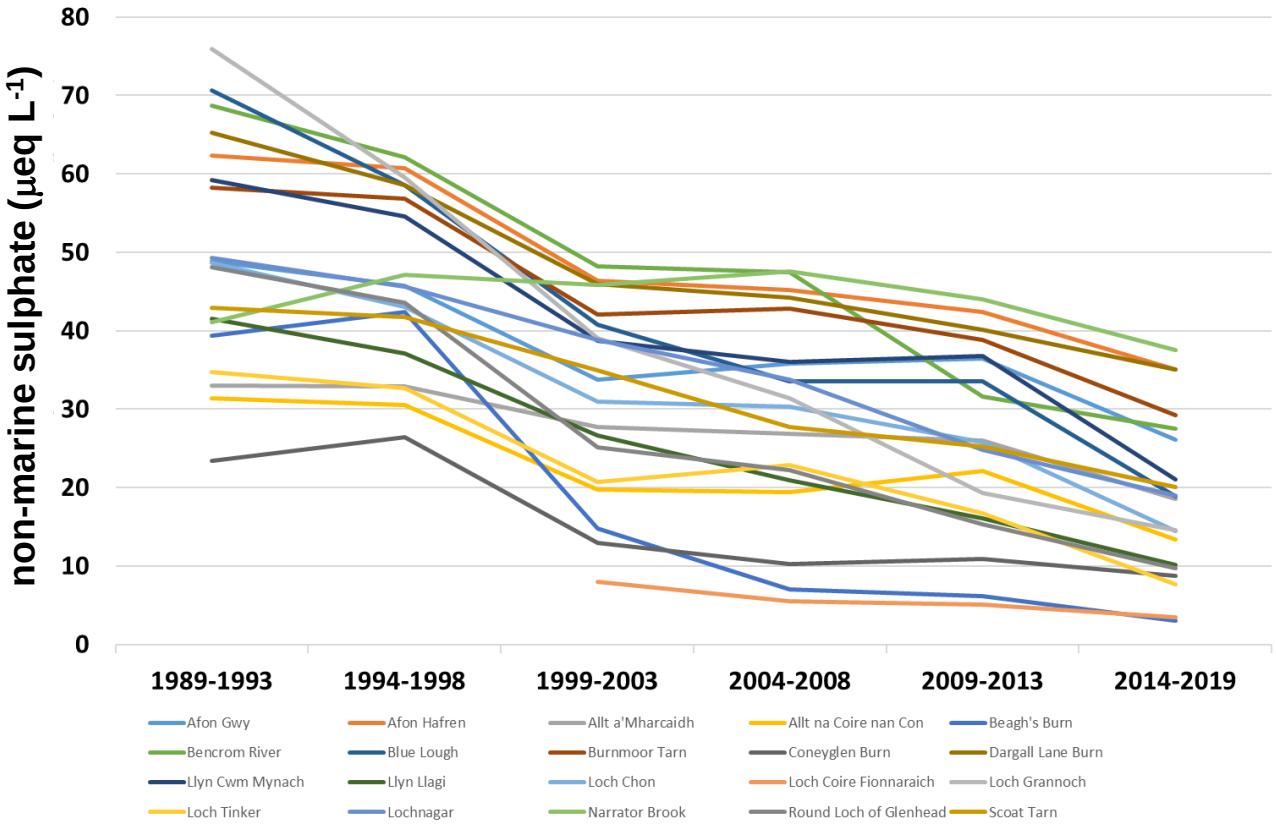
UK sulphur emissions and surface water sulphate concentrations

Sulphur dioxide emissions



https://naei.beis.gov.uk/overview/pollutants?

Non-marine sulphate concentration



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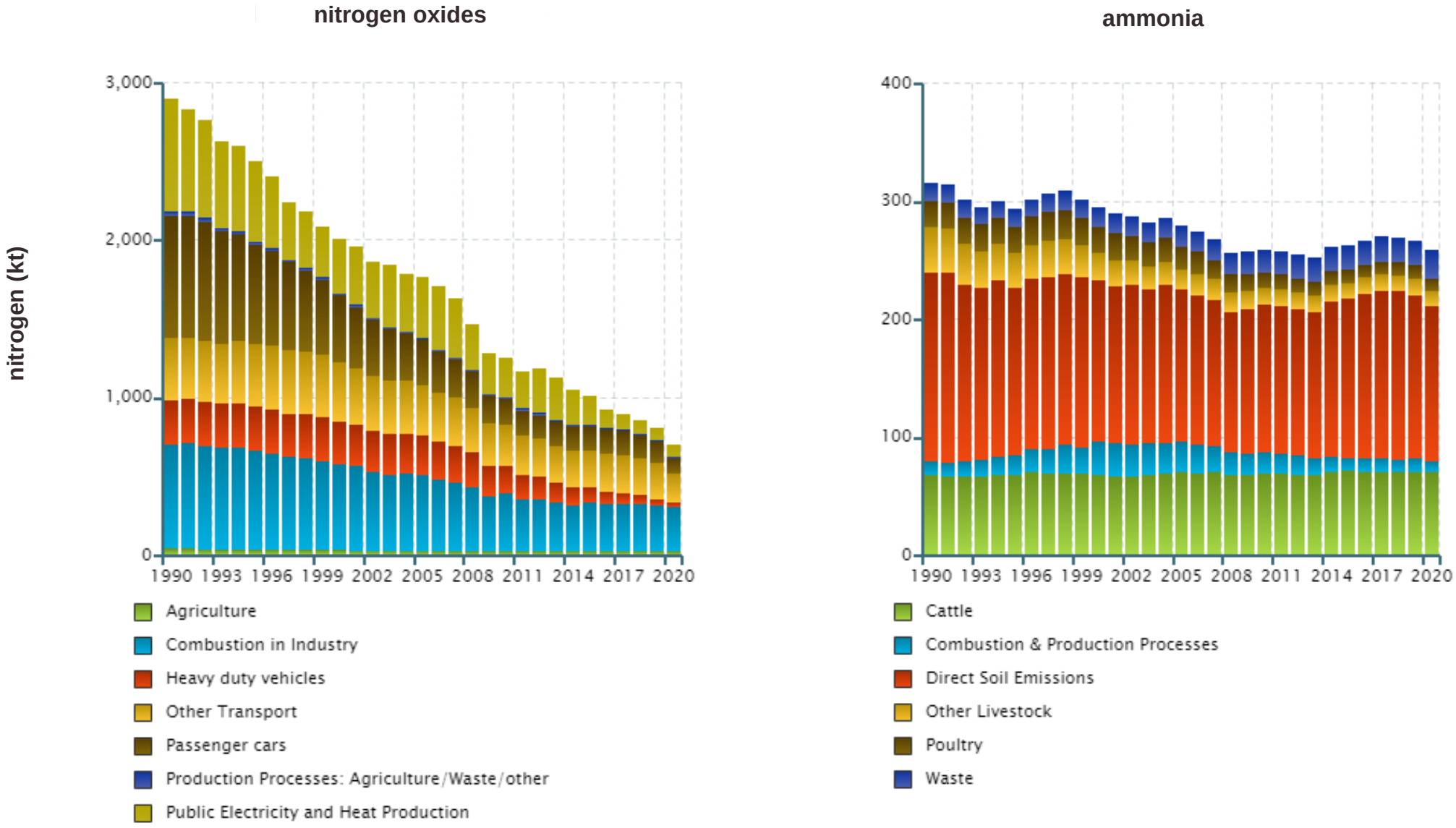
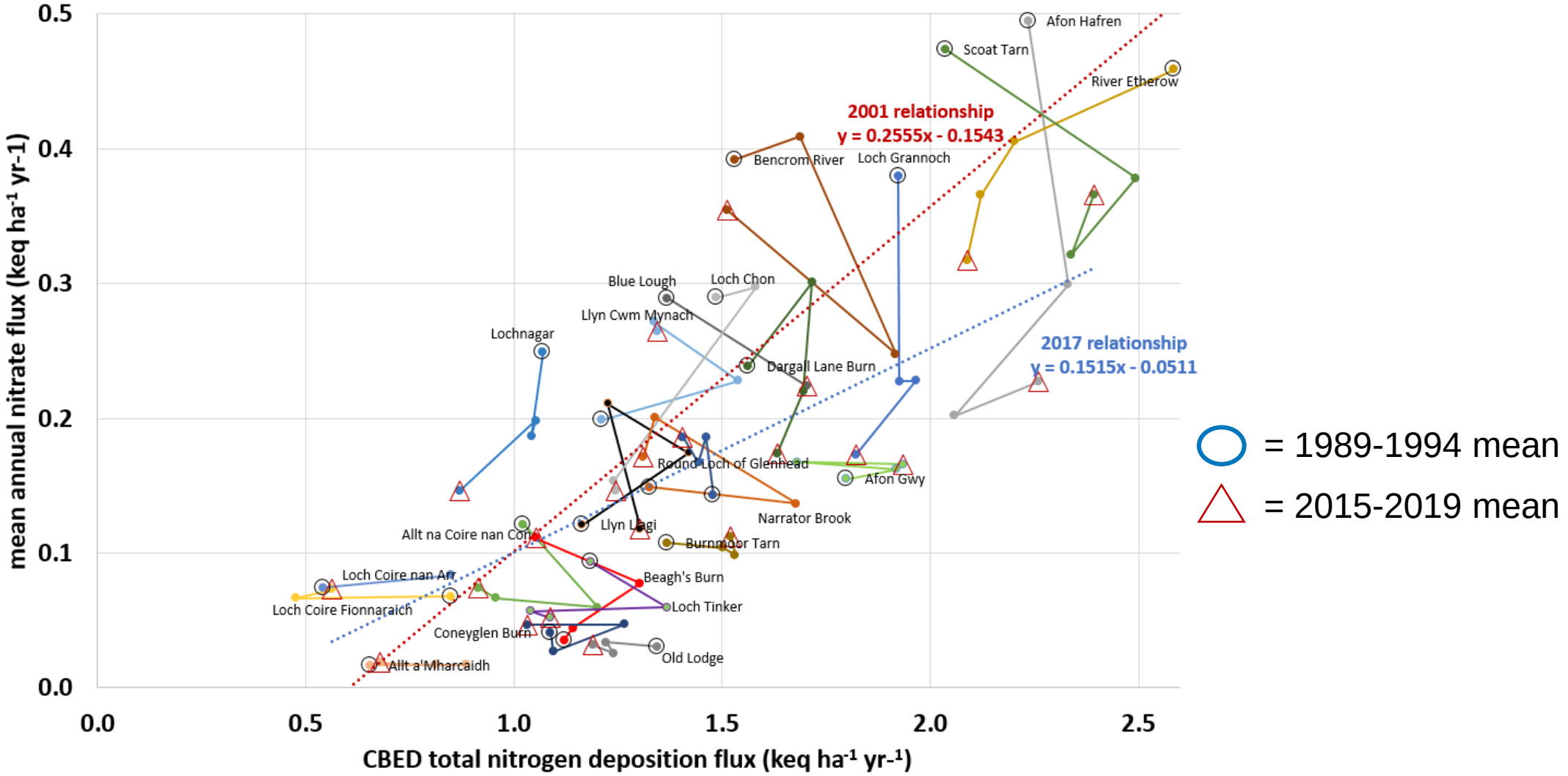
UK nitrogen emissions



https://naei.beis.gov.uk/overview/pollutants?

Trends in UWMN nitrate flux vs total N deposition flux



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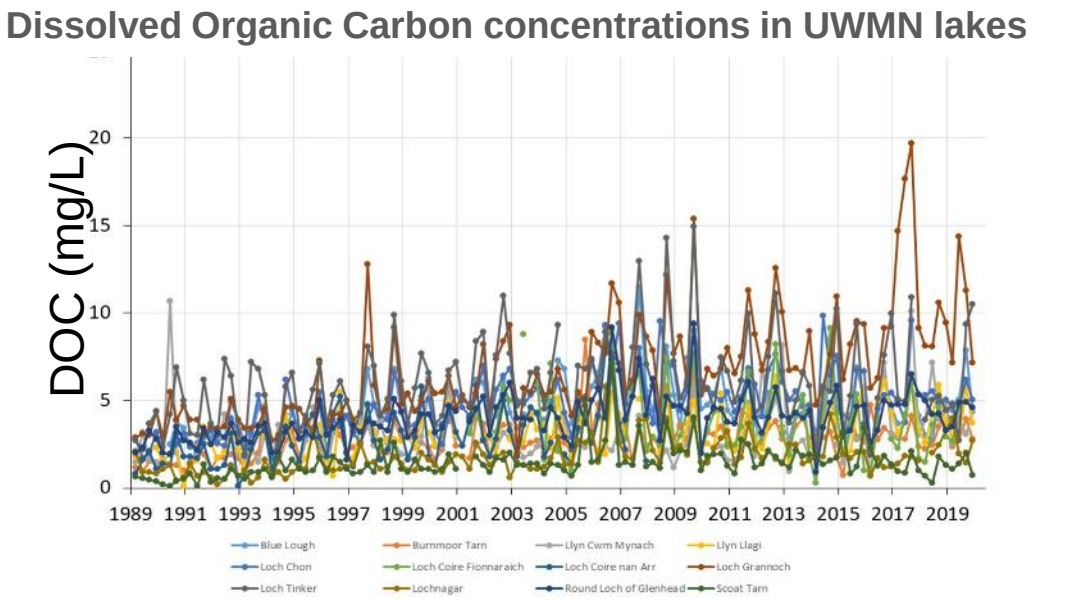
Dissolved organic matter concentrations are increasing



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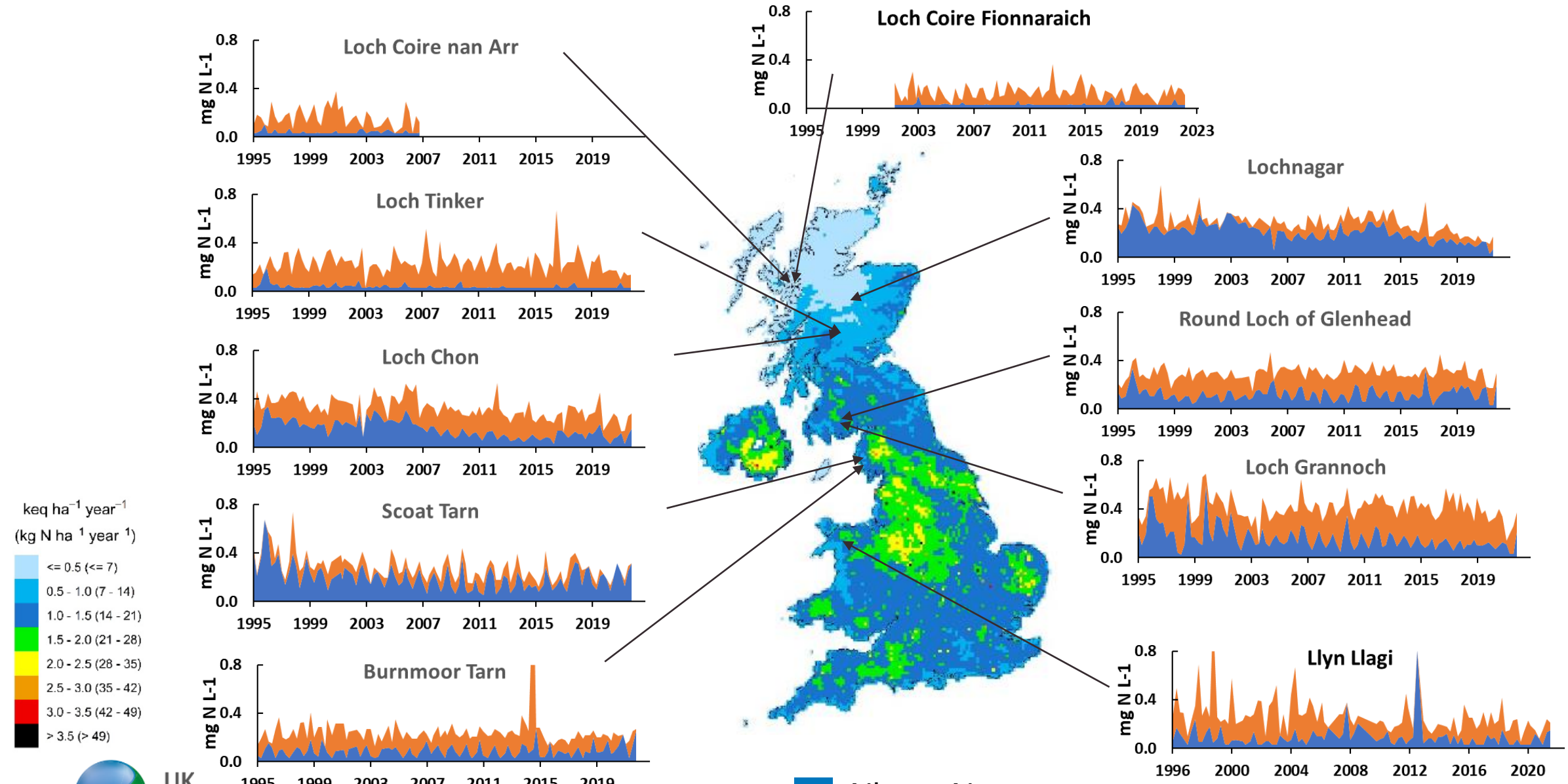
Trends in total nitrogen at UWMN sites



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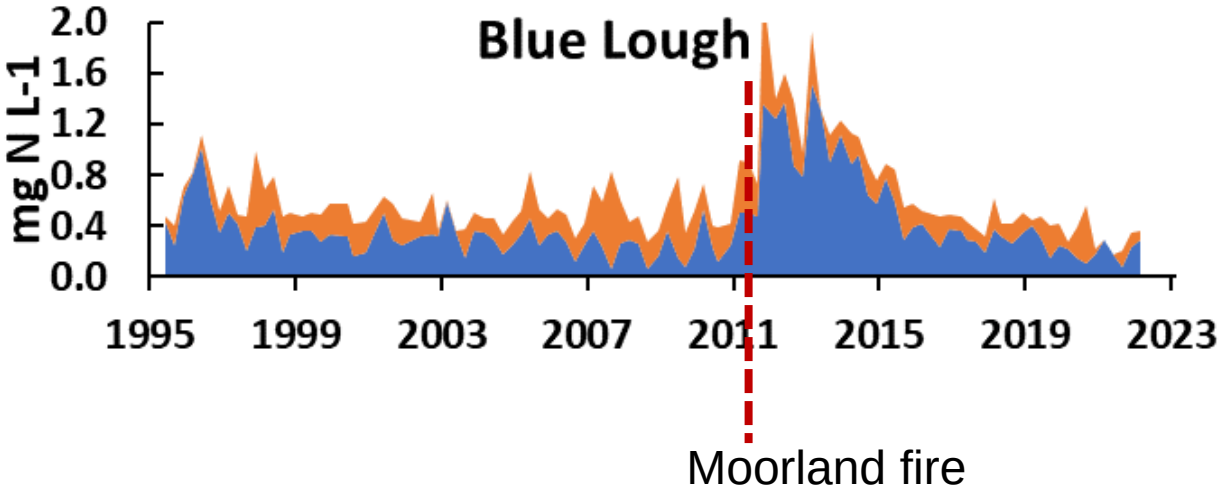
Impacts of disturbance on N leaching



For further information see: Evans, C.D. *et al.* Sustained Biogeochemical Impacts of Wildfire in a Mountain Lake Catchment. *Ecosystems* 20, 813–829 (2017). https://doi.org/10.1007/s10021-016-0064-1

So are UK upland lake ecosystems currently compromised by nitrogen deposition?

- Strong evidence that the algal productivity of UK upland lakes is commonly co-limited by N and P (e.g. (Maberly *et al.,* 2002; Maberly *et al.,* 2003).
- Strong evidence from studies of N isotopes in sediment cores that N composition of lake organic matter has changed on similar time scale to lake acidification
- Some suggestion of deleterious trends in aquatic macrophyte species indicative of N-enriched conditions
- Dissolved Organic Matter relatively recalcitrant in these low residence upland hydrological systems. Yet, understanding of the potential for these ecosystems to utilise organic N in these habitats still poorly understood

Photo: Ben Goldsmith

Summary

- Despite major reductions in acid deposition across the UK, and corresponding reductions in lake acidity, nitrate concentrations in the majority of UK Upland Waters remain unnaturally high.
- In waters still considered to be acidified, nitrate is now making a similar contribution to sulphate as an acidifying anion.
- Nitrate concentrations have declined a little in some of the most atmospherically polluted sites, but concentrations of organic N have been increasing – resulting in only modest reductions in total N inputs.
- Difficult to separate the influences of soil and aquatic processes on the nutrient chemistry of water samples – which represent the net effects of both
- Determining the extent to which the ecology of our upland waters is currently shaped by anthropogenic N (as a nutrient) is challenging – but more work is required in order to shape future UK N emission control strategy

Thanks to:

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Ben Goldsmith – Goldsmith Ecology

UKCEH and Marine Scotland water chemistry laboratories

numerous colleagues at UKCEH, QMUL and UCL and volunteer water samplers

Funding

- NERC National Capability funding to UKCEH
- Defra
- NatureScot
- Natural Resources Wales
- Welsh Government
- Forest Research

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