Development and independent testing of a new biotic index of stream macroinvertebrate response to deposited fine-grained sediment

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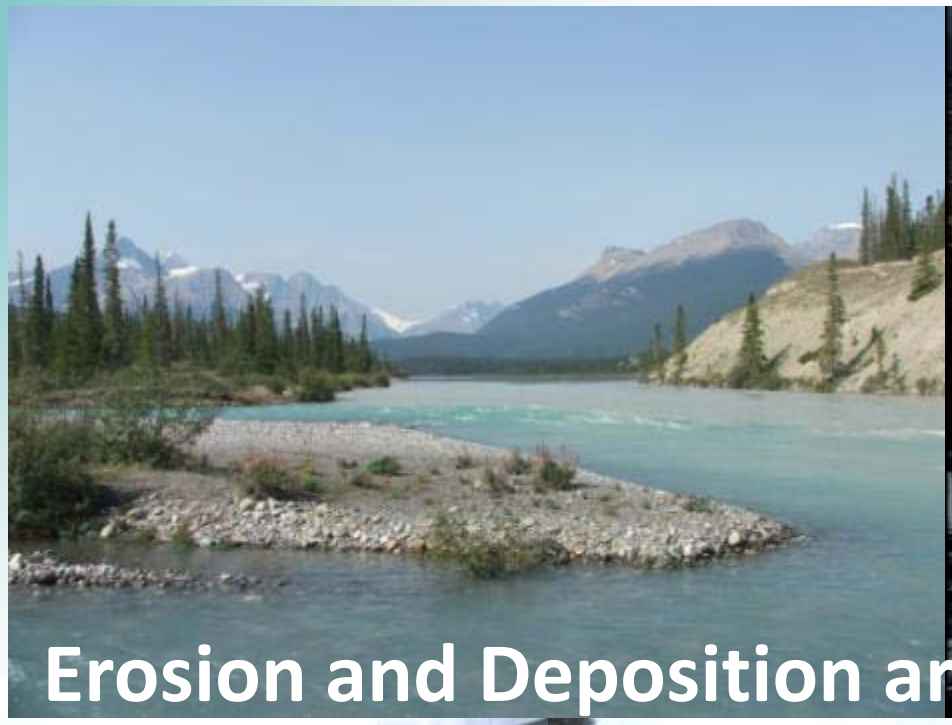


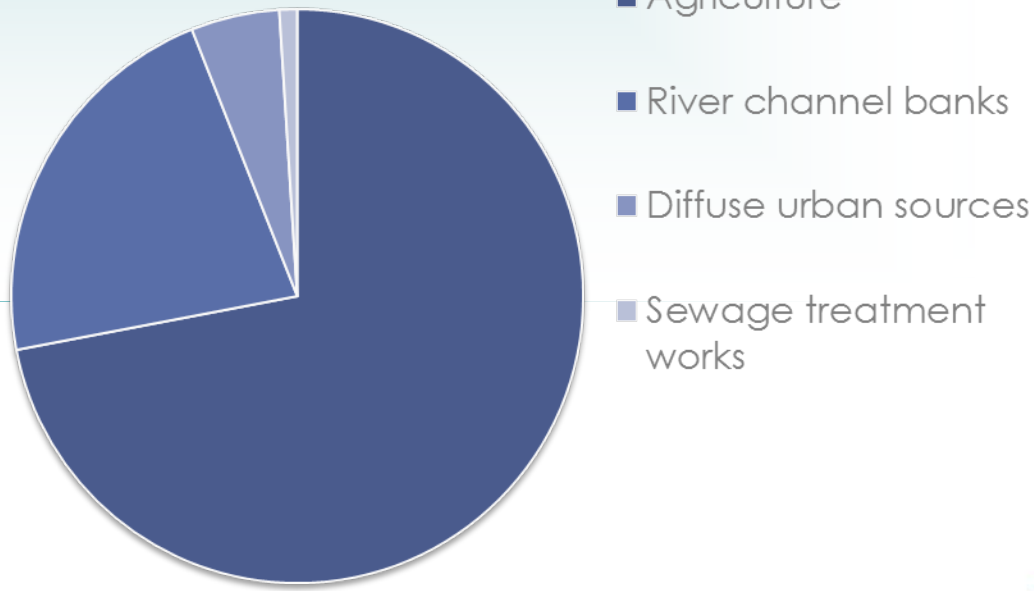
Erosion and Deposition are Natural Processes

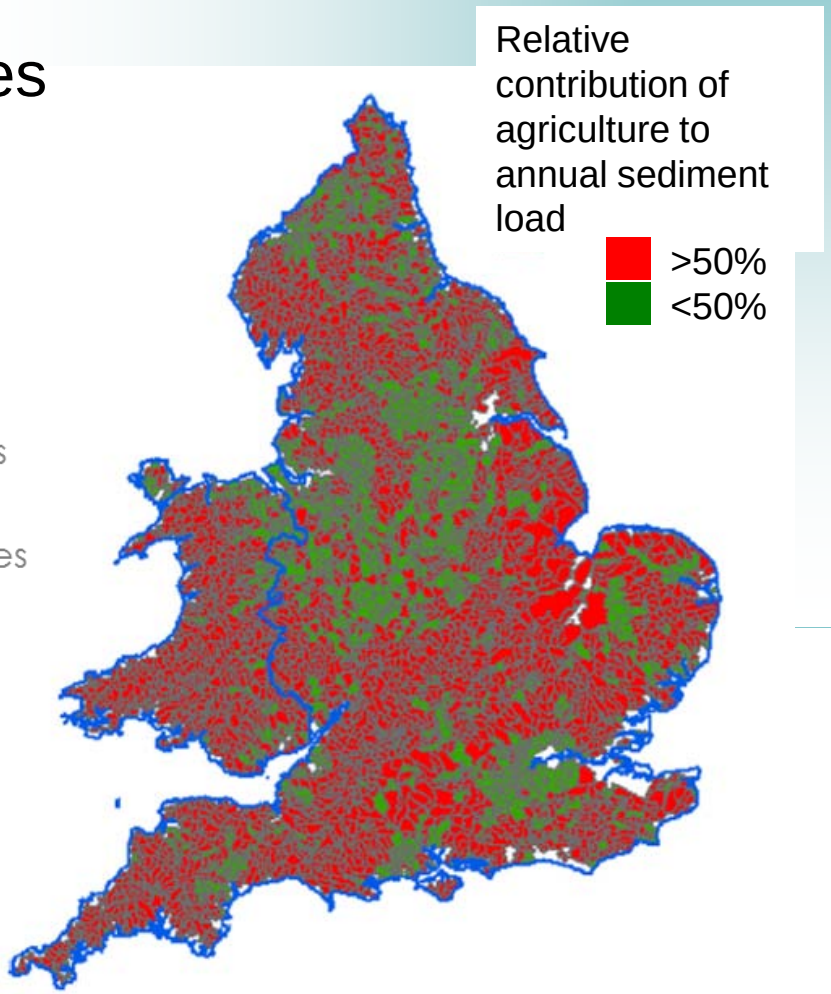
Human Activities Influence Load, Composition and Retention

Sources of fine sediment

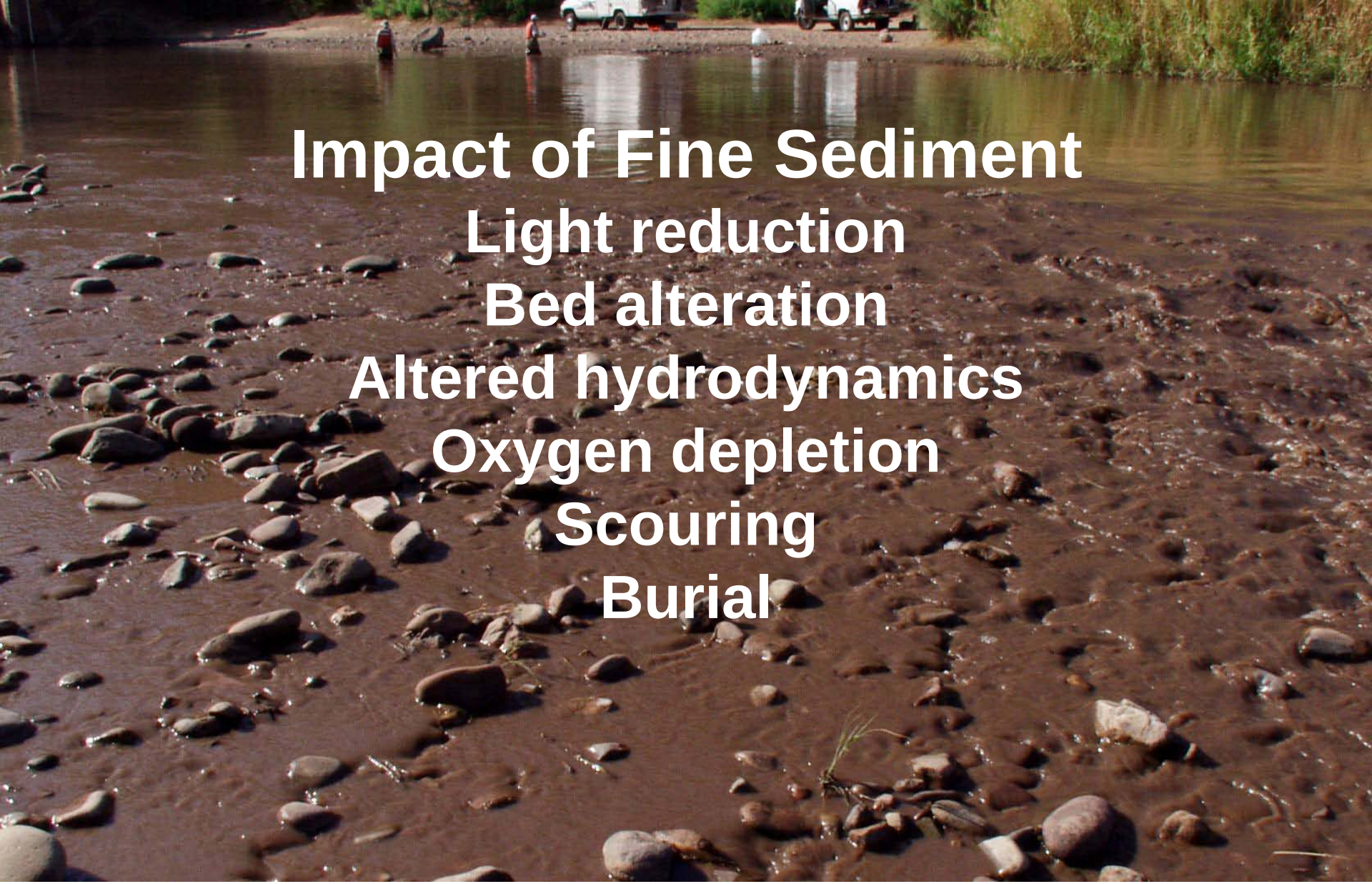
National-scale sediment source apportionment for England & Wales

Zhang, Collins *et al*. (2014) *Env. Sci. Pol*. **42**:16-32





Fine sediment is now considered one of the most widespread and detrimental forms of aquatic pollution



Impact of Fine Sediment

Light reduction
Bed alteration
Altered hydrodynamics
Oxygen depletion
Scouring
Burial

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Managing the problem

EU Water Framework Directive provides the mandate

UK government requires tools to diagnose where excessive fine sediment is impairing ecological condition

Better targeting of mitigation

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Review Impact of Fine Sediment on WFD BQEs

Fish

[Kemp et al. (2011) *Hydrological Processes* 25: 1800-1821]

Invertebrates

[Jones et al. (2012) *River Research and Applications*, 28: 1055-1071]

Macrophytes

[Jones et al. (2012) *River Research and Applications*, 28: 1000-1018]

Diatoms

[Jones et al. (2014) *Hydrological Processes* 28, 1226–1237]

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Impacts via
Suspended Sediment
Deposited Sediment


Existing knowledge not always at appropriate spatial scale for management
Better understanding of susceptibility of biota required

Improved Ecological Evidence

Invertebrate response to sediment stress

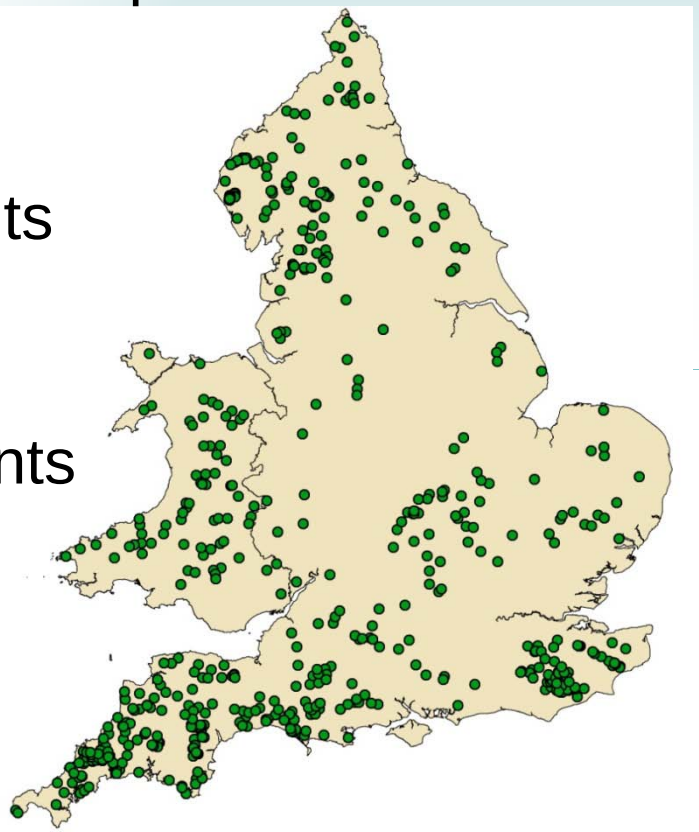
- **Correlative field survey**
- **Manipulative experiments**

Objectives

- Establish relationships
- Develop a diagnostic biotic index
- Independently test new index

Calibration dataset

- 230 sites sampled for macroinvertebrates & deposited fine sediment
- across a gradient of modelled sediment pressure
- across a gradient of stream types
- free from STW and urban area inputs
- upstream of lakes & reservoirs
- predominantly agricultural catchments



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Macroinvertebrate sampling

At each site:

- macroinvertebrate sample (RIVPACS protocol)
  - record physical features of site
  - acquire map-based data




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Fine sediment sampling

At each site:

- remobilisation stilling well

sample surface drape and embedded fine sediment from erosional and depositional areas

Processed in the lab for:

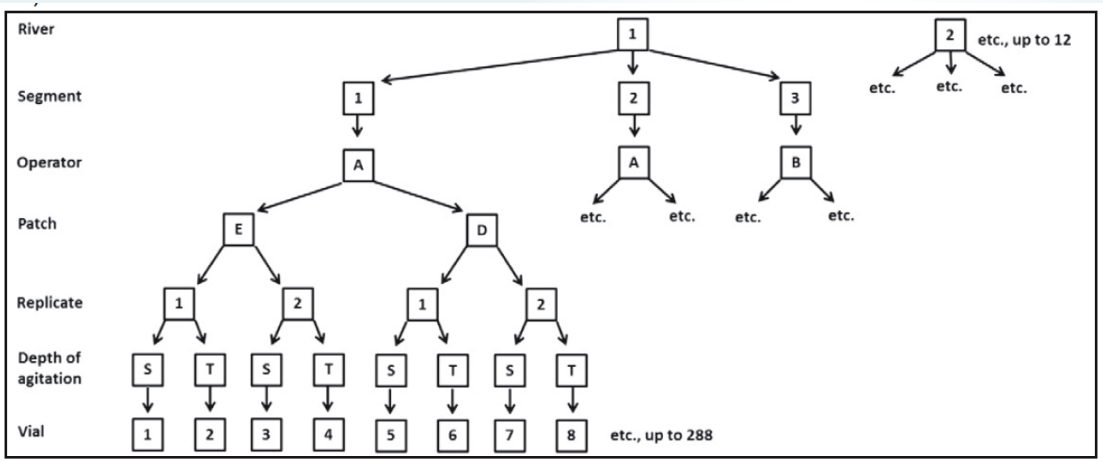
- mass of sediment
- organic content
- particle size

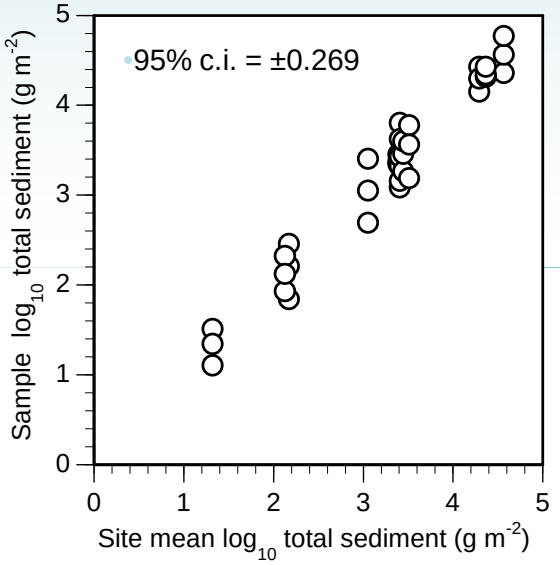
[Duerdoth *et al*. (2015) *Geomorphology* 230: 37–50]

Fine sediment sampling

Reach scale measurement

Known confidence intervals





> 95% variation between rivers

Operator < 1% (not sig.)

[Duerdoth *et al*. (2015) *Geomorphology* 230: 37–50]

Assessment of reach-scale fine sediment sampling

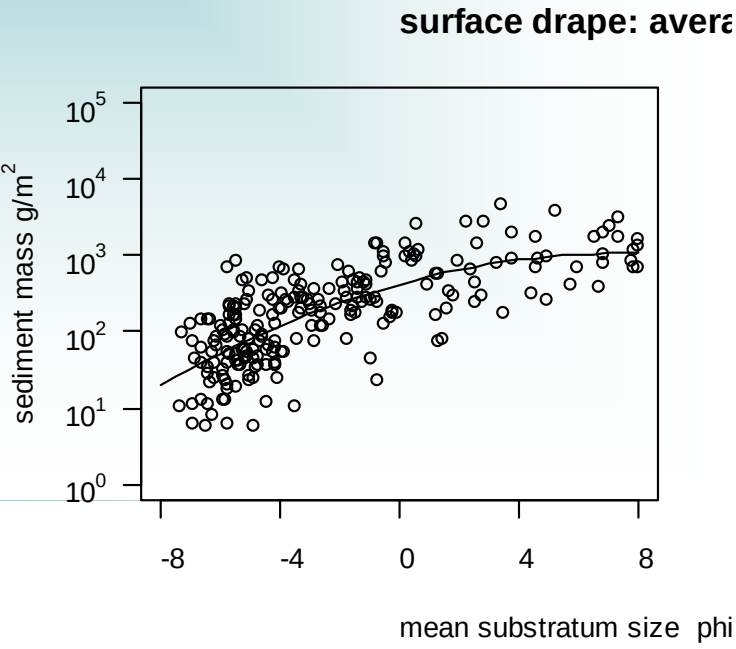
- Visual estimates of % cover of fine sediment
- 4 visual estimates at 16 sites on three occasions

Source	% Variance
Between river site	94.0*
Operator	2.3*
Replicate sample	3.6
Season	0.1

- **Visual estimates affected by operator bias**

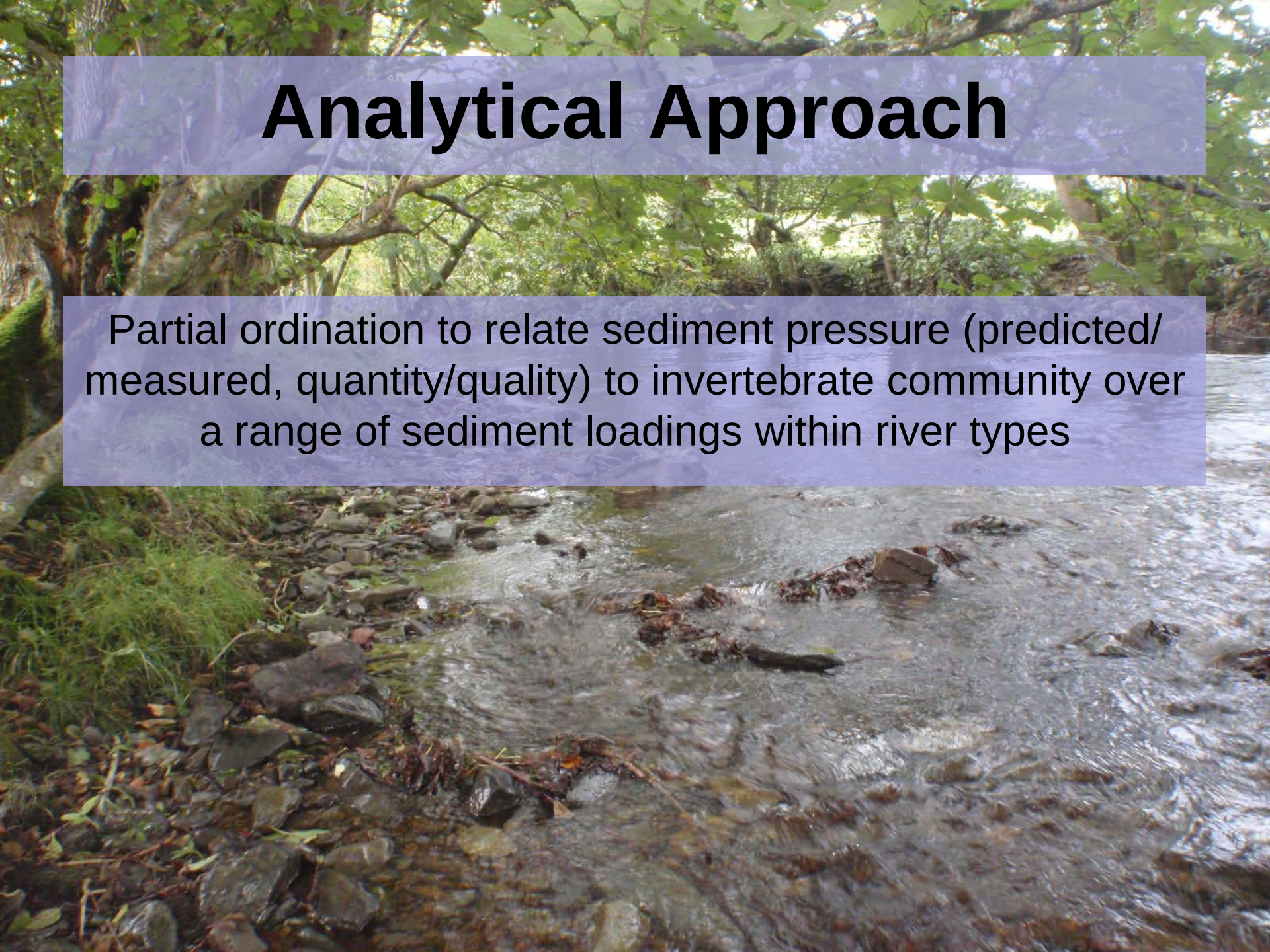
[Duerdoth *et al*. (2015) *Geomorphology* 230: 37–50]

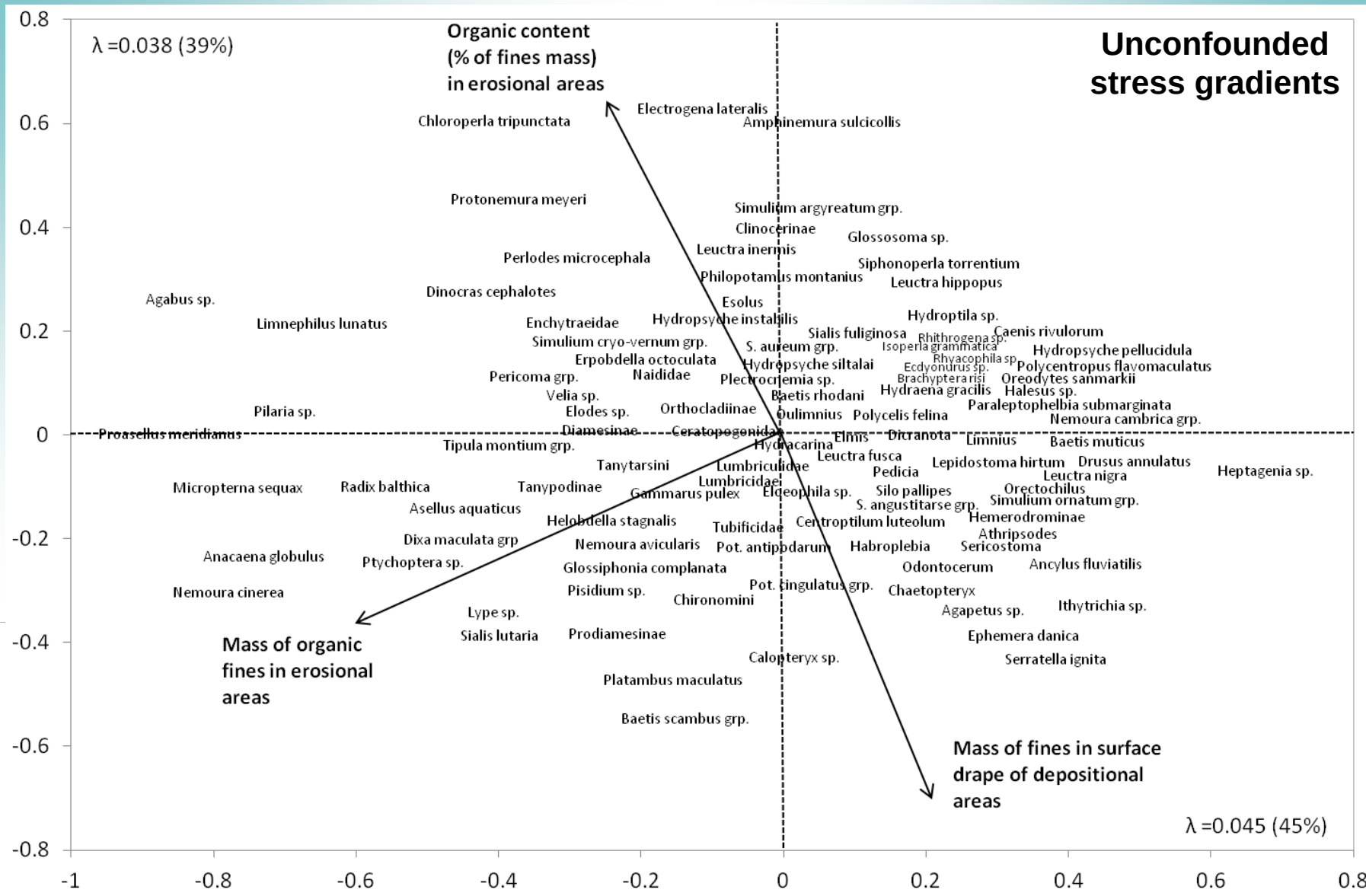
Comparison with visual estimates of bed composition



Analytical Approach

Partial ordination to relate sediment pressure (predicted/ measured, quantity/quality) to invertebrate community over a range of sediment loadings within river types





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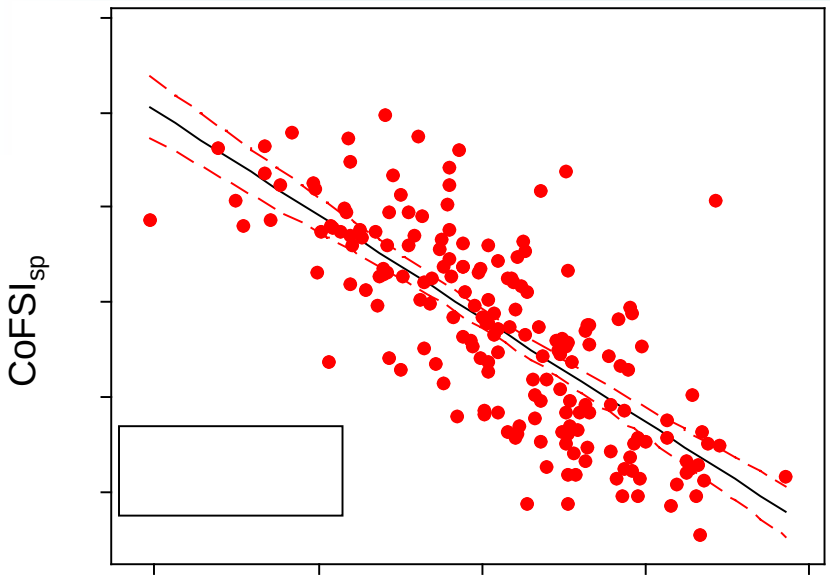
Index Development

Invertebrate response to fine sediment stress comprises two distinct components

ToFSI$_{sp}$ index of response to inorganic component of fine sediment
oFSI$_{sp}$ index of response to organic component of fine sediment

The results of these two indices are then combined

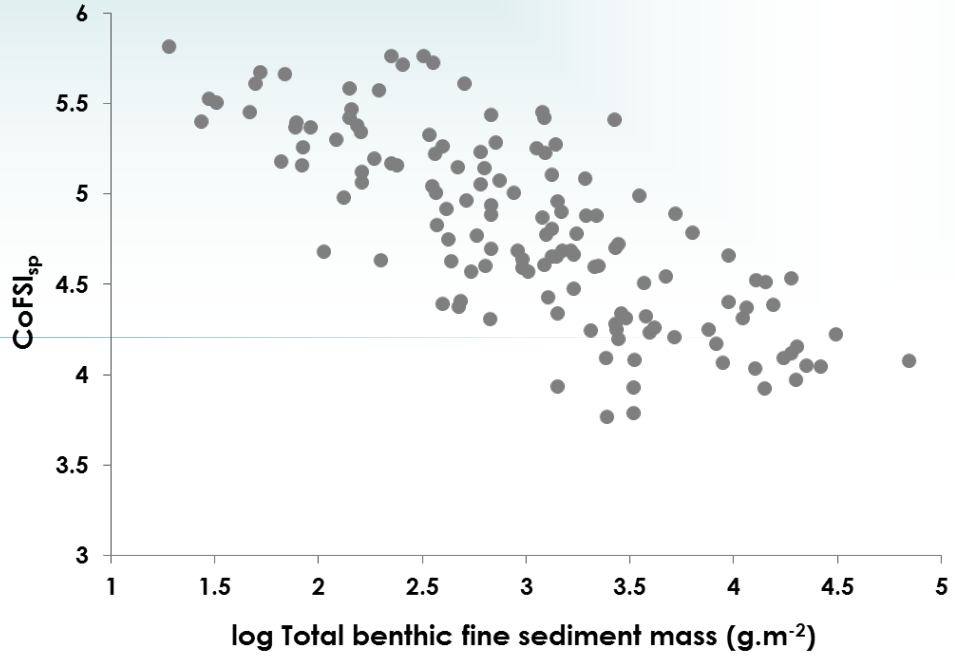
CoFSI$_{sp}$ – combined index of fine sediment stress



[Murphy et al. (2015) *Freshwater Biology* 60: 2019-2036]

Independent test

26 sites retained from the survey and 57 stream sites in Wales

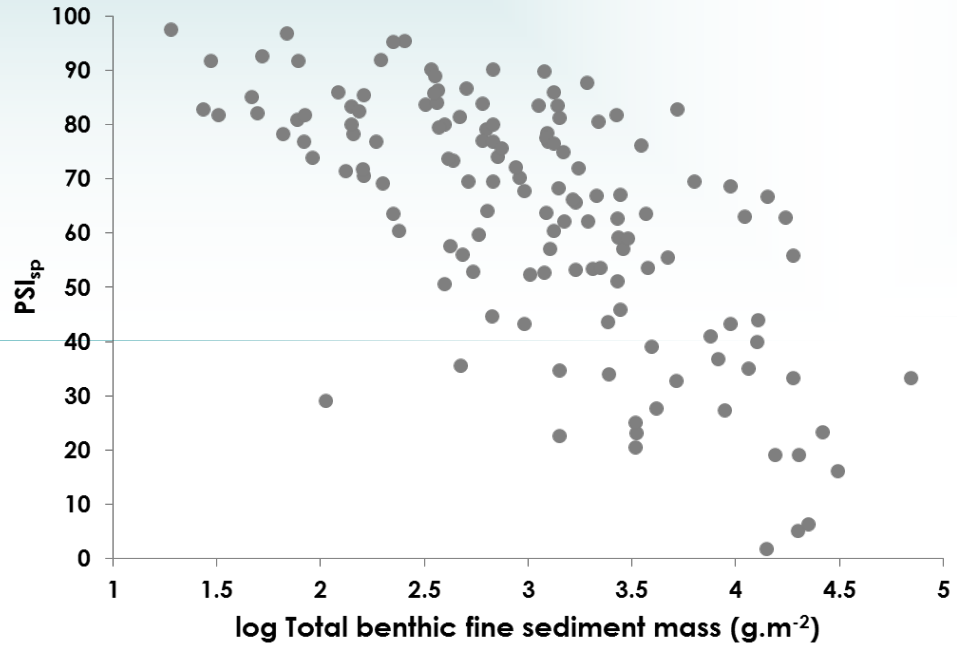


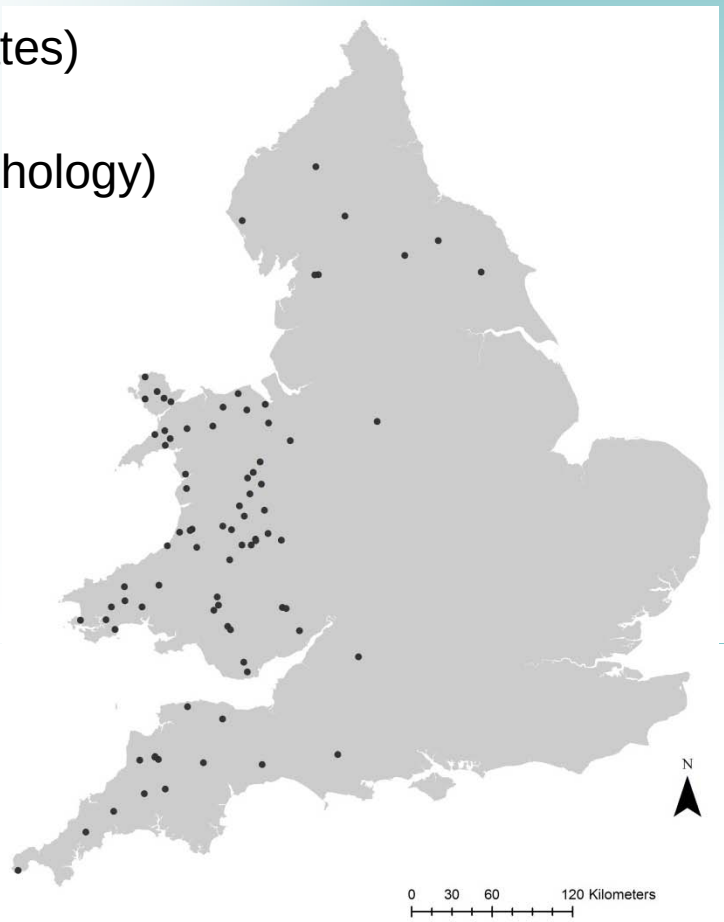
[Murphy et al. (2015) *Freshwater Biology* 60: 2019-2036]

Independent test

PSI (Proportion of sediment sensitive invertebrates)

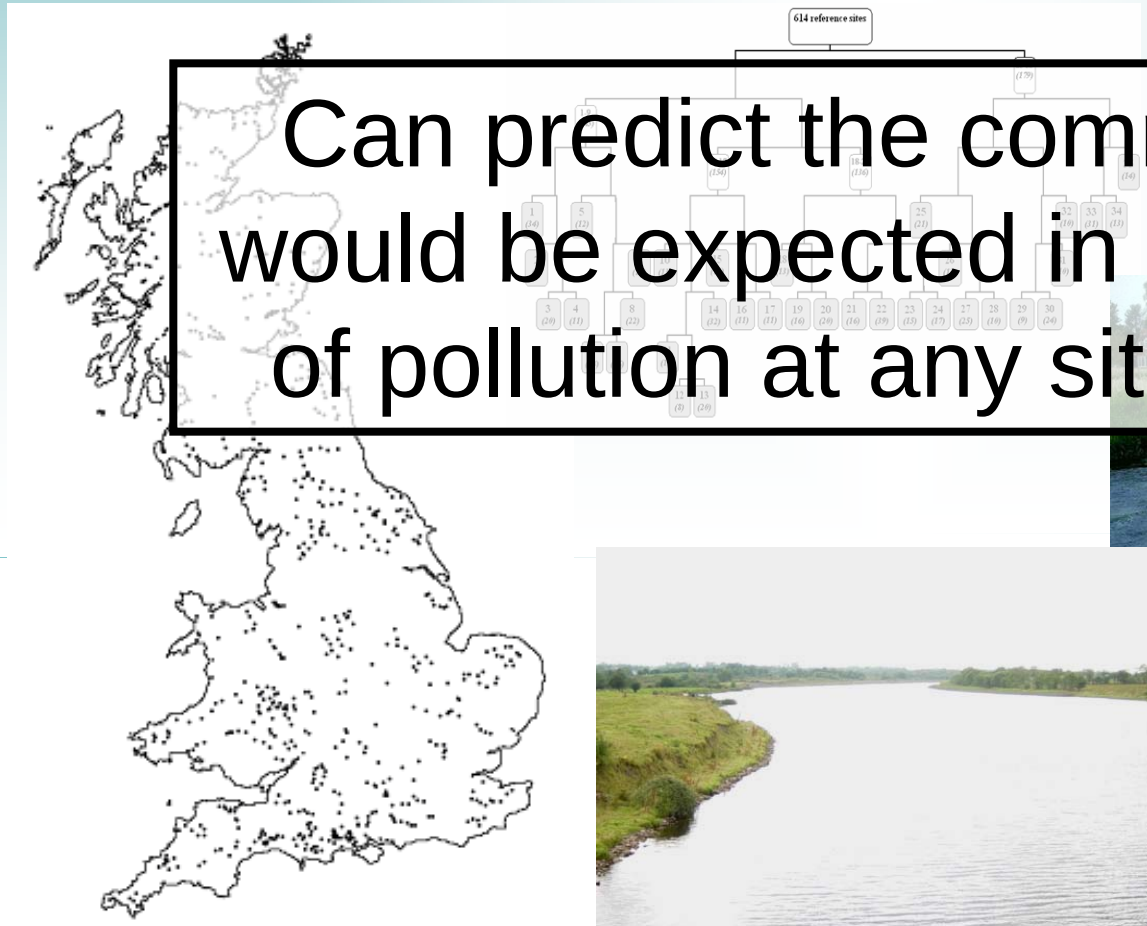
Expert judgement (habitat preference/morphology)



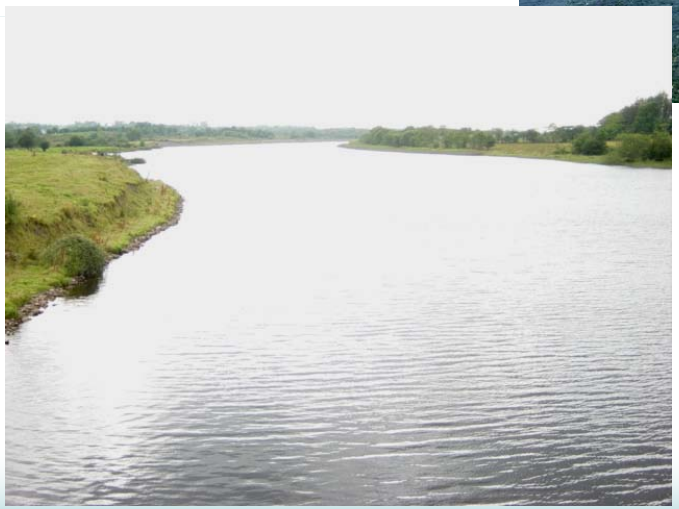


[Murphy et al. (2015) *Freshwater Biology* 60: 2019-2036]

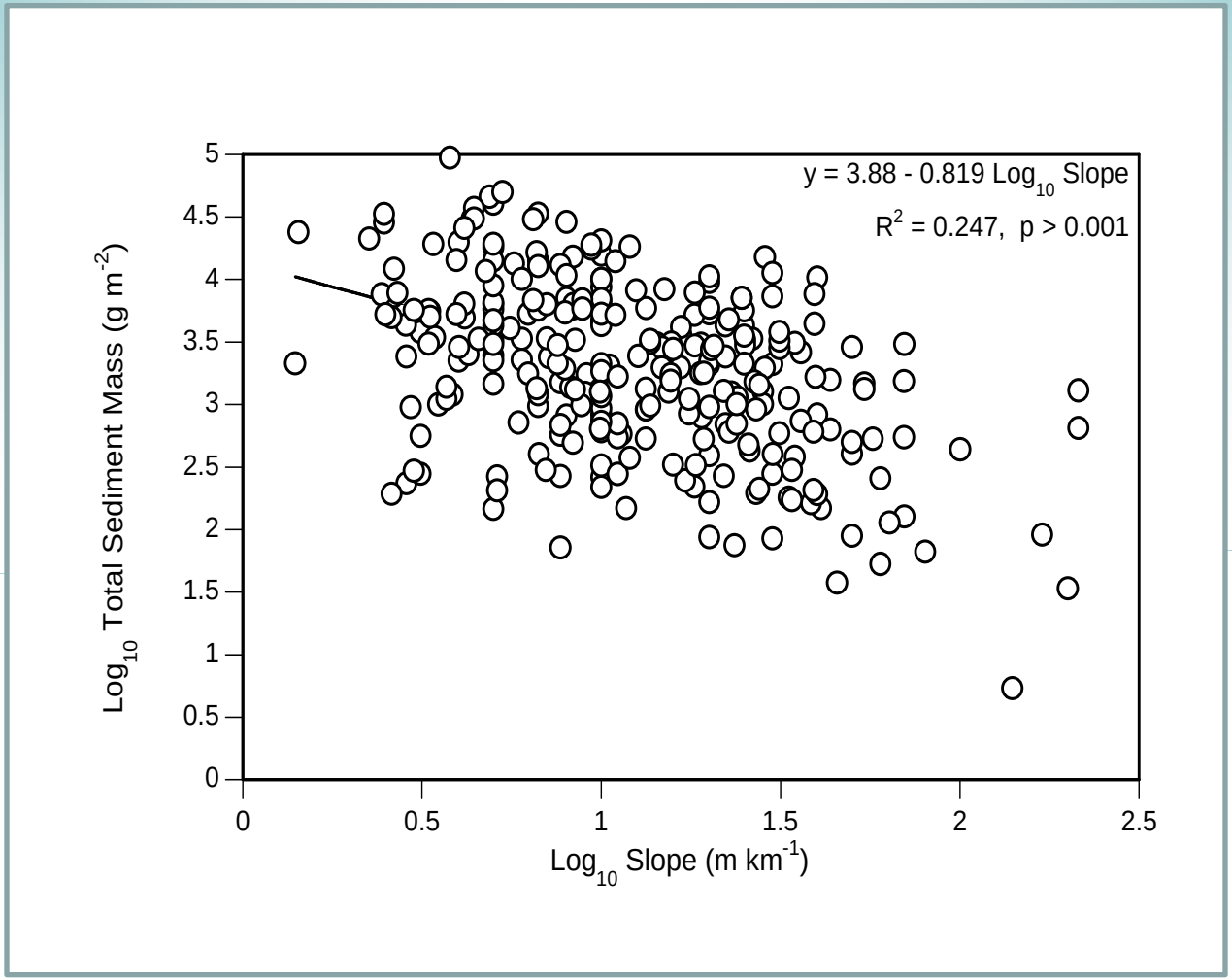
RIVPACS – River Invertebrate Prediction and Classification System



Can predict the community that would be expected in the absence of pollution at any site in the UK



A better descriptor of sediment stress



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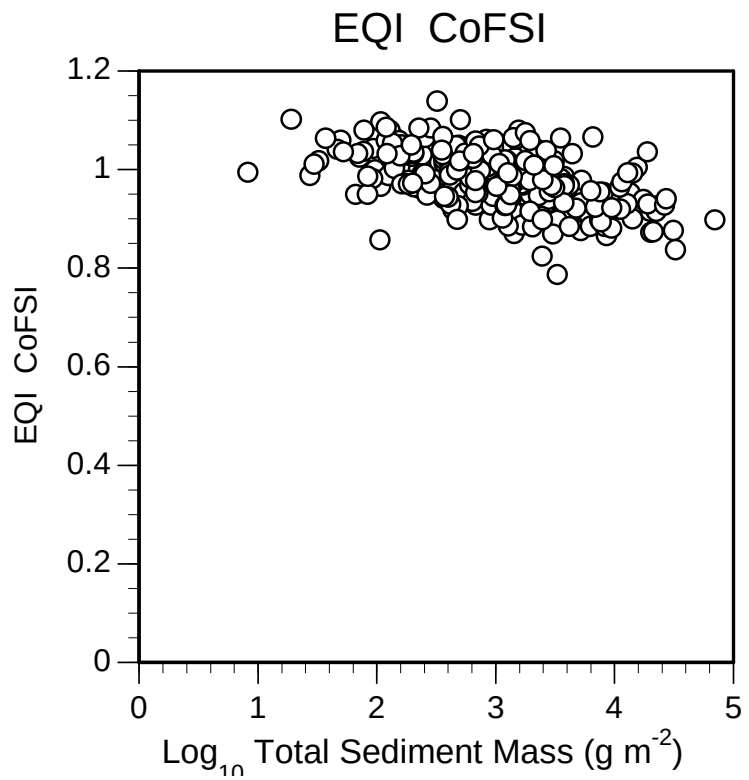
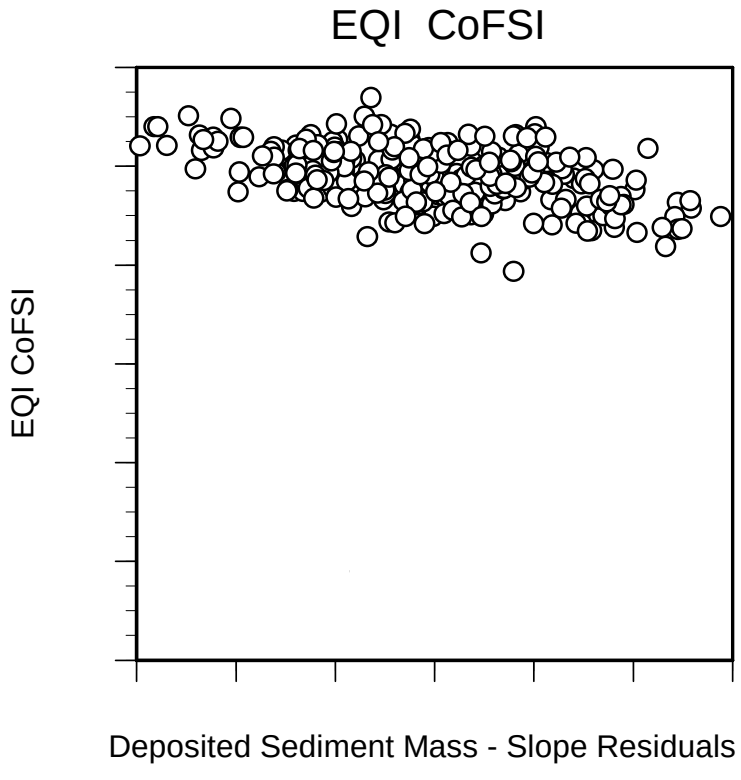
CoFSI and WFD classification





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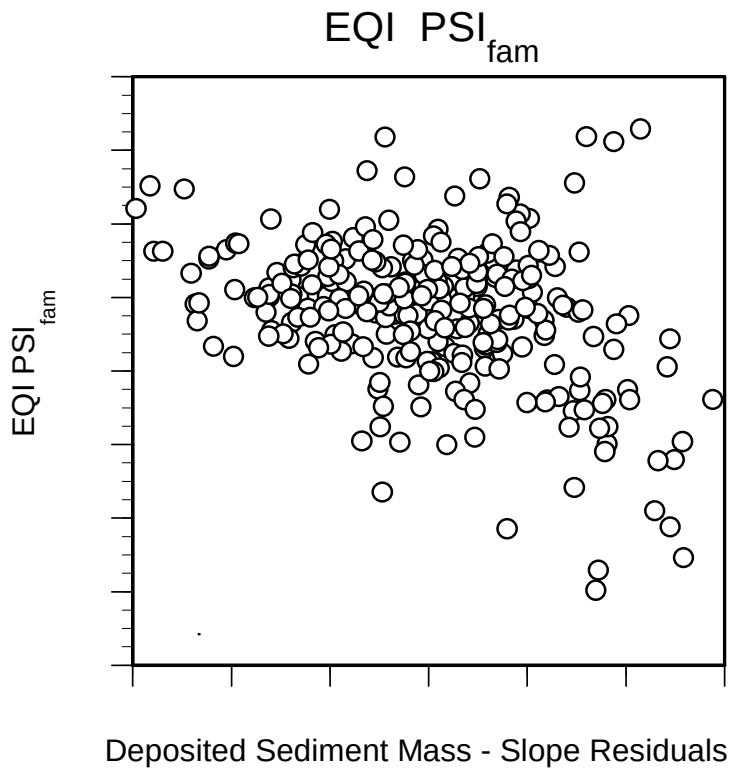
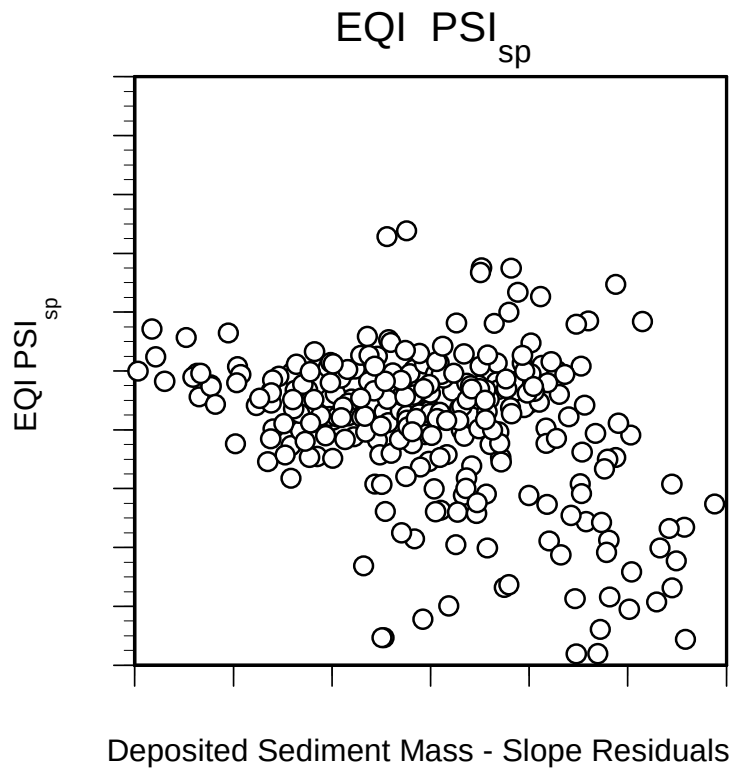
PSI and WFD classification





PSI is unstable at high levels of pressure

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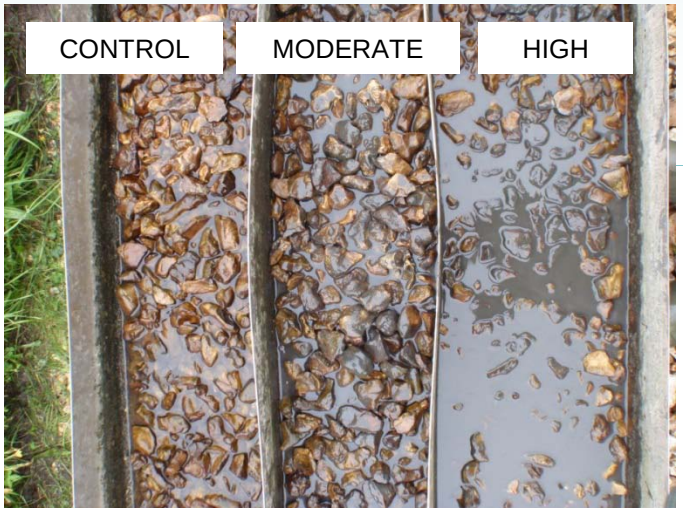
Sediment Experiments in Artificial Stream Channels

Response variables

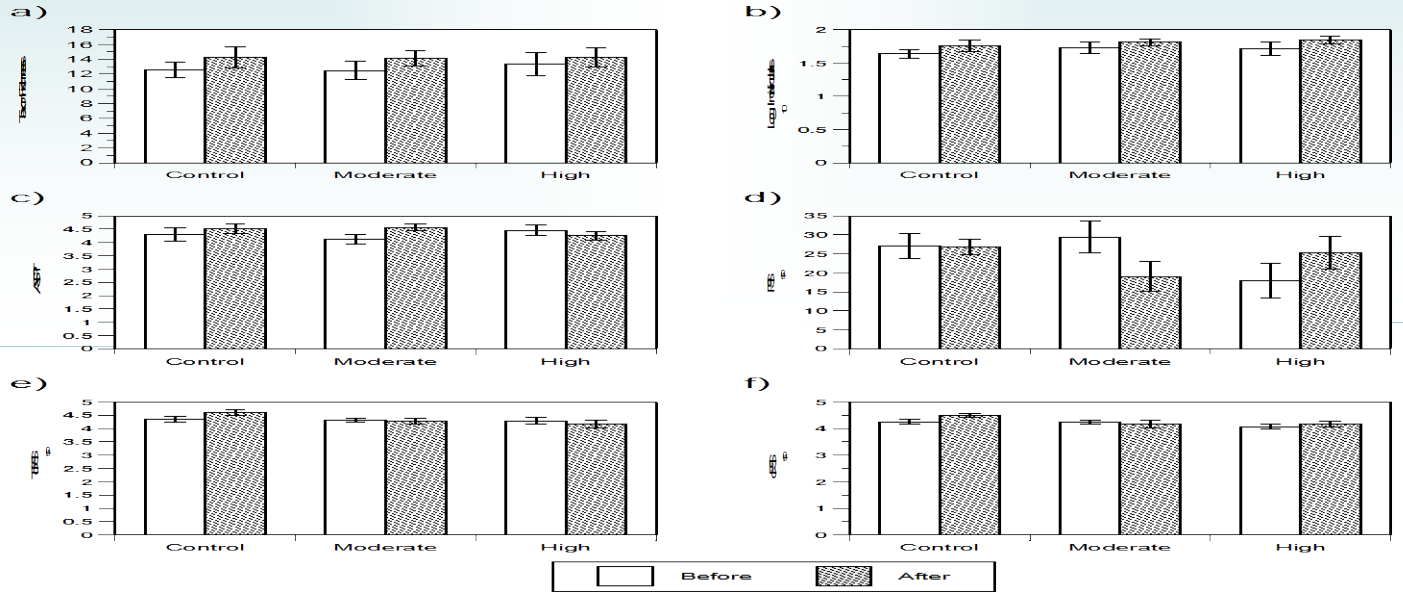
Turbidity
Deposited Sediment Mass
Oxygen Penetration
Hyporheic Chemistry
Interaction with Flow

Drift
Community Composition
Index Values
Trait Composition
Hyporheic Invertebrates



[Jones *et al*. (2015) *Freshwater Biology* 60: 813–826]
[Growns et al. (submitted)]

$CoFSI_{sp}$ index performs well



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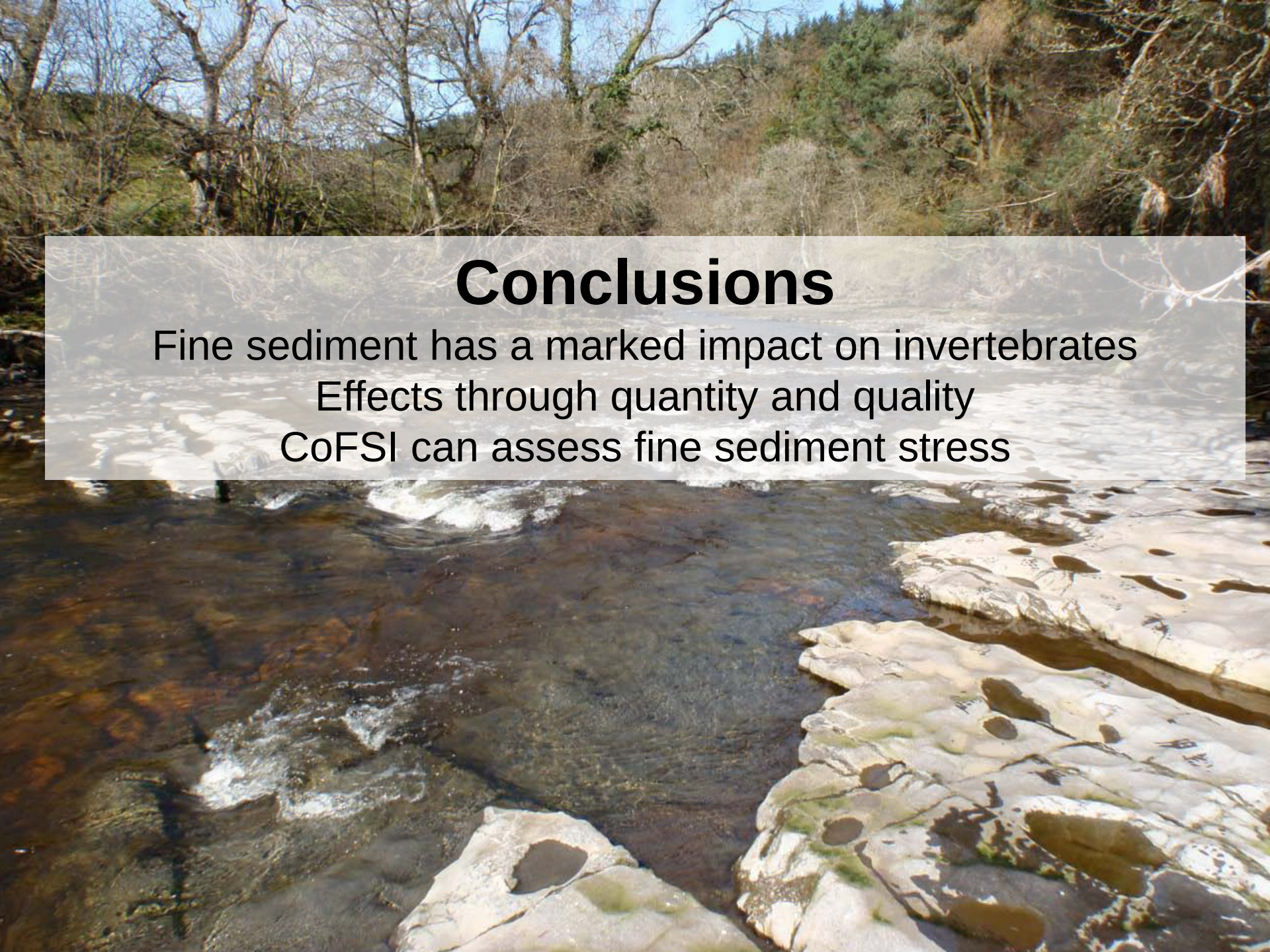

Conclusions

Fine sediment has a marked impact on invertebrates

Effects through quantity and quality

CoFSI can assess fine sediment stress

Acknowledgements

Landowners and farmers
RivComms staff, Ivor Growns, all others involved