
Challenges in linking hydromorphologic to ecology
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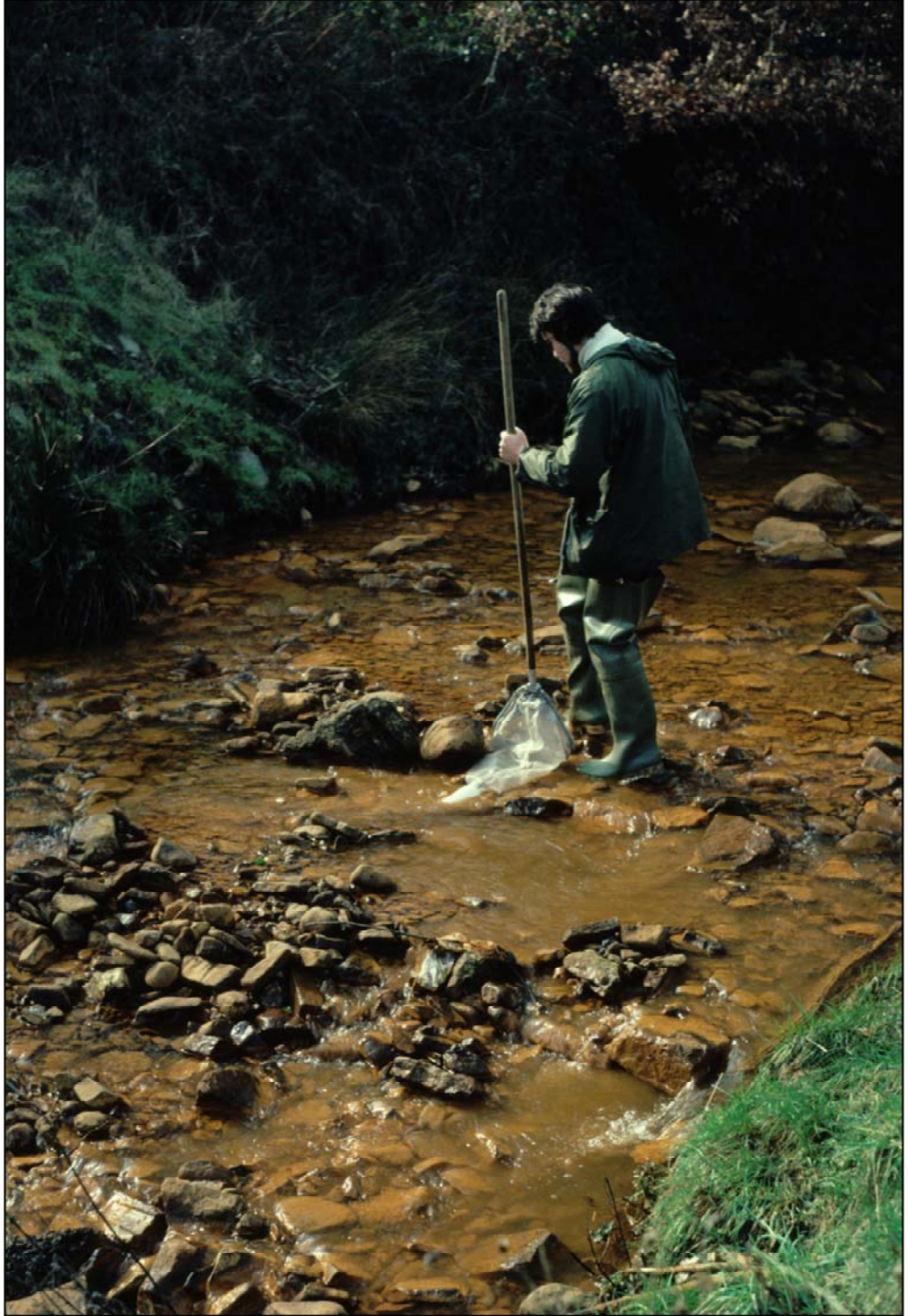
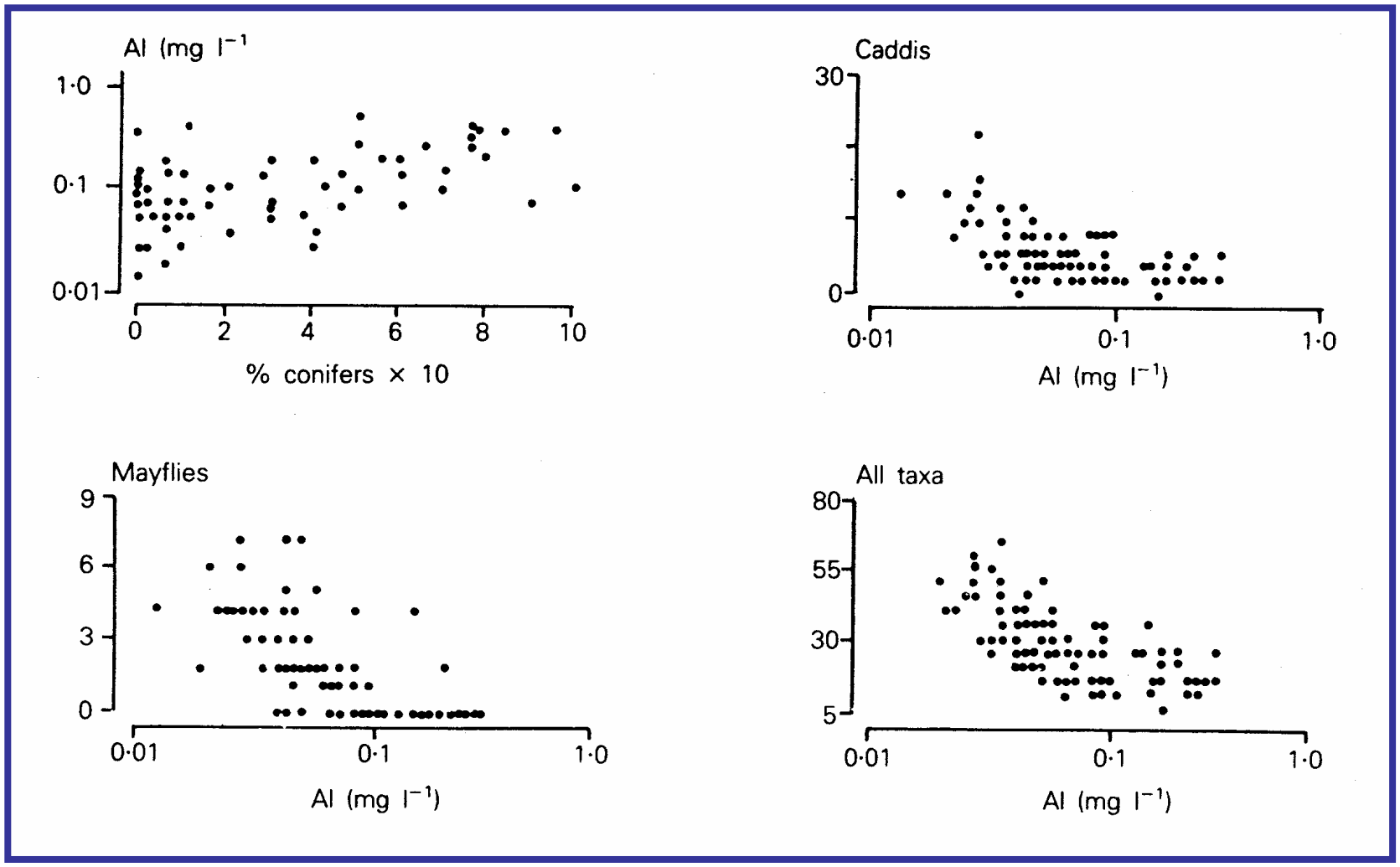
Foto: Rune Stokkebekk

Scope:

- *Parallels with water quality*
- *Hydromorphology: two simple needs*
- *A review of science capability*
- *Some challenges*
- *Possible research appoaches*

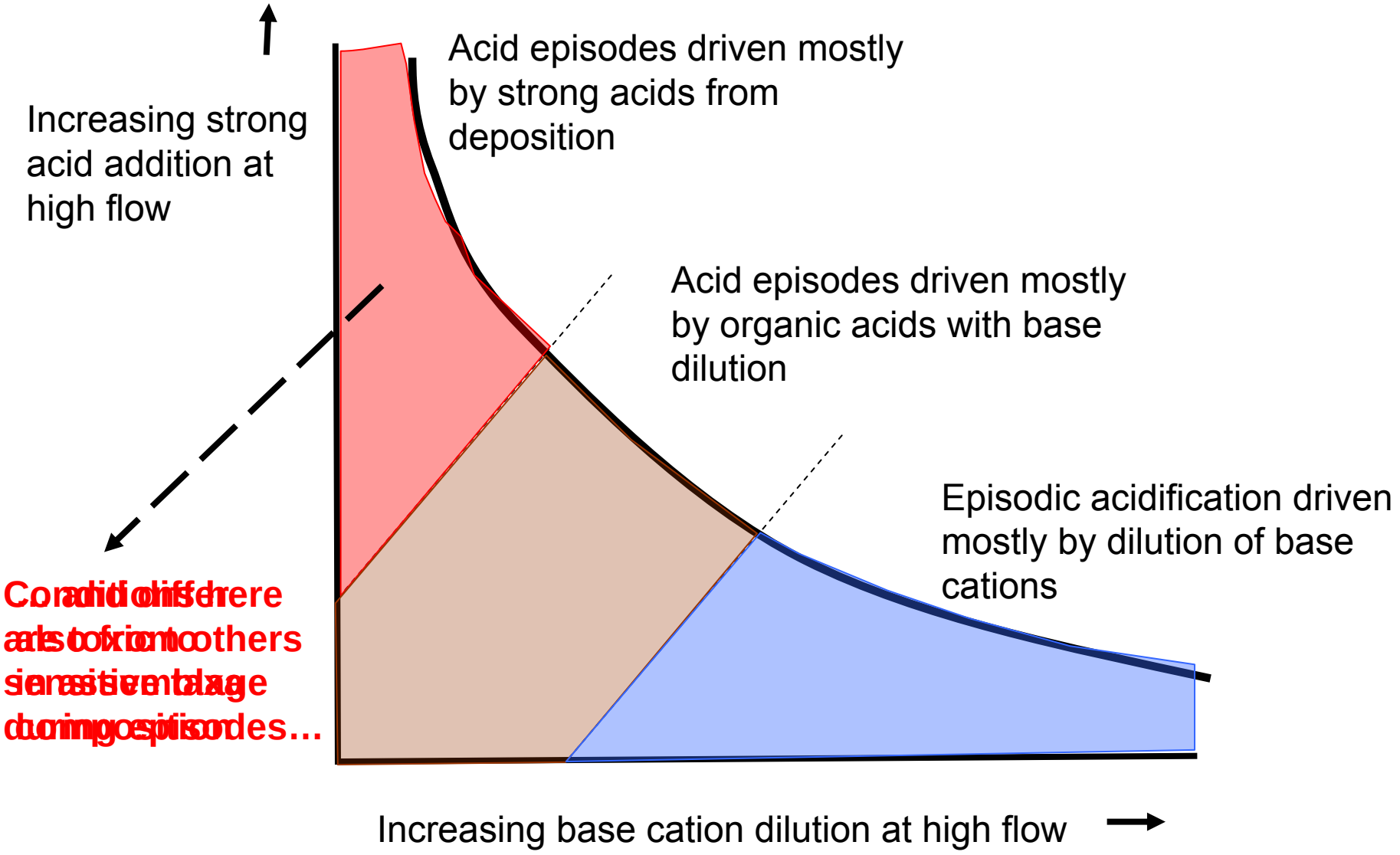


(Ormerod et al. 1987)

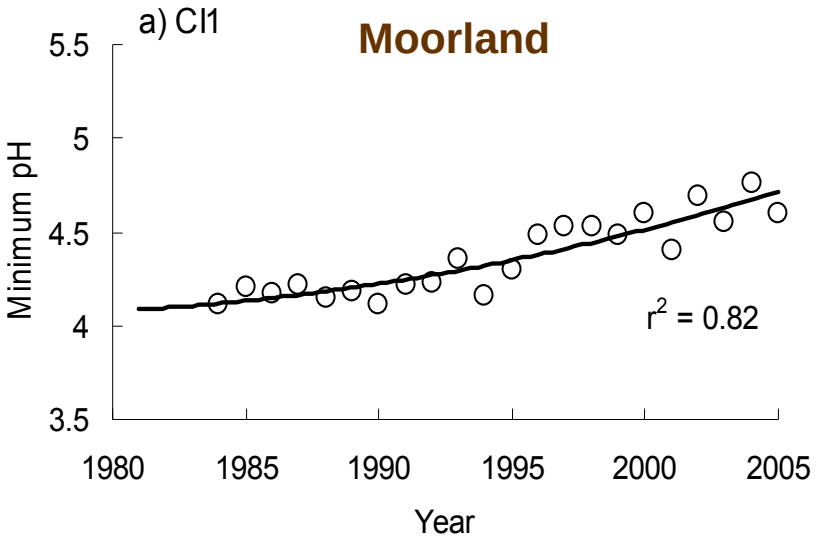


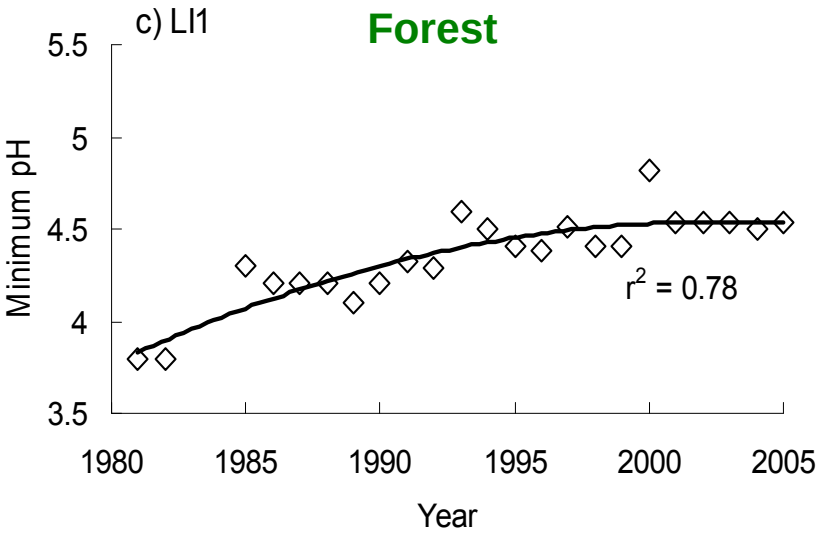
Invertebrate species richness in Welsh streams in relation to mean dissolved aluminium (<0.45 μm) and catchment afforestation,

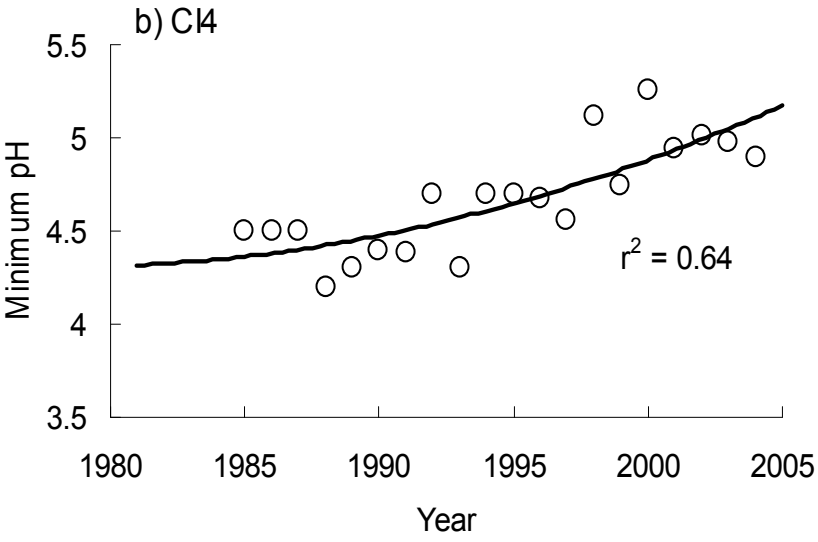
A schematic representation of processes in episodic acidification

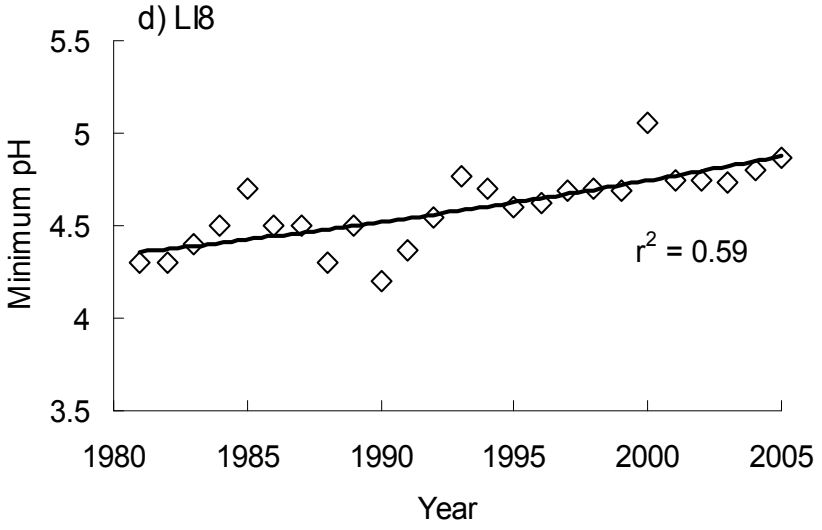


Long-term trends in pH minima at Llyn Brianne

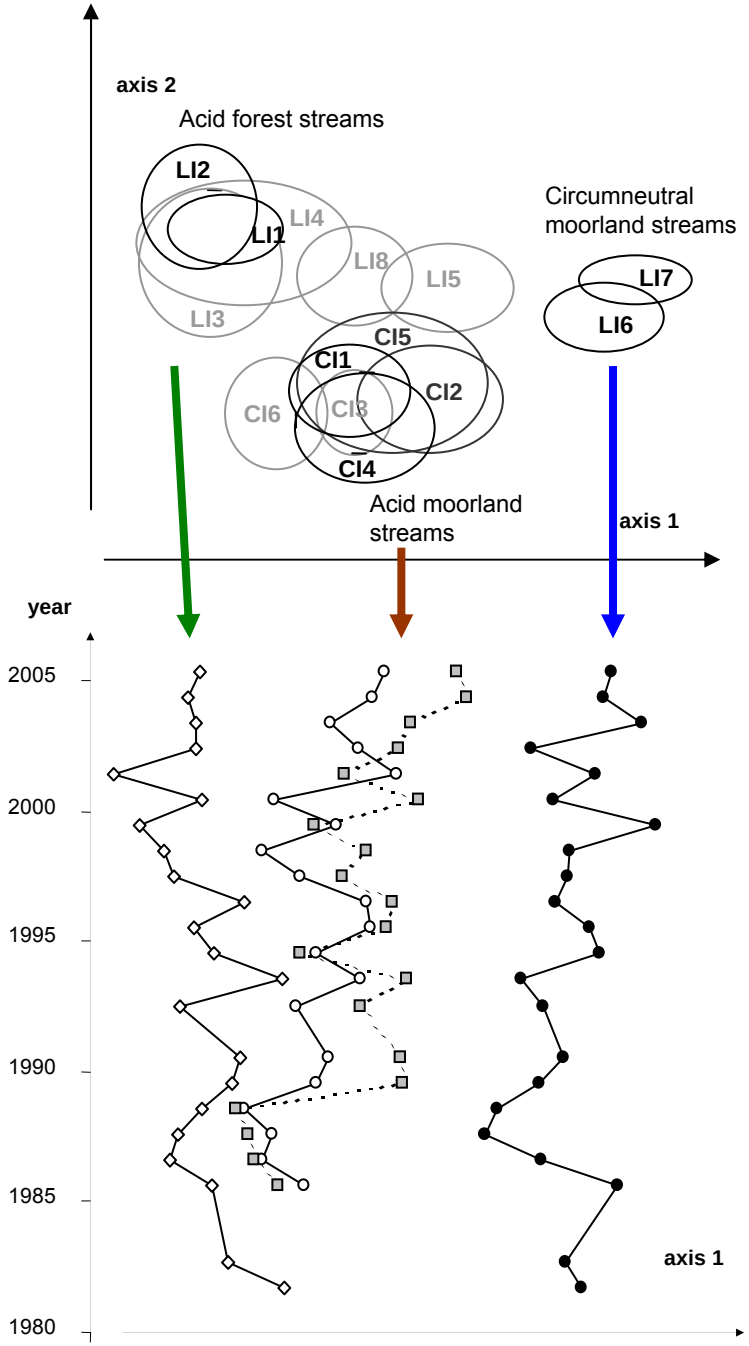








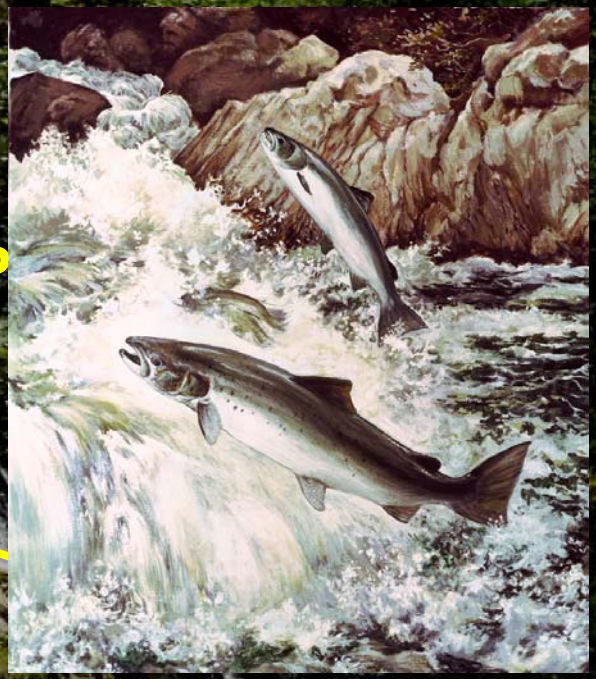
(Ormerod & Durance 2009)



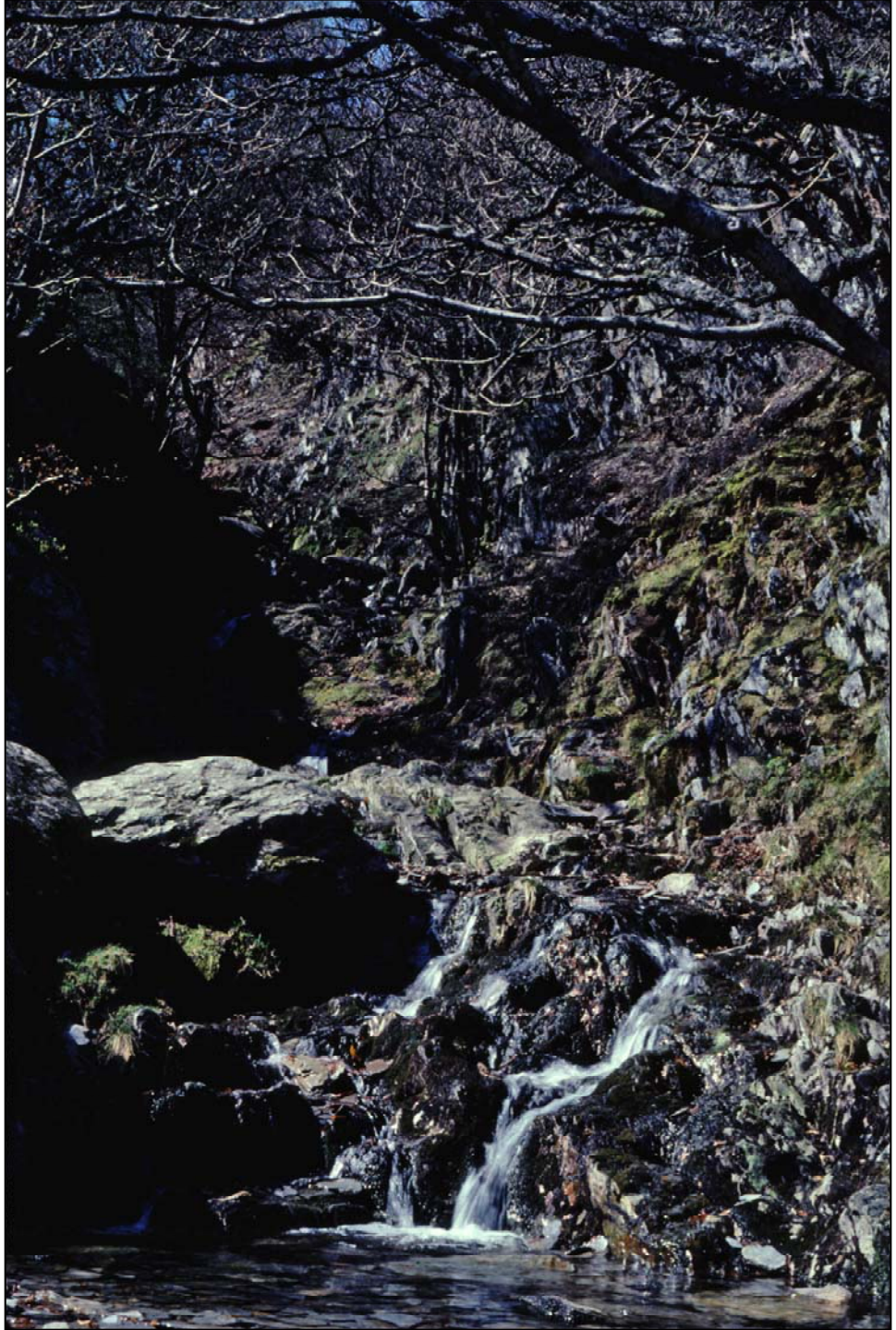
Changes in invertebrate assemblages (1981-2005) at Llyn Brianne in circumneutral (●), acid moorland (○), limed (■), and acid forest streams (◊)

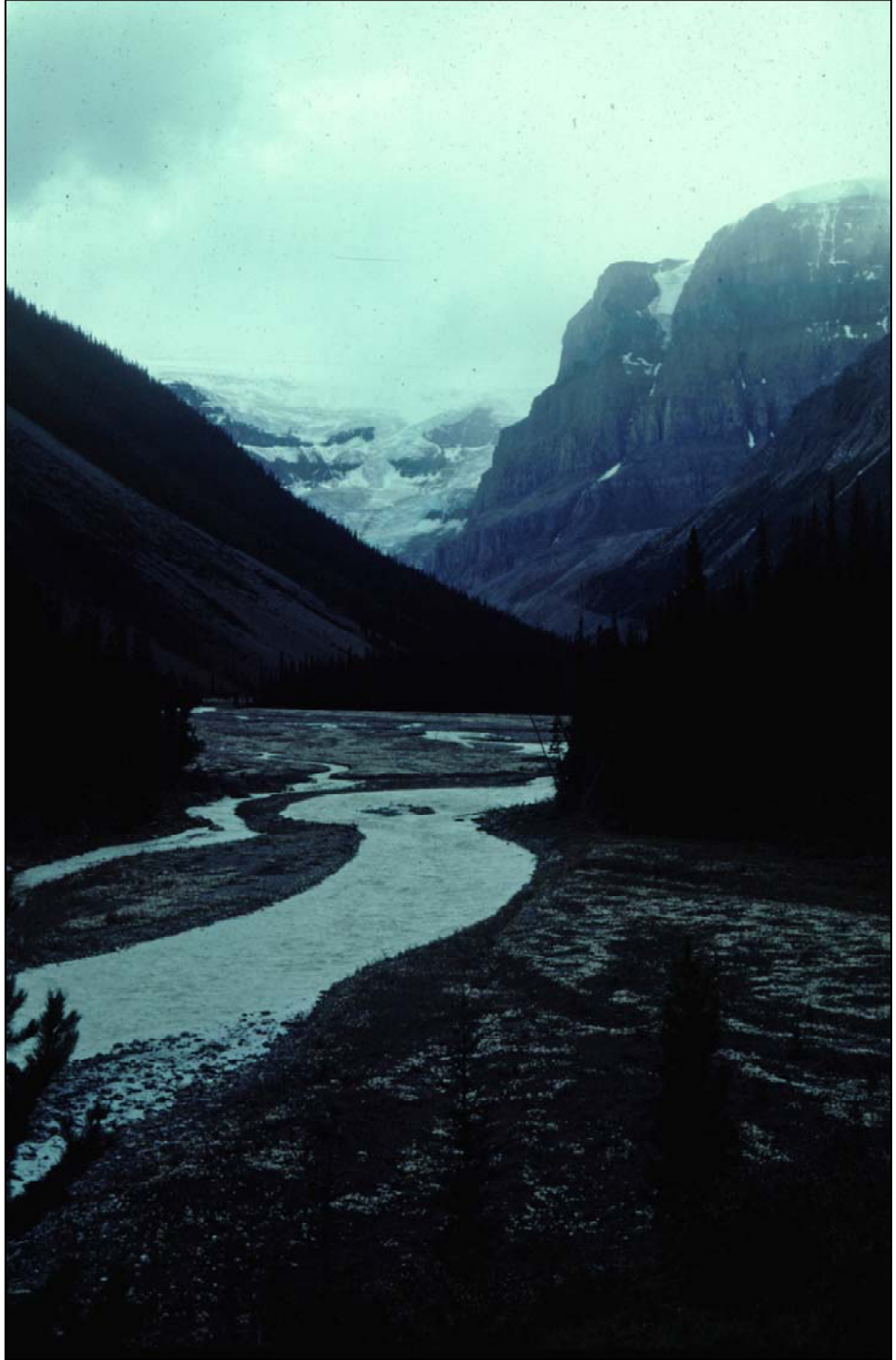
(Ormerod & Durance 2009)

Filter-feeding *Philopotamus*



Scraper-grazer *Baetis*






Afon Tywi SAC

Hydromorphology and river biota: linking river physical structure to ecology.

S. J. Ormerod, I. P. Vaughan and Isabelle Durance
Catchment Research Group, Cardiff School of Biosciences, PO Box 915, Cardiff CF10 3TL UK.

A review of >3000 papers published globally

Some widespread assumptions:

i) River hydromorphology is linked directly to biological quality and biodiversity

ii) Hydromorphological changes due to abstraction, enhancement, river restoration, flood defence, engineering, diffuse habitat degradation and climate change engender changes among organisms

iii) Schemes that model or record fluvial geomorphology and hydrology can represent biological quality, ecosystem processes, conservation value, the habitat requirements of organisms, and the effects of modification

Key conclusions:

Links between biological pattern, ecological processes, river structure, hydrological processes and modification in rivers are irrefutable…

…but extremely poorly quantified in fundamental science or application.

Very little research has been tailored to regulatory needs…

… and lags behind pollution ecology, fisheries management or bio-assessment

What we know:

Ecological conditions vary between river biotopes (e.g. pools, riffles, marginal vegetation, woody debris, floodplain, hyporheic zones…)

Clear consequences for the distribution of organisms and the composition of communities

Includes riparian or floodplain environments as well as the wetted channel

What we know:

Ecological mechanisms linking organisms to hydromorphology are understood in outline:

habitat richness/complexity/area, connectivity, hydraulic character, stability and refugia, energy processing and production, ontogeny, biotic interactions, succession, keystone species…

Knowledge varies between taxonomic groups, biotopes and river types

Basic qualitative principles rather than quantitative relationships

Towards quantification:

Synoptic geomorphological and hydrological assessment at the reach scale offers promise.

But….

Movement of organisms/plasticity in habitat use

Scale-effects related to body-size

Ecological limits imposed at other scales

Current approaches static rather than process-driven; structural more than functional

Univariate (e.g. sediment; flow pattern) rather than multivariate

Poor understanding of multiple drivers (e.g. hydromorphology, hydrology and water quality)

Limited ability to diagnose biological departures from expected conditions, i.e. to distinguish hydromorphological effects

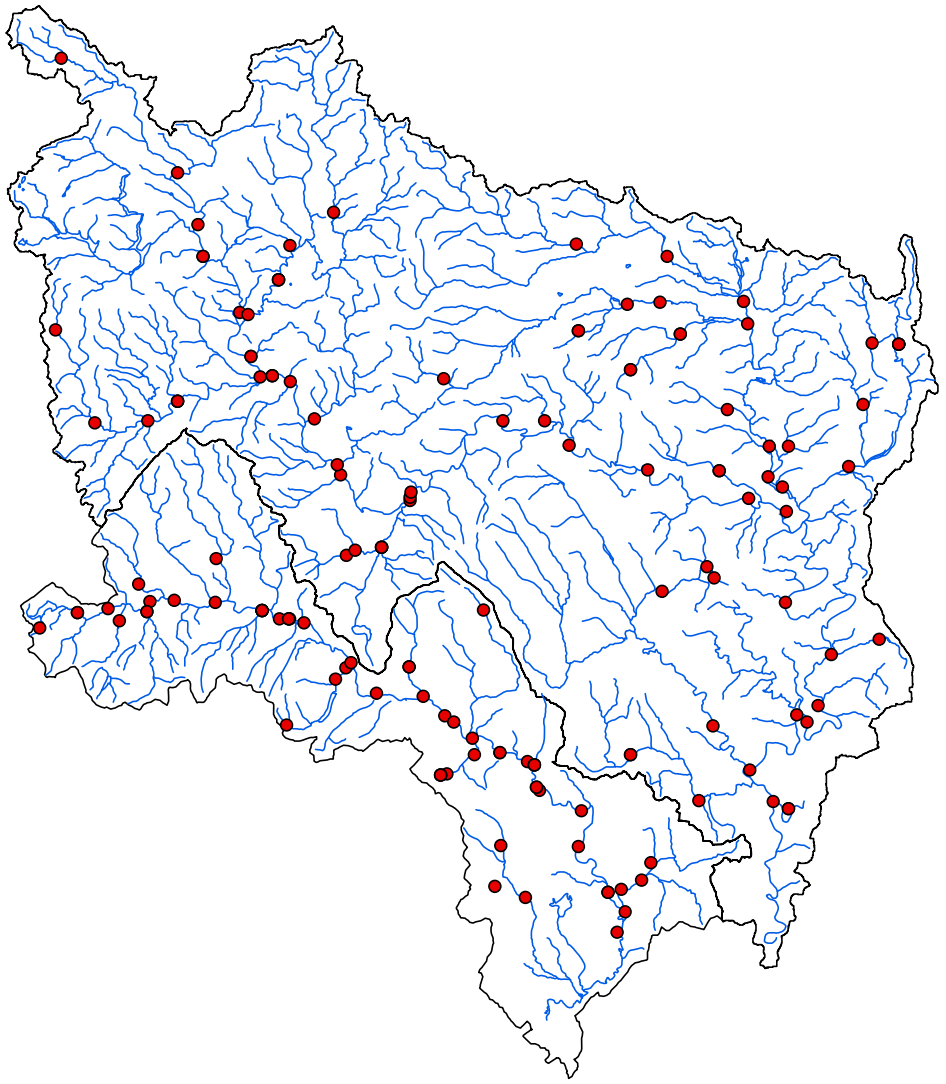
Factors affecting ecological resilience/resistance barely considered by researchers or managers.

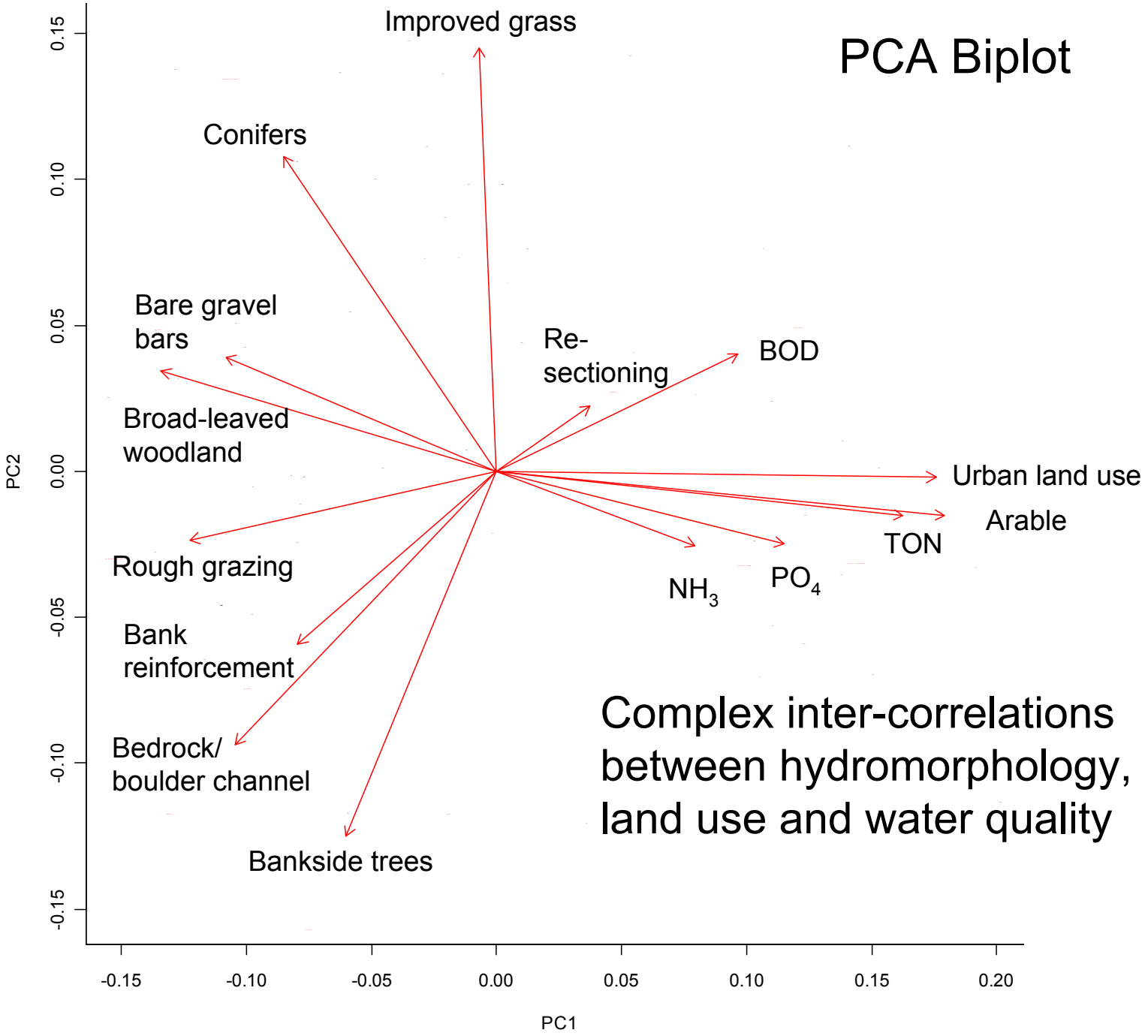
Practical challenges in linking ecology to hydromorphology

- Numerous issues – apply both to existing data sets and new data collection
  - *Separating hydromorphology from other correlates and drivers*
  - *Generalising across scales*
  - *Inference about processes/dynamics from static measurements (no temporal dimension)*
  - *Improving biological sampling*

Separating hydromorphology from other influences

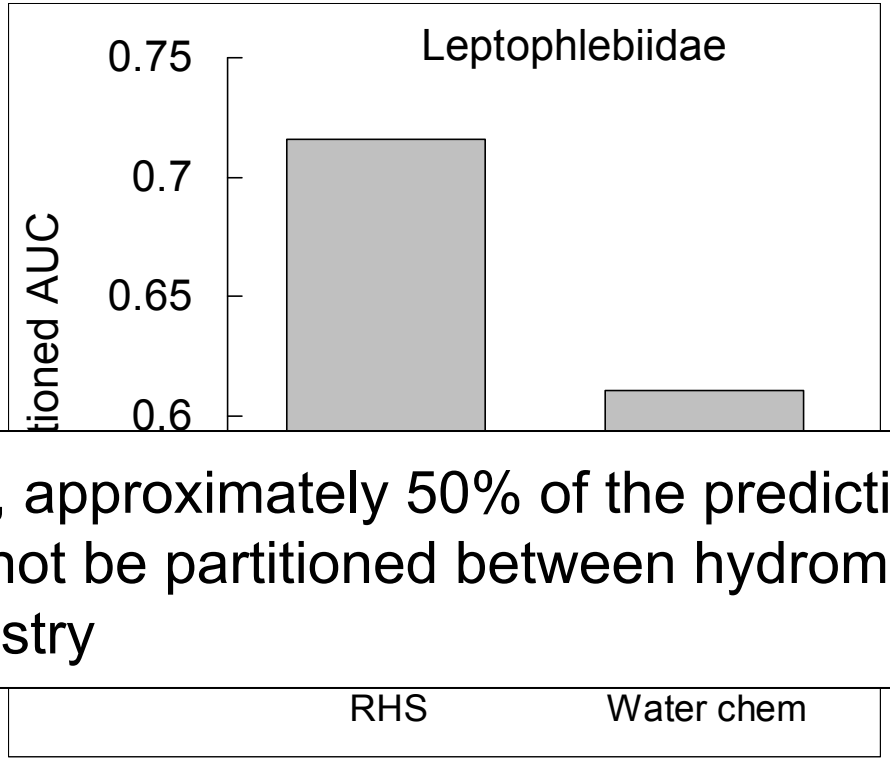
- Sites across the Wye and Usk catchments in Wales
  - water chemistry
  - River Habitat Survey, summarised as indices of habitat characteristics or modifications
  - land use adjacent to the channel




PCA Biplot
Improved grass
Conifers
Bare gravel bars
Broad-leaved woodland
Rough grazing
Bank reinforcement
Bedrock/ boulder channel
Bankside trees
Re-sectioning
BOD
Urban land use
Arable
TON
PO_4
NH_3
Complex inter-correlations between hydromorphology, land use and water quality
PC1
PC2
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20

Species distribution modelling

- Modelled the distributions of 51 invertebrate families using logistic regression and a mix of RHS and water chemistry
- Partitioned their predictive abilities between RHS, chemistry and shared variance (due to collinearity)



On average, approximately 50% of the predictive abilities of the models cannot be partitioned between hydromorphology and water chemistry

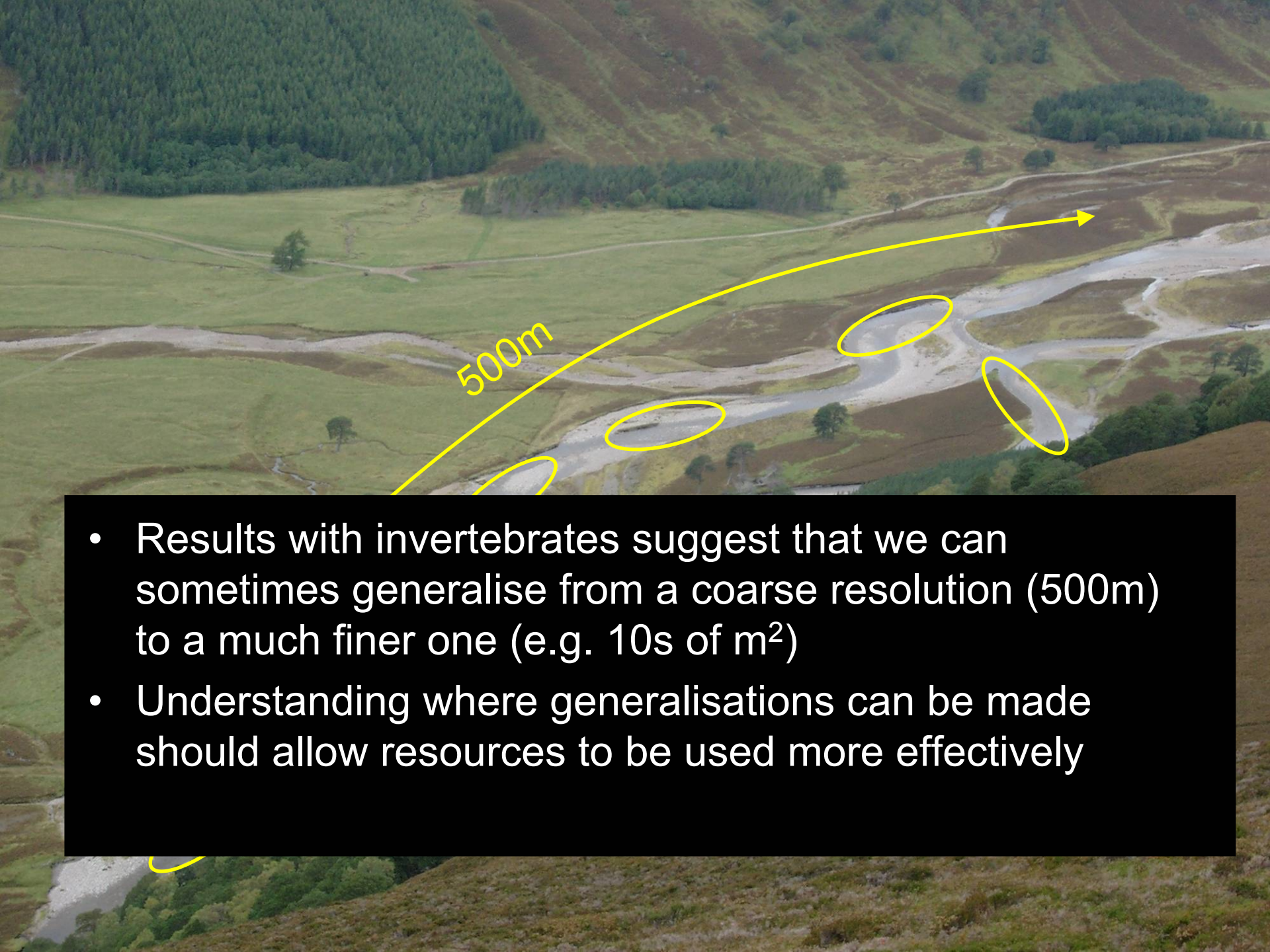
Separating hydromorphology from other influences

- Separating multiple influences/stressors is a perennial problem in ecology
- This problem has to be overcome to understand the mechanistic links
- The opportunities for finding sites that only vary in their hydromorphology are likely to be limited
  - Experimentation
  - Pre-/post-modification monitoring

  } *Only address certain issues*
- An inability to distinguish the unique role of hydromorphology may not matter in certain circumstances
  - Define general impacts, such as 'urbanisation'

Generalising across scales

- In an ideal world…
  - highest resolutions, largest extents/longest timeframes
  - employing multiple scales
  - careful matching of scales for ecology & hydromorphology
- In practice…
  - low resolution, limited extent/single measurements
  - single/few scales
  - mis-match between measuring ecology and physical habitat
- Can ecology–hydromorphology relationships be generalised across scales?
  - Can domains of scale be identified within which ecology-hydromorphology relationships remain constant?



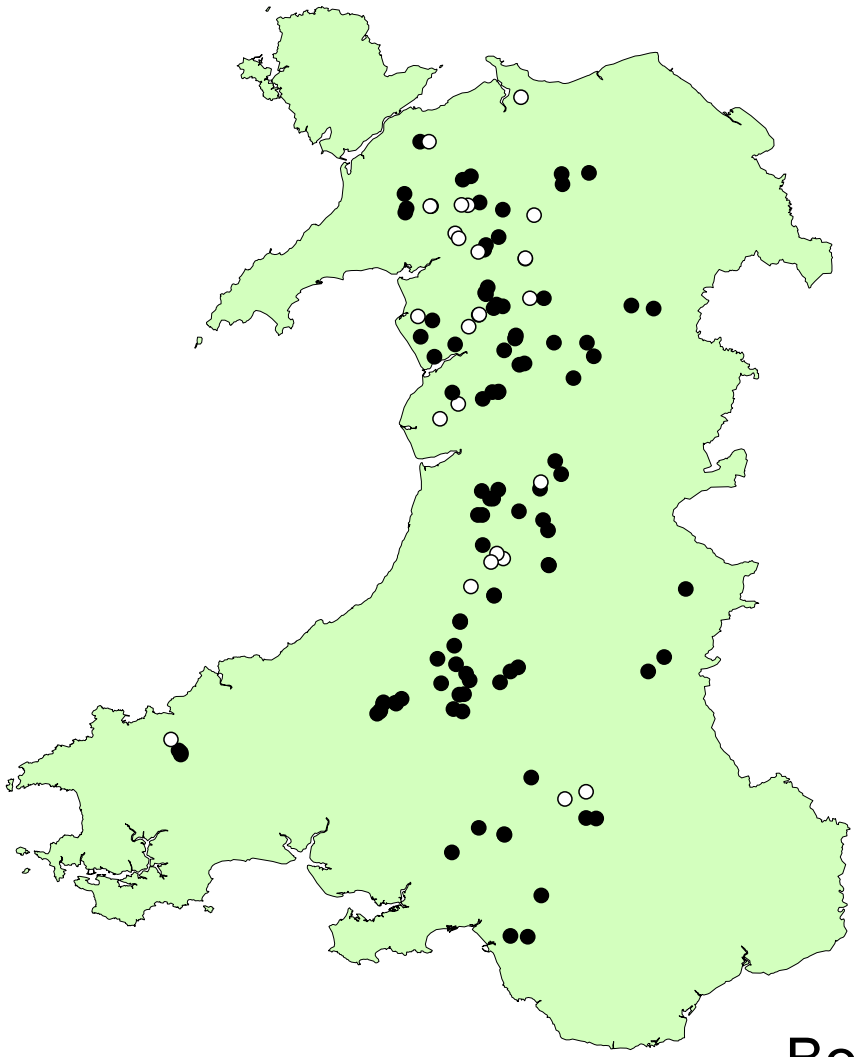
- Results with invertebrates suggest that we can sometimes generalise from a coarse resolution (500m) to a much finer one (e.g. 10s of m^2)
- Understanding where generalisations can be made should allow resources to be used more effectively

Static vs process measurements

- The easiest and most widespread recording methods (ecology and hydromorphology) are essentially static, unless repeat measurements are made at the same points over time
  - Lists/abundance of taxa, recognisable hydromorphic features…
- Widespread recognition of:
  1. the need to quantify and link process, and understand mechanisms
  2. the limitations imposed by time and money
- Observed forms/patterns are realisations of the underlying processes. As such they must reveal something about the underlying processes. *To what extent can they be used in lieu of them?*

Biological sampling

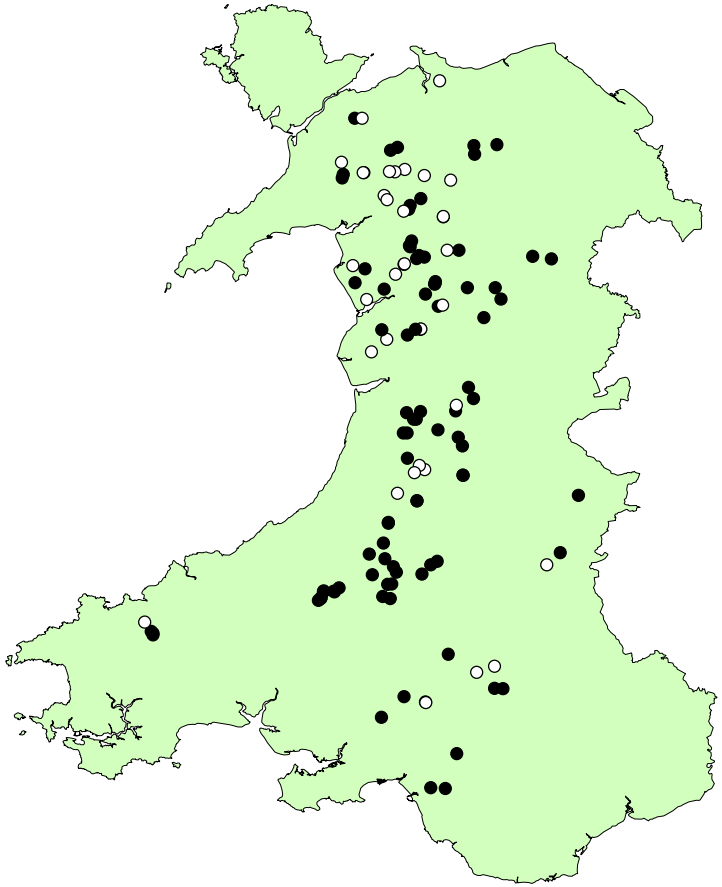
- Few ecological methods were developed with hydromorphology in mind
- A two-stage appraisal is required:
  1. How effective are current methods and where do their deficiencies lie?
  2. How best to capture ecological communities and processes to quantify their links to hydromorphology?
- One major deficiency with current methods could be the use of relatively low-resolution biological data
  - Invertebrates form a major strand of river monitoring
  - Usually recorded at family level – could obscure species-level responses?
  - Cost-benefit trade-off

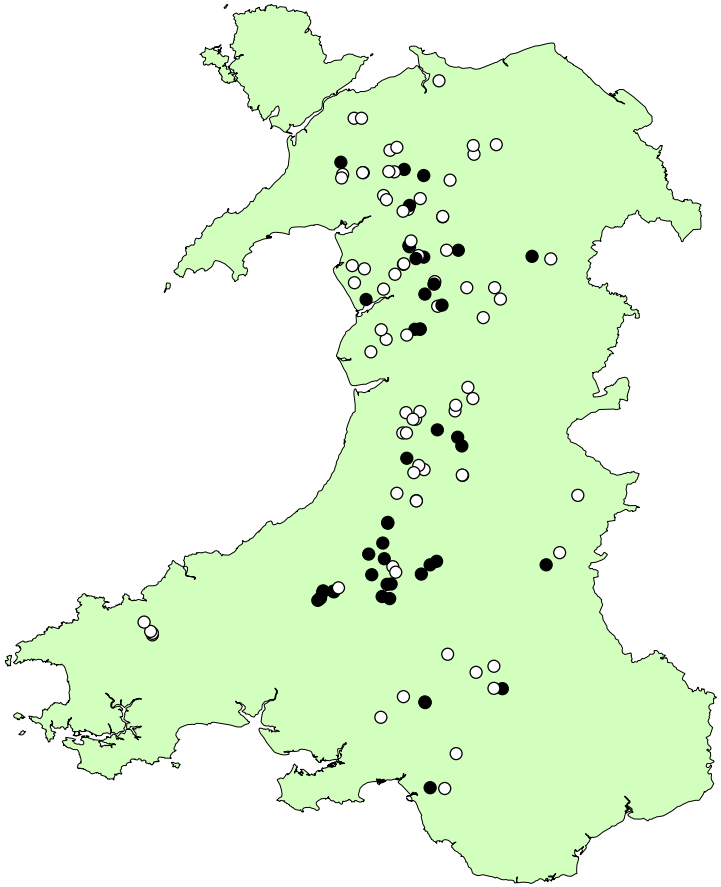


- Sites across upland Wales sampled in the mid-1990s: invertebrates, RHS and water chemistry
  - RHS described: tree cover, bank vegetation, bedrock/boulder channel, bank reinforcement, re-sectioning
- Modelled species separately, and combined at family level
- Illustrate with two *Chloroperla* stoneflies

Chloroperlidae

Bootstrapped AUC = 0.66
No clear correlations with any of the chemical or hydromorphic variables





- *C. torrentium*
  - Bootstrapped AUC = 0.73
  - Hydromorphology – bedrock/boulder channel + associated flow types
  - No correlations with water chemistry

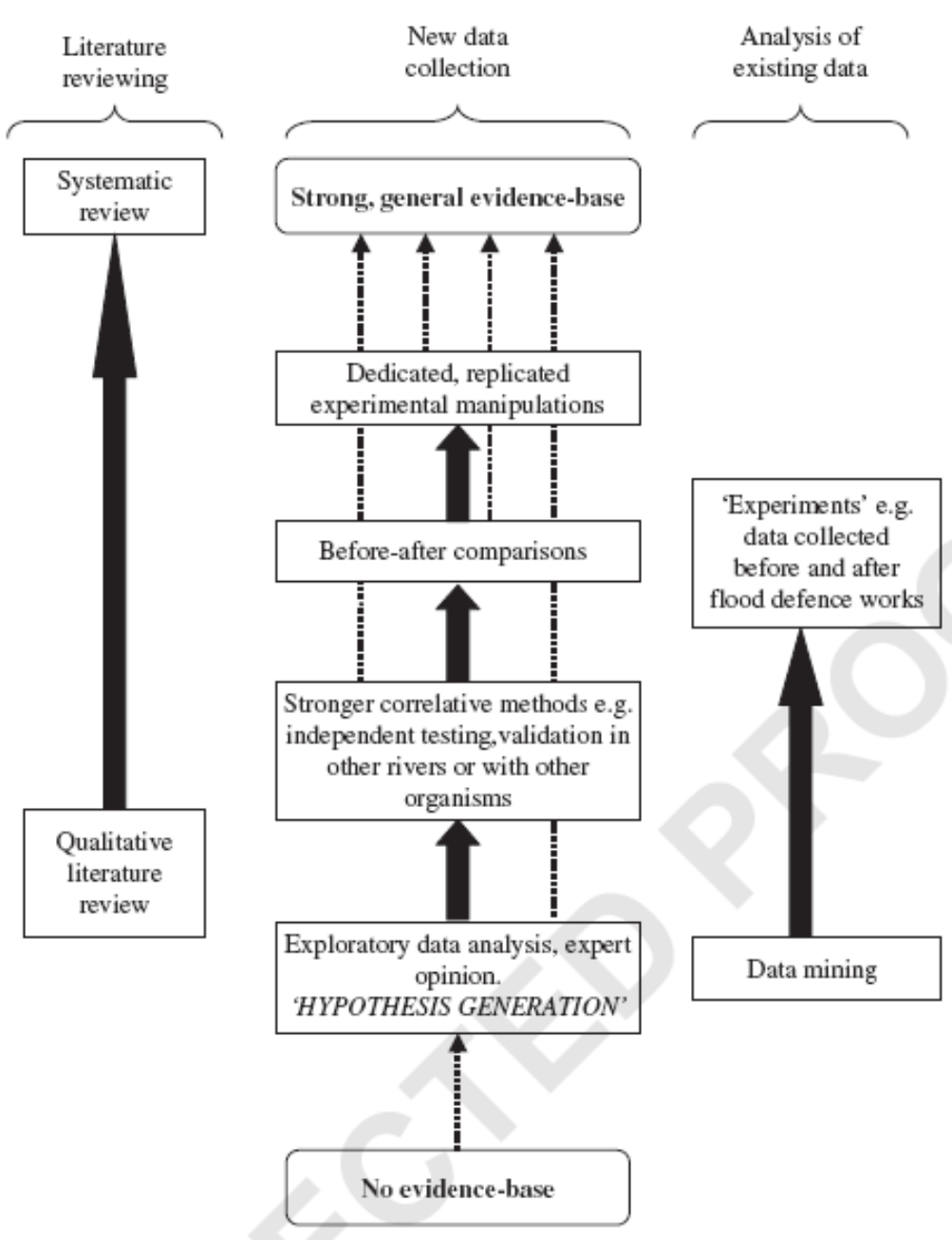
- *C. punctata*
  - Bootstrapped AUC = 0.68
  - Acid sensitive
  - No correlations with hydromorphology

- Similar results in other families, such as Baetidae and Hydropsychidae
- Heterogeneity in species' responses are masked at family level
- Conclusion – simple, pragmatic decisions about sampling could hinder:
  - understanding the role of hydromorphology in shaping biological assemblages
  - management tools, as predictive accuracy can be reduced

(Vaughan et al. 2009)

Understanding processes

Recognising pattern



A 'ladder of evidence' approach to gap-filling in eco-hydromorphology