

Air Pollution Monitoring in the UK

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Introduction

- Brief resumé of UK monitoring networks
- Monitoring the air pollution burden
- Impacts monitoring
 - Freshwaters
 - Terrestrial
- Enough monitoring?

Air Quality Network

•Automatic

- >100 urban & rural sites for O₃, NO_x, NO₂, NO, CO, SO₂, pm₁₀

•Non-automatic

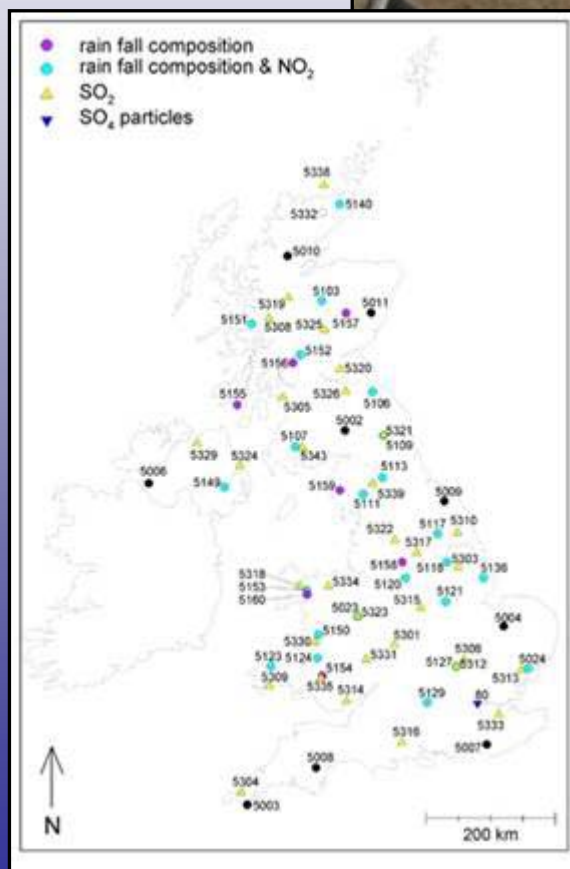
- >1100 urban sites for NO₂ using diffusion tubes
- >220 mainly urban sites for SO₂ / smoke

Figure 1a: Air quality automatic monitoring sites in operation, United Kingdom. June, 2002



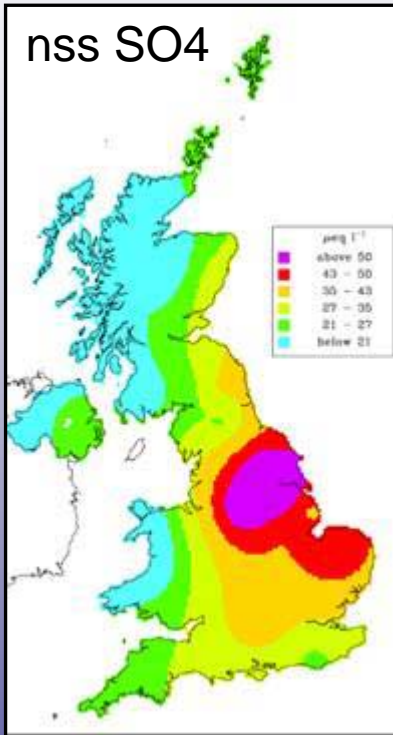
Acid Deposition Network

- Wet deposition c.40 rural sites
- SO₂ c. 50 sites
- NO₂ c. 30 sites
- SO₄ aerosol c.10 sites
- NH₃ c. 100 sites
- Nitric acid c.12 sites
- + ECN sites for wet dep + NO₂



Deposition Mapping Procedure

Wet deposition



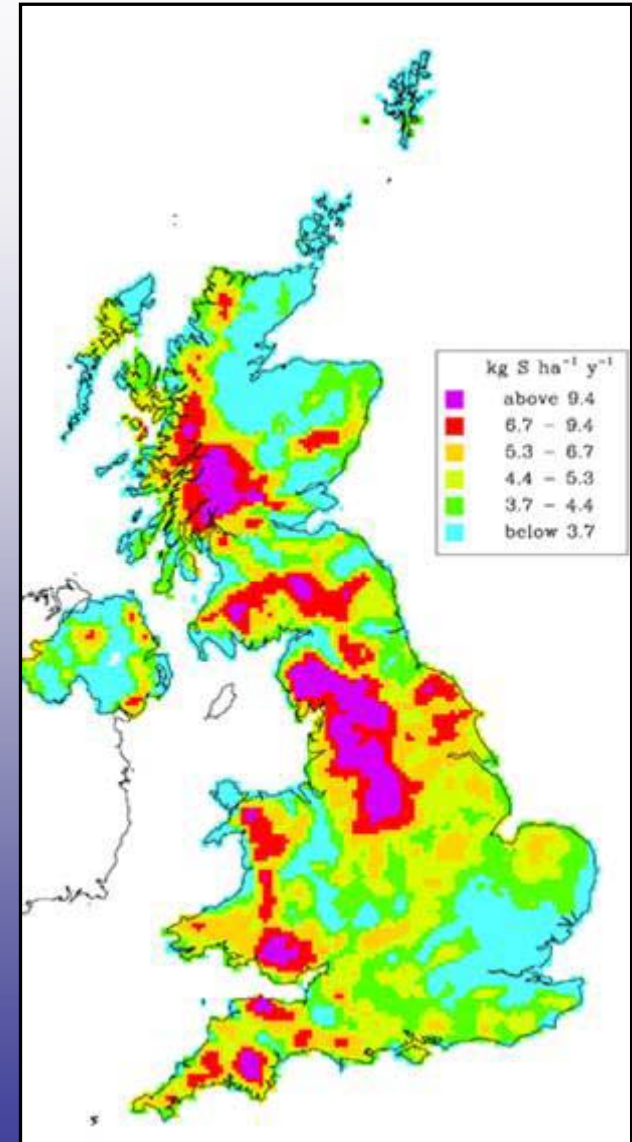
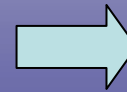
Interpolation from site mean concentrations



Combine with rainfall data

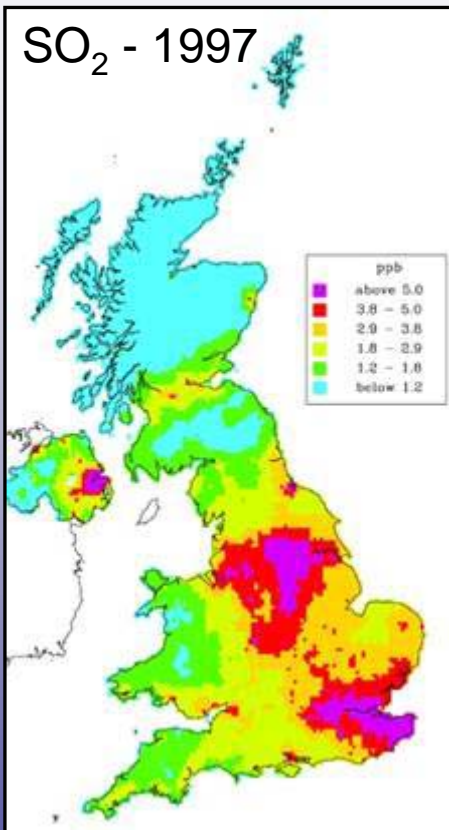
Modify for orographic effects
(empirical relationship)

Map to 5 km grid

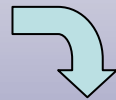


Deposition Mapping Procedure

Dry deposition NOX & SO2



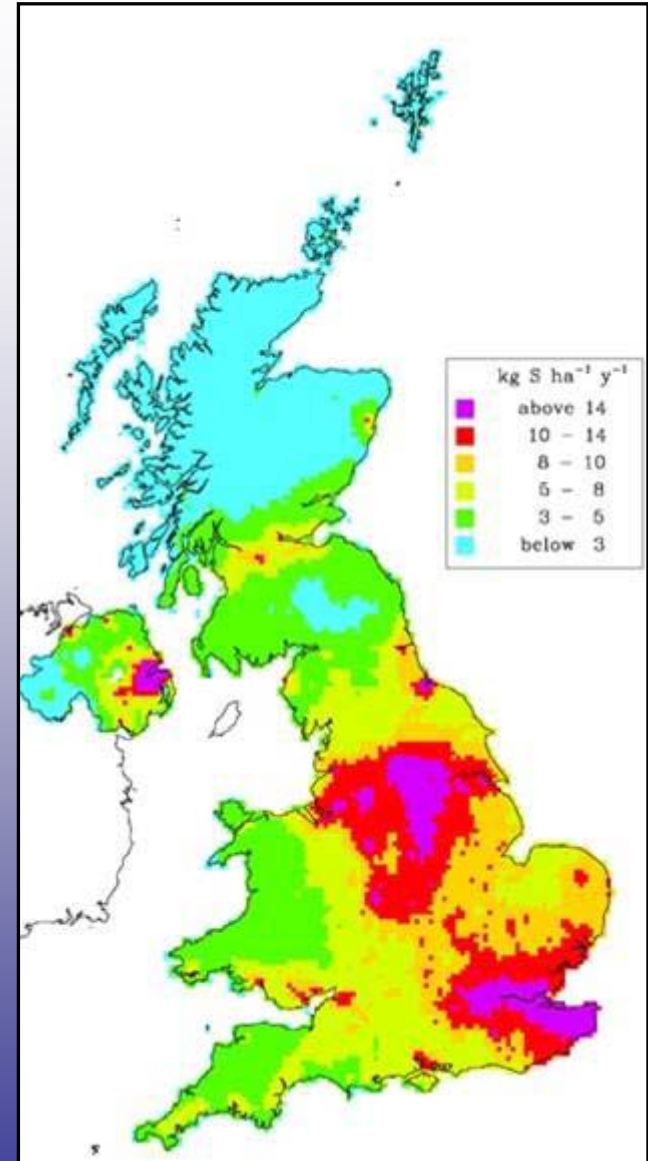
Interpolation from site concentrations + Urban enhancement



Process based deposition model

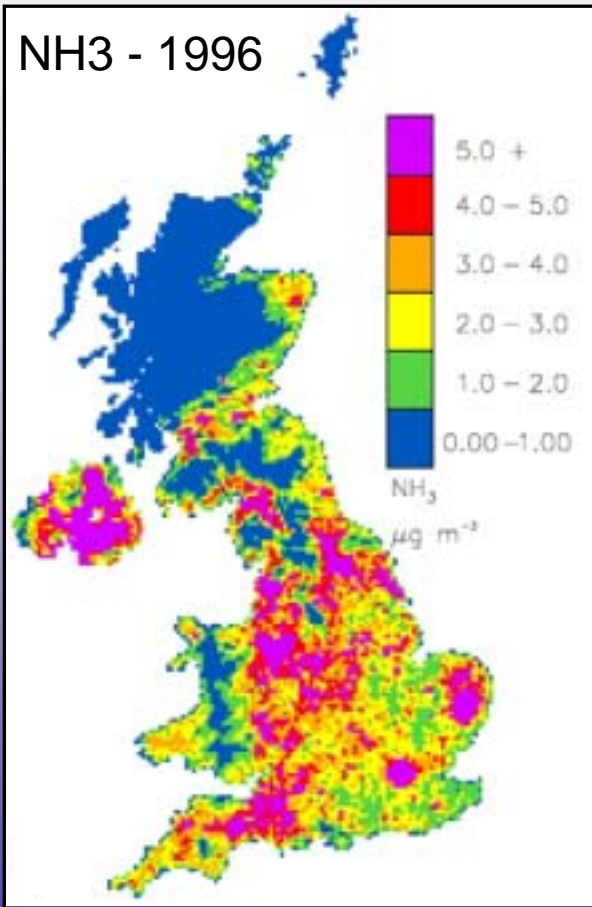
5 receptor types
(arable, grassland, moorland, forest & urban)

Map to 5 km grid



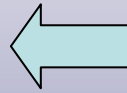
Deposition Mapping Procedure

Dry deposition NH₃



Derived from emissions data via FRAME model

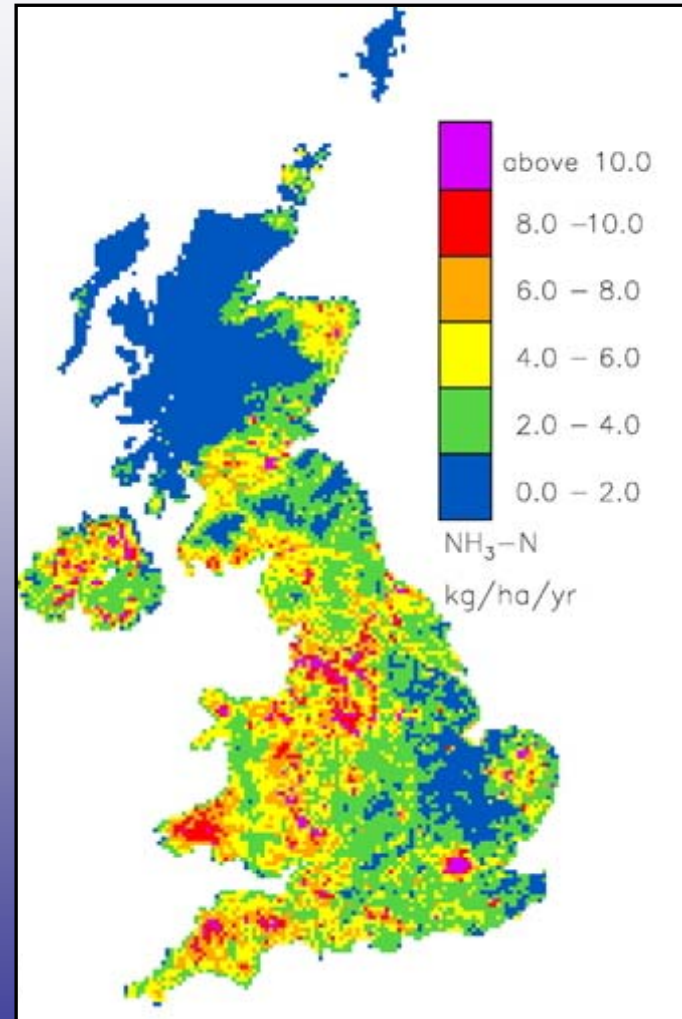
Calibration vs rural site data



Process based deposition model

5 receptor types (arable, grassland, moorland, forest & urban)

Map to 5 km grid

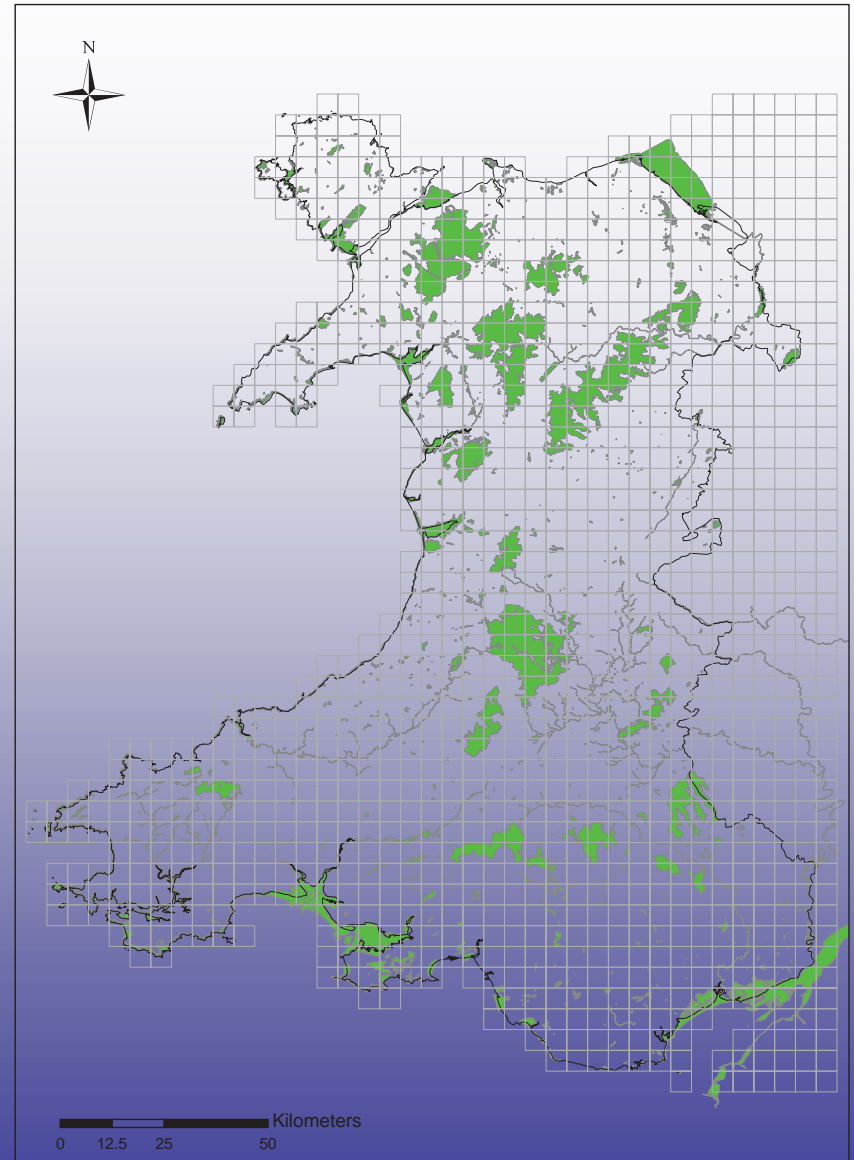


But....

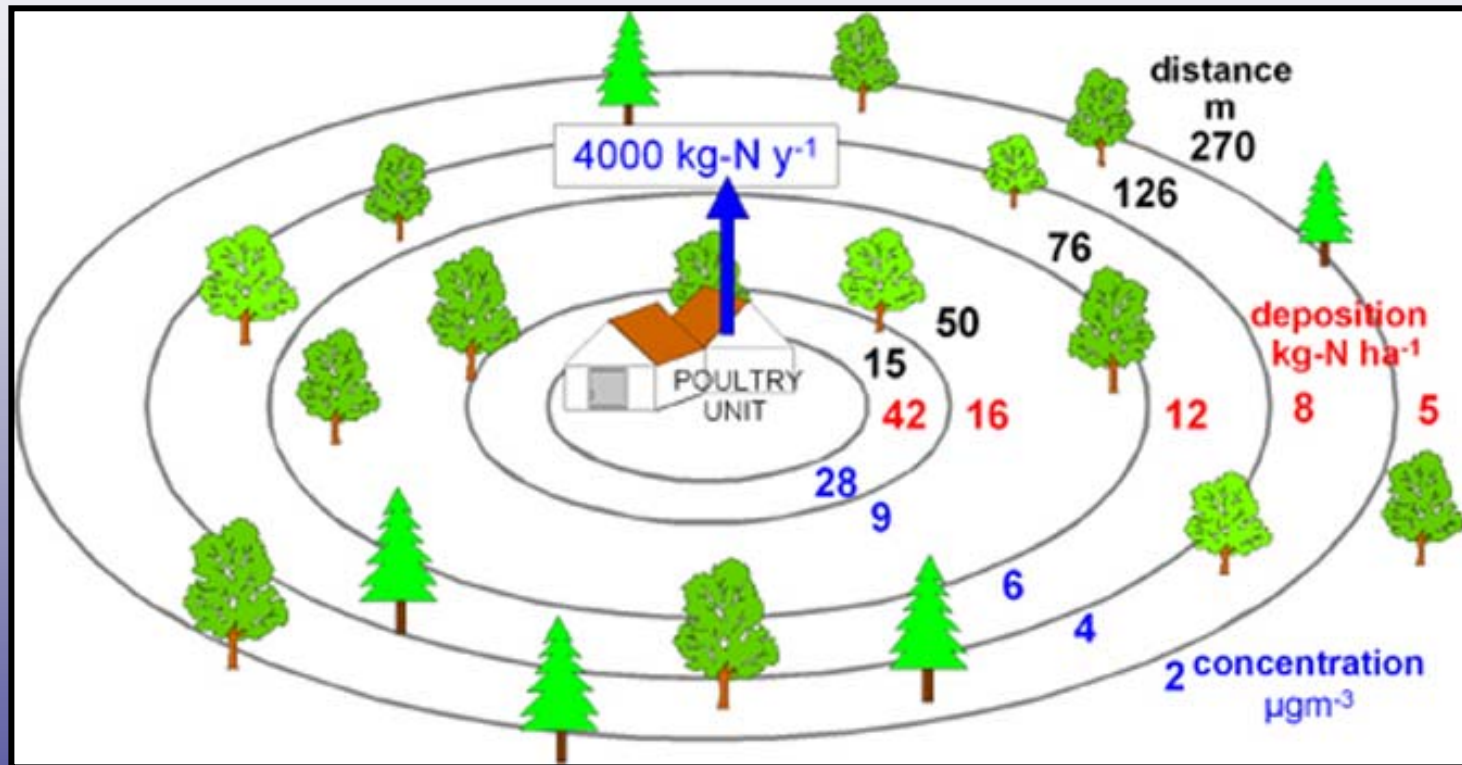
- Relatively coarse scale resolution
- 5 'generic' land cover types
- Hides considerable within square variability

SSSI boundaries

5 km grid

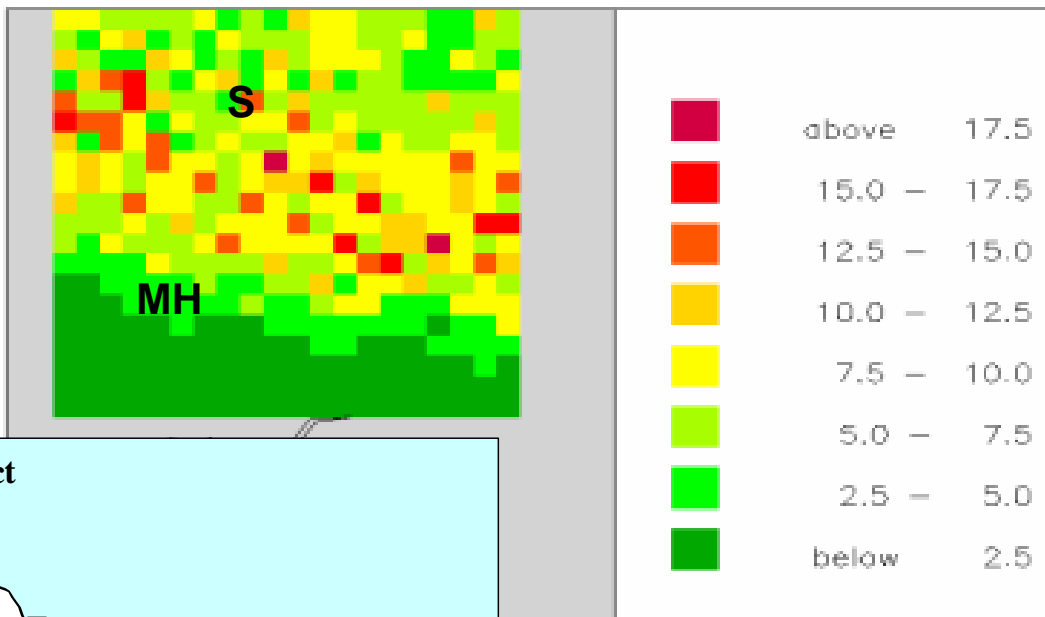


Point source NH₃ emissions



Complex Terrain

SO₄ deposition (kgS / ha / year)

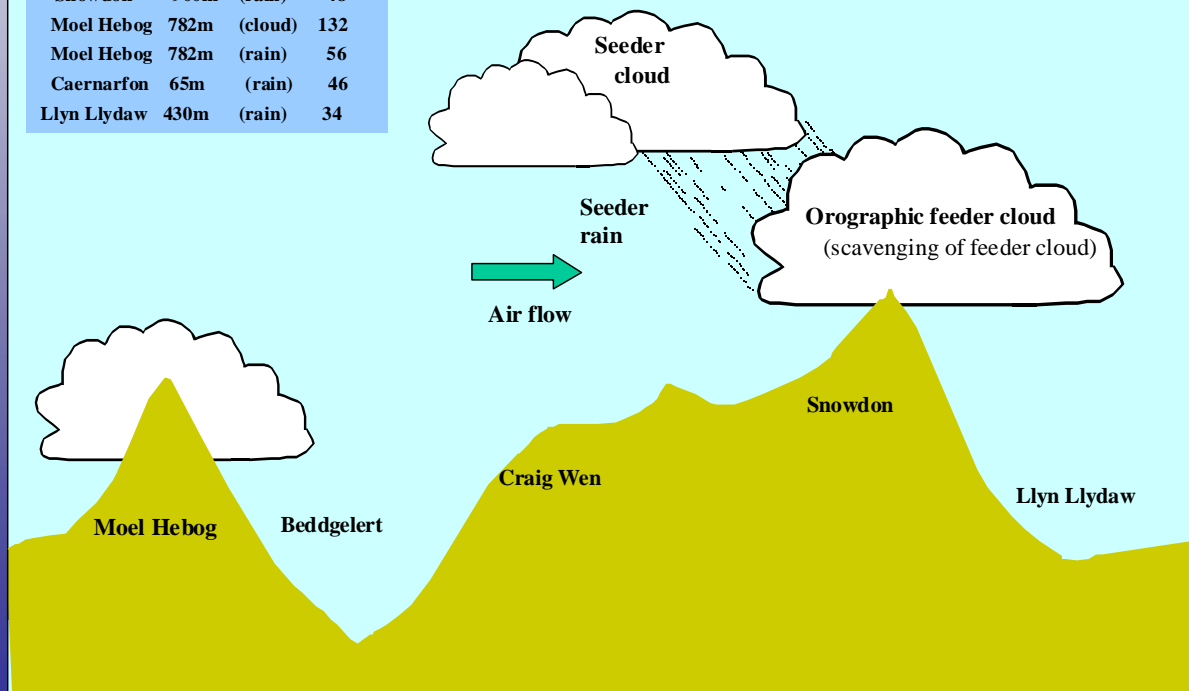


20 km x 20 km

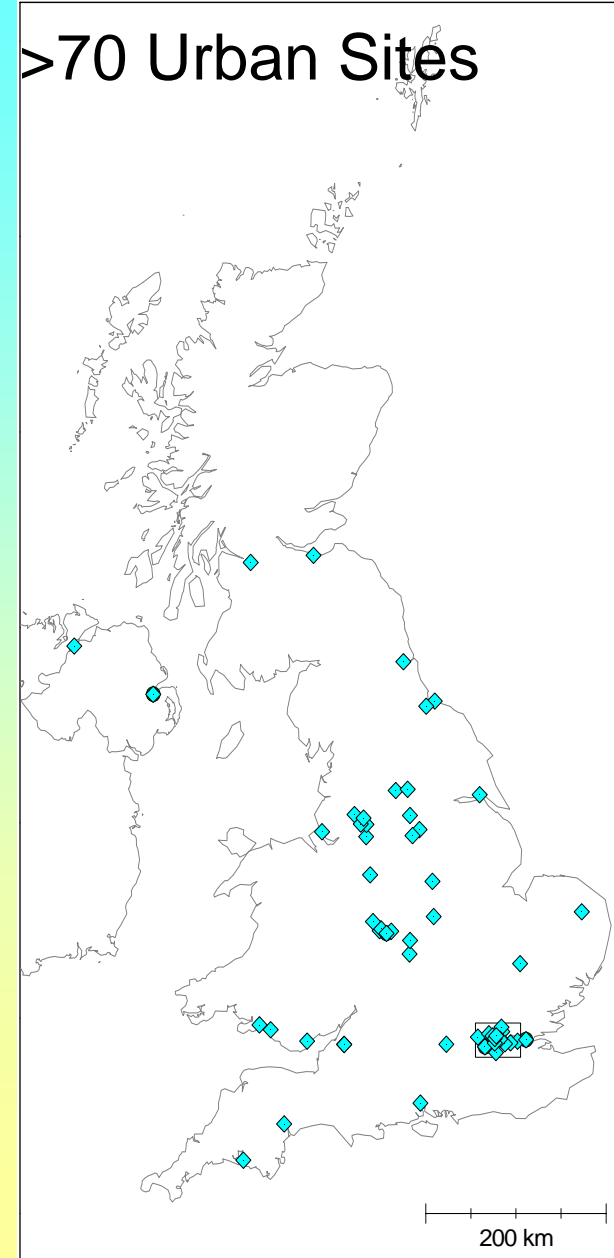
SO₄²⁻ concentration (µeq l⁻¹)

Snowdon	900m	(cloud)	106
Snowdon	900m	(rain)	48
Moel Hebog	782m	(cloud)	132
Moel Hebog	782m	(rain)	56
Caernarfon	65m	(rain)	46
Llyn Llydaw	430m	(rain)	34

SW - NE Transect



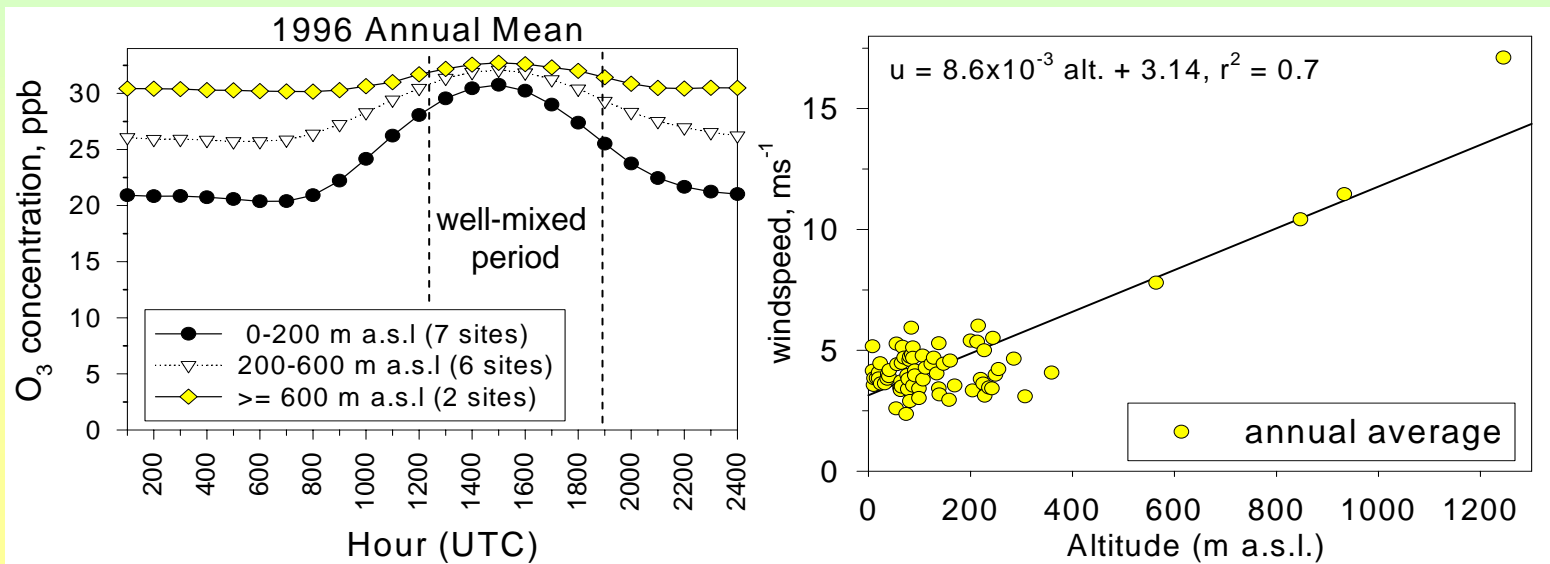
Rural and Urban O3 Monitoring Sites



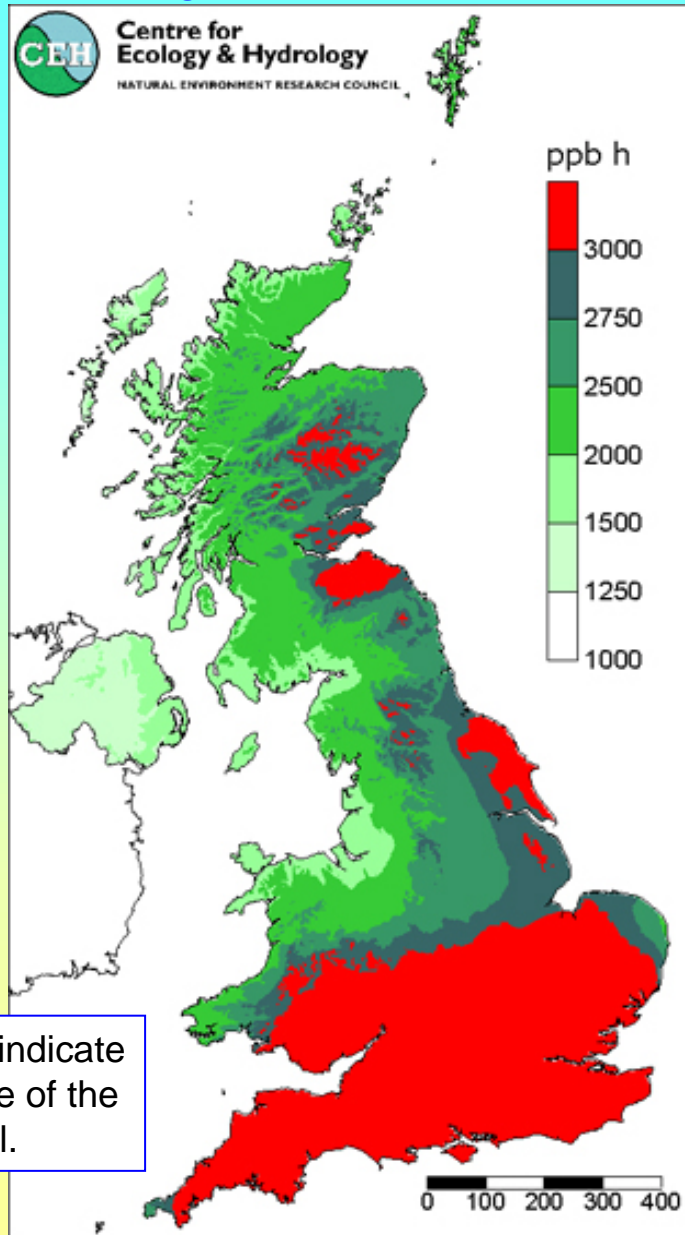
Mapping UK Ozone Levels

- During the afternoon “well-mixed” period ozone monitoring sites measure concentrations representative of a wide geographical area
 - interpolate the variable calculated during this well-mixed period to give a low resolution base map
- The degree of nocturnal O₃ depletion at a site can be related to windspeed and the site’s altitude. Hence the “well-mixed” map is modified to account for the diurnal cycle in O₃ concentration.
 - apply derived altitude relationship to the well-mixed map with a 1 km x 1km scale altitude map of the UK to obtain a map of the required variable at high resolution, eg:

$$\text{AOT40 Wheat} = \text{AOT40 wheat well-mixed} (1.42 + 7.4 \times 10^{-3} \text{altitude})$$

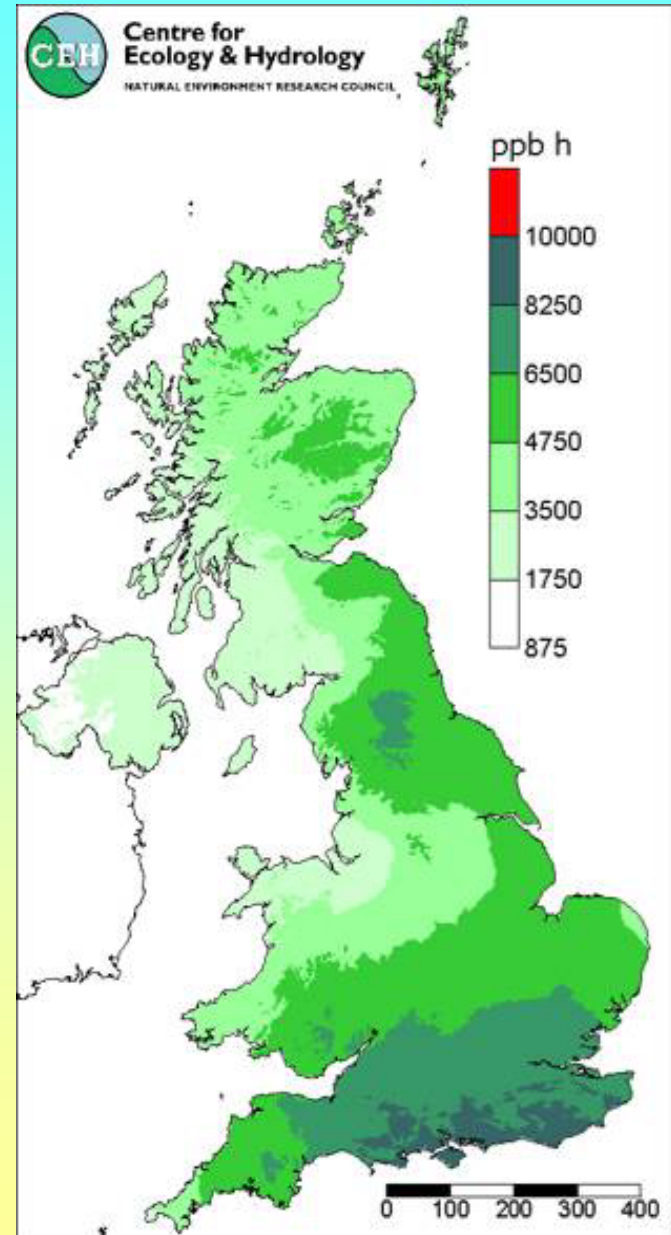


AOT40 Crops and Semi-Natural Vegetation 1997-2001



Red areas indicate exceedance of the critical level.

AOT40 Forests 1997-2001

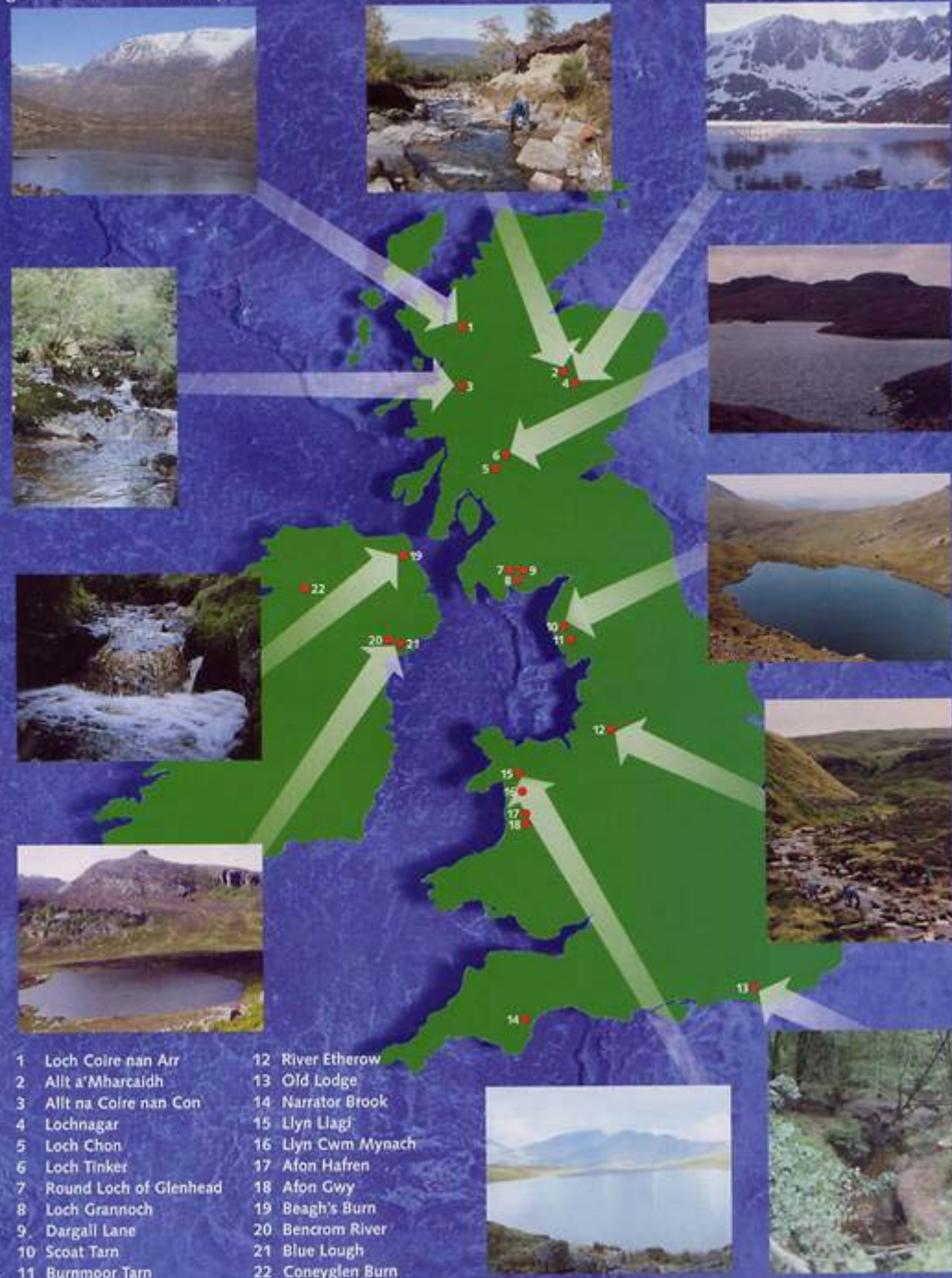


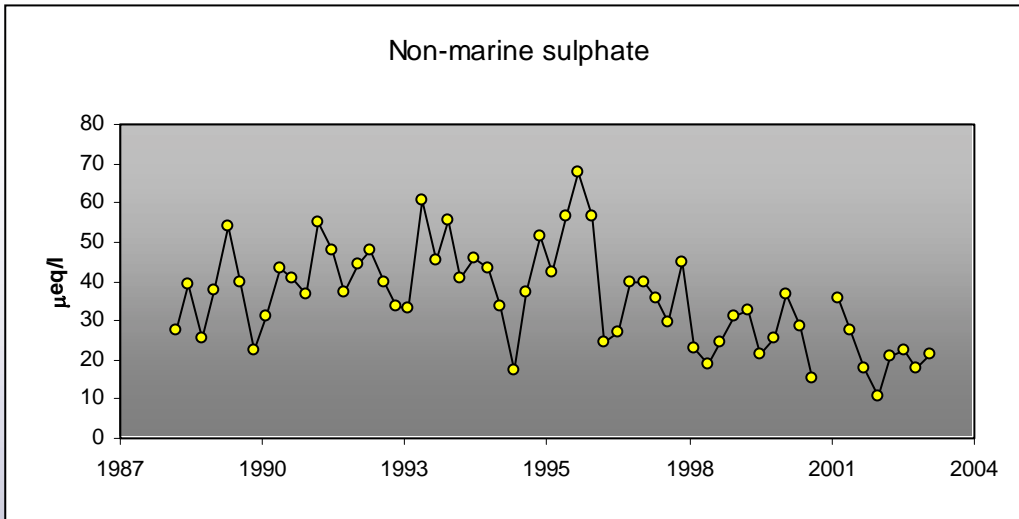
The UK Acid Waters Monitoring Network

(www.ukawmn.ucl.ac.uk)

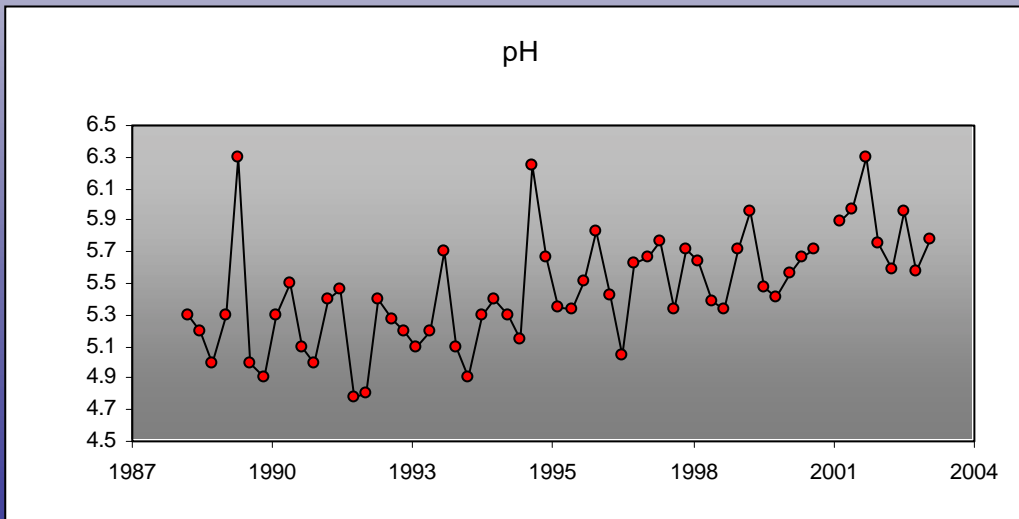


Figure 4. UKAWMN site map





Llyn Llgi Snowdonia



- **Established 1988**

- **Chemistry:**

- streams – monthly

- lakes – quarterly

- **Aquatic biology**

- streams & lakes annually

**The UK Acid Waters
Monitoring Network**

Other sites

FR / EA forest sites

Acid sensitive area

10 forest sites

2 moorland sites

monthly chemistry

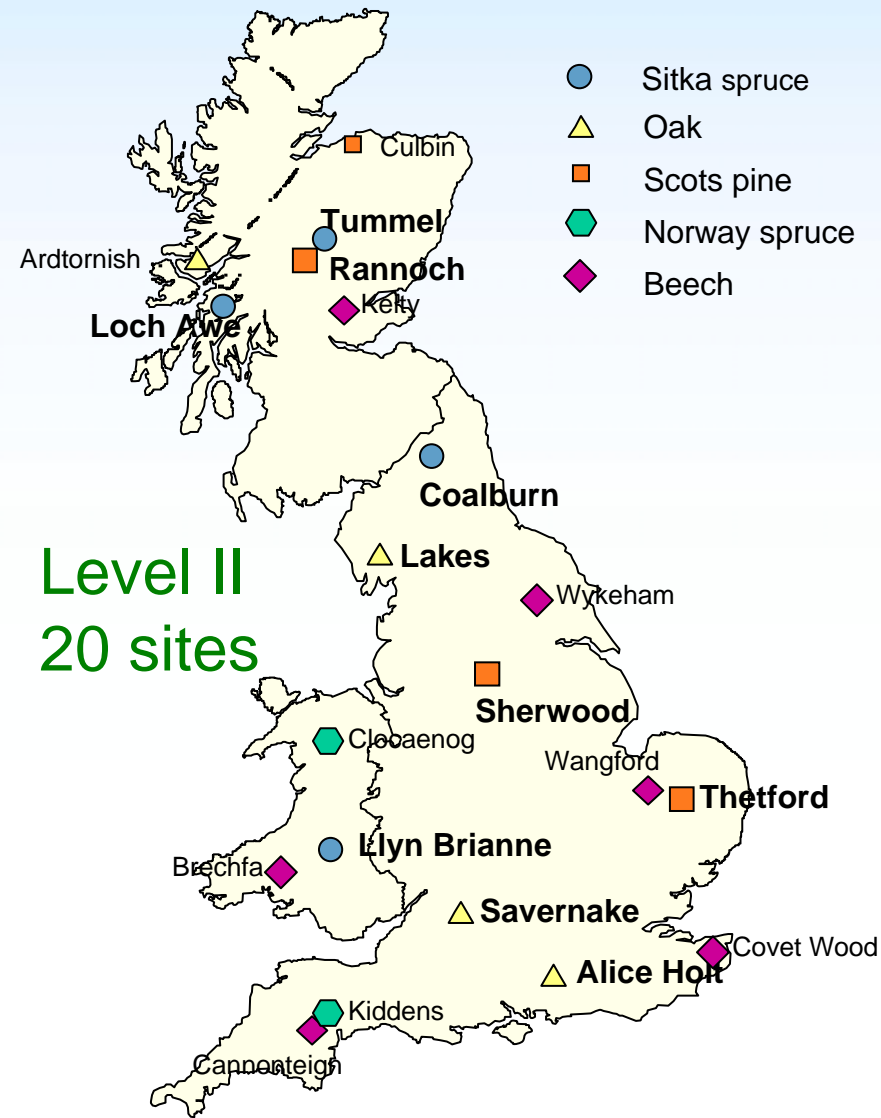
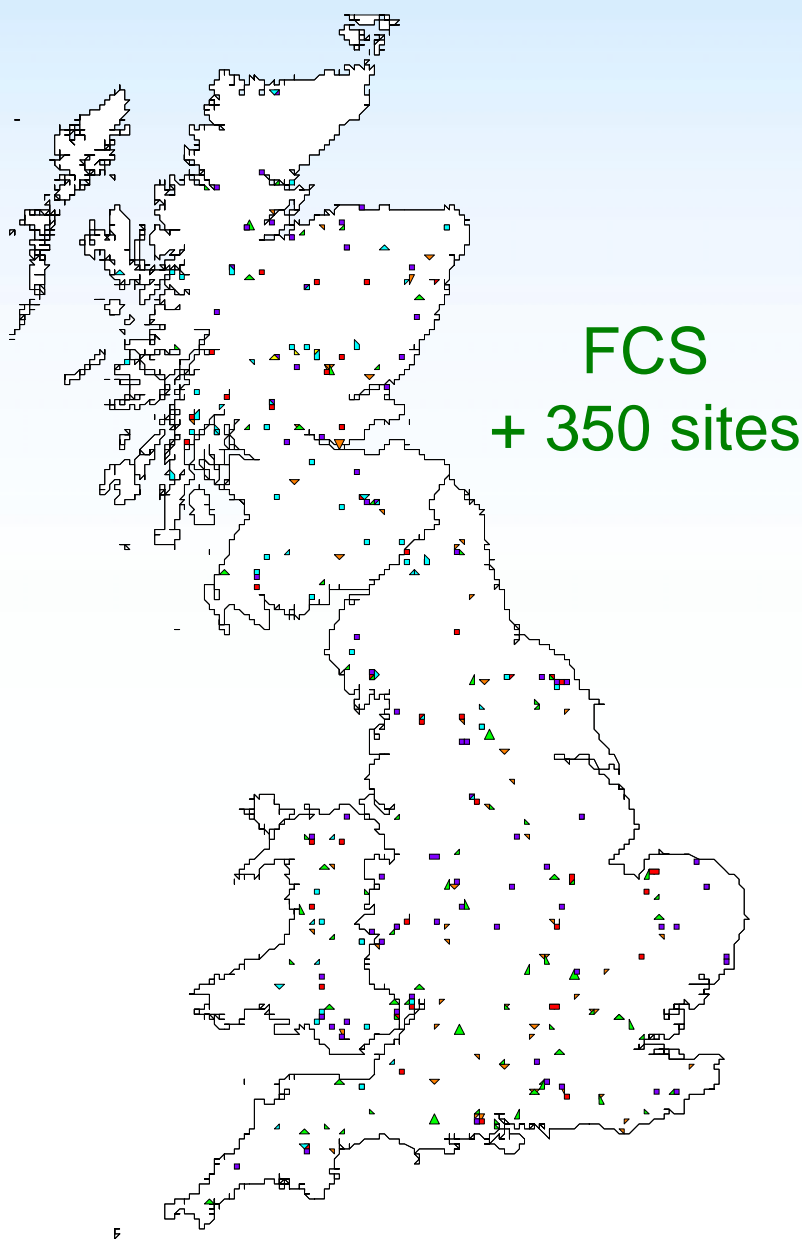
1992 - present



Macaulay Institute, Freshwater Fisheries Lab – Scotland

CEH Windermere – Lake District

CEH Wallingford / Bangor / EA – mid Wales



Environmental Change Network

12 Terrestrial
Sites

42 Freshwater
Sites

Freshwater sites			
▲ River sites		■ Lake sites	
1	Eden (Cumbria)	A	Upton Broad
2	Esk	B	Hickling Broad
3	Coquet	C	Wroxham Broad
4	Exe	D	Windermere
5	Wye	E	Esthwaite Tarn
6	Lathkill	F	Loch Leven
7	Cringle Brook	G	Scoat Tarn
8	Frome	H	Llyn Llgi
9	Bradgate Brook	I	Lochnagar
10	Bure	J	Loch Lomond
11	Old Lodge	K	Loch Katrine
12	Stinchar	L	Loch Davan
13	Lower Clyde	M	Loch Kinord
14	Allt a'Mharcaidh	N	Loch Dee
15	Spey (Fochabers)	O	Lough Neagh
16	Tweed (Galafoot)	P	Lough Erne
17	Eden (Fife)		
18	Cree		
19	Faughan		
20	Garvary		
21	Bush		
22	Trout Beck (Moor House)		
23	Coln		
24	Lambourn		
25	Eden (Kent)		
26	Ewe		

● Terrestrial sites



Environmental Change Network

Climate & Atmospheric deposition

Soil & soil water chemistry

Vegetation & Site management

Vertebrates & Invertebrates

Soil acidification / recovery?

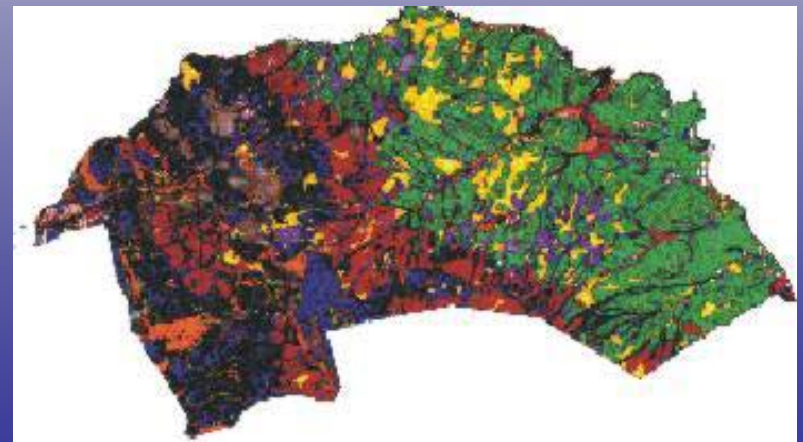
Nitrogen enrichment effects?

Ozone impacts?

Soil water sampling



Vegetation at Moor House

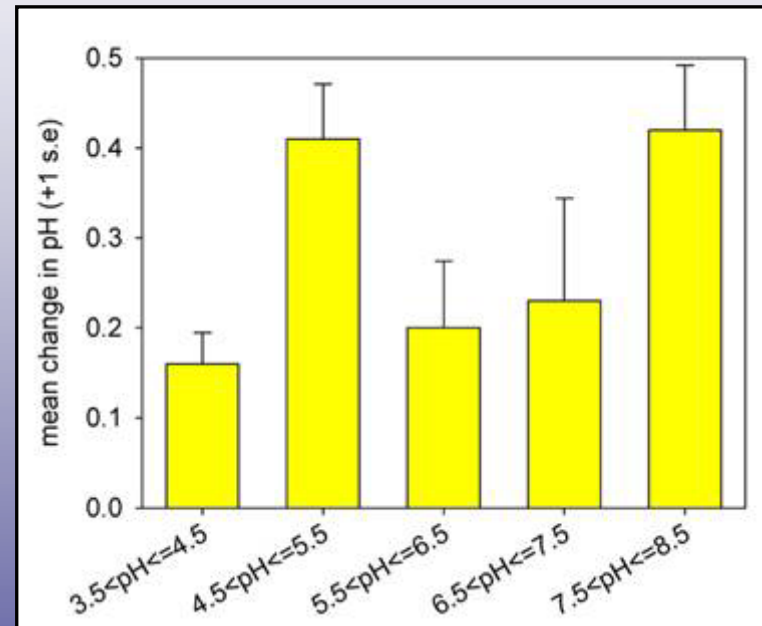


Repeated surveys

- **Landcover**
- Countryside Survey
- > 250 1 km squares
- 1978, 1990, 1998
- **Lichens**
- British Lichen Soc
- 10 km grid
- **Soils**
- NSI – 5692 points @ 5 km grid
- RSS – Farm based
- **Water**
- Welsh Acid Waters Survey -
77 sites 1984 & 1995

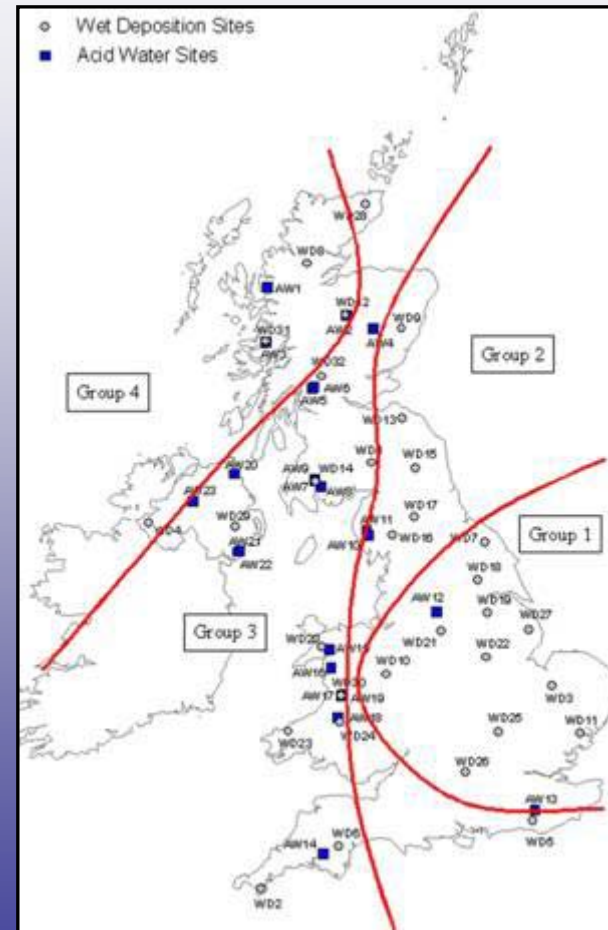
CS2000

Soil pH 1978 – 1998



Enough monitoring?

- Adequate network to define broad spatial patterns & temporal changes in S & N deposition across UK
- Limitations for site-specific assessment



Enough monitoring?

- Evaluate impacts & recovery
- Verify evidence-based policy
- Validate & inform modelling
- Reveal the unexpected

Fresh waters – OK

Forest / trees – acceptable

Semi-natural veg – could do better

Soils – could do better

