Biological monitoring and classification in the face of uncertainty

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Overview

Challenges:

- Characteristics of biological systems
- Quantifying and minimising classification uncertainty

Progress:

- Understanding sources of uncertainty
- Reducing measurement error
- Designing more efficient monitoring networks

Prospects:

- Integration of modelling and monitoring to classify water bodies more reliably

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Challenges

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Challenges

- High inherent spatial and temporal variability
- Often significant measurement error
- High cost of monitoring → limited coverage and small sample sizes

variability + small sample sizes = uncertainty in classification result (EQR) → **risk of mis-classification**

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Why worry about mis-classification?

- Knowing the risk of mis-classification allows us to manage the risks of:
  - failing to act because a water body has been wrongly reported as better than it is, or
  - wasting resources on water bodies that have been wrongly classed as worse than they are.
- Strategically, this allows managers to prioritise programmes of measures to improve status and where to focus future monitoring effort
- Understanding and quantifying uncertainty is more important than a point estimate of status

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Progress

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Understanding sources of variation

- **Spatial variation**
  - Among rivers, among water bodies, within water bodies
- **Temporal variation**
  - Among year, among month, within month
- **Operator variation**
  - Measurement error

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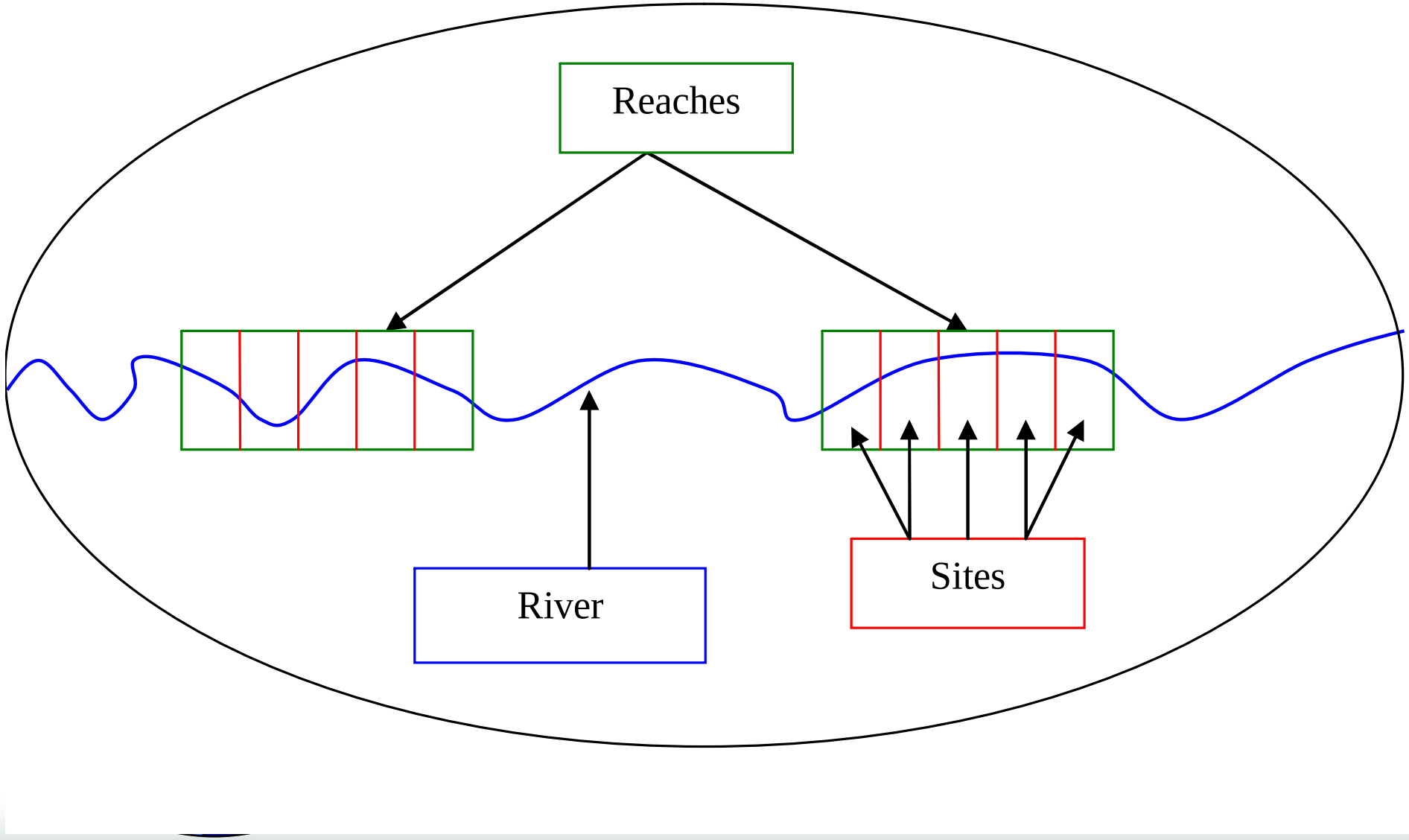
Quantifying sources of variation



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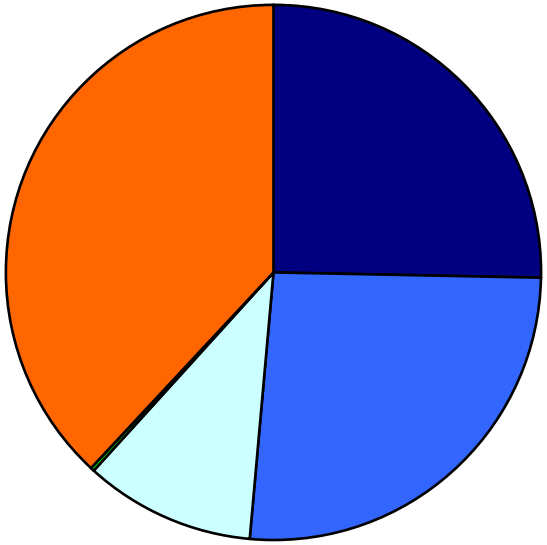
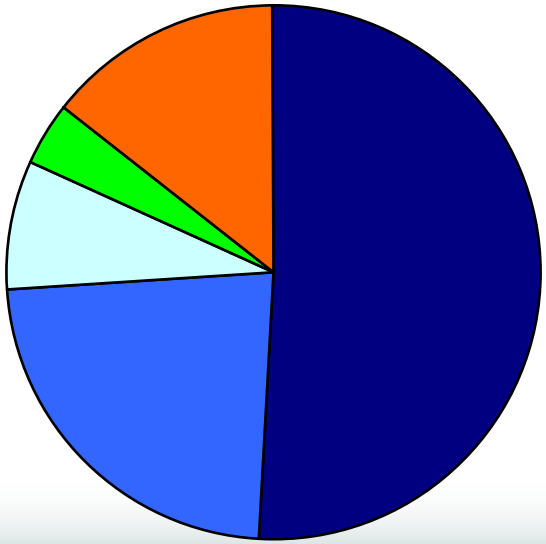
Quantifying sources of variation



% variation in NTAXA

- River
- Reach (500 m)
- Site (100 m)
- Month
- Operator



% variation in EQR

- River
- Reach (500 m)
- Site (100 m)
- Month
- Operator

Monthly surveys of riverine macrophytes in 10 rivers in England, Wales and Scotland. Surveys of replicate 5x100m sites performed in replicate reaches.

REML analysis of two metrics: NTAXA and overall EQR

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Reducing measurement error

- More rigorous and frequent training and accreditation of operators
- More consistent use of appropriate equipment (e.g. waders, snorkels)
- Better adherence to current monitoring protocols
- Development and use of clearer monitoring protocols
- Employing pairs of operators instead of lone operators

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Optimising the sampling strategy

A series of trade-offs:

- **Spatial:** More 100m sites or more 500m reaches?
- **Temporal:** More months or more years?
- **Spatial vs temporal:** Emphasis on spatial or temporal coverage?

	Reach1	Reach2	Reach3
Year1	X		
Year2			X
Year3		X	

	Reach1	Reach2	Reach3
Year1		X	
Year2		X	
Year3		X	

	Reach1	Reach2	Reach3
Year1			
Year2	X	X	X
Year3			

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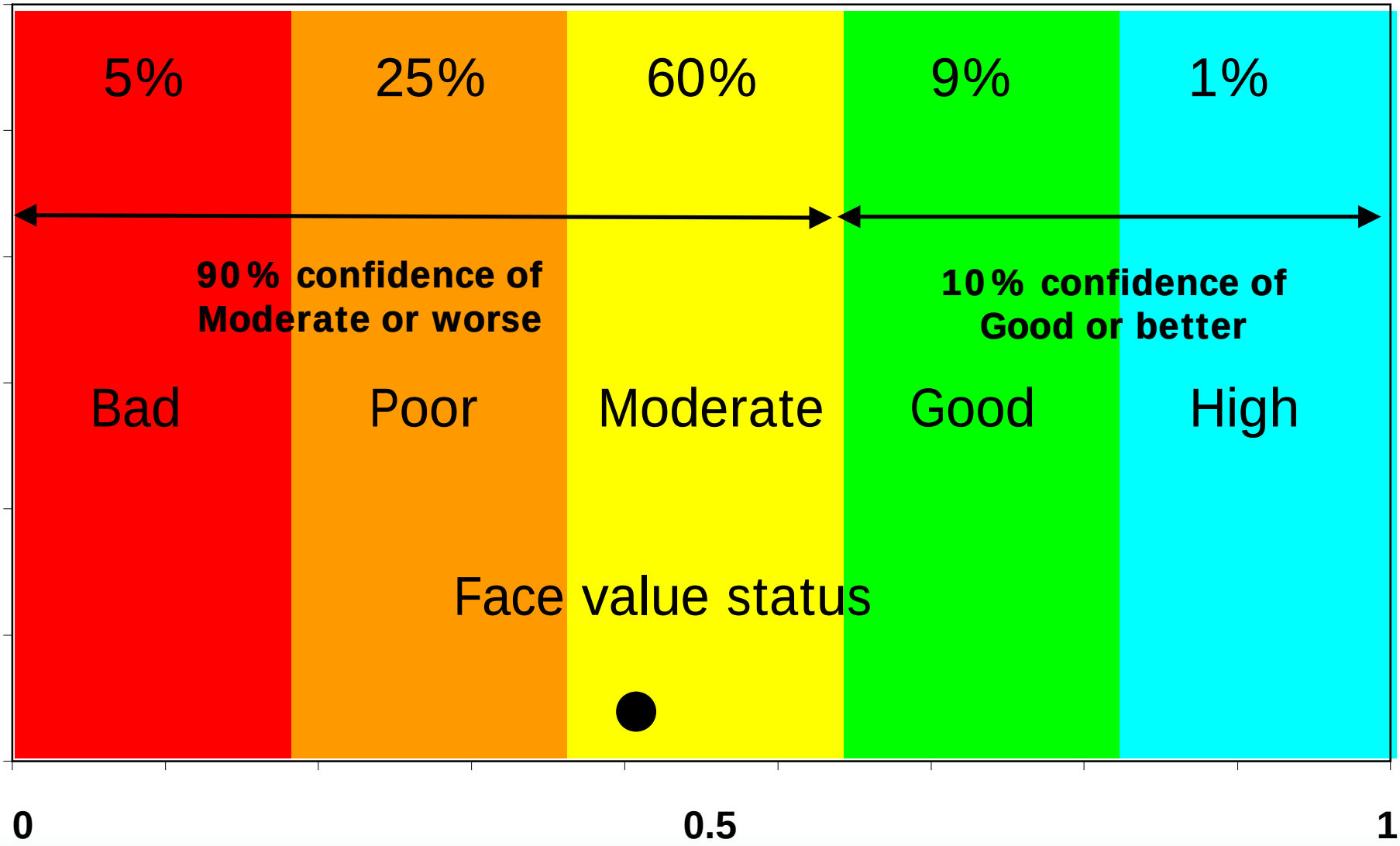
Risk of mis-classification (RoM)



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Prospects

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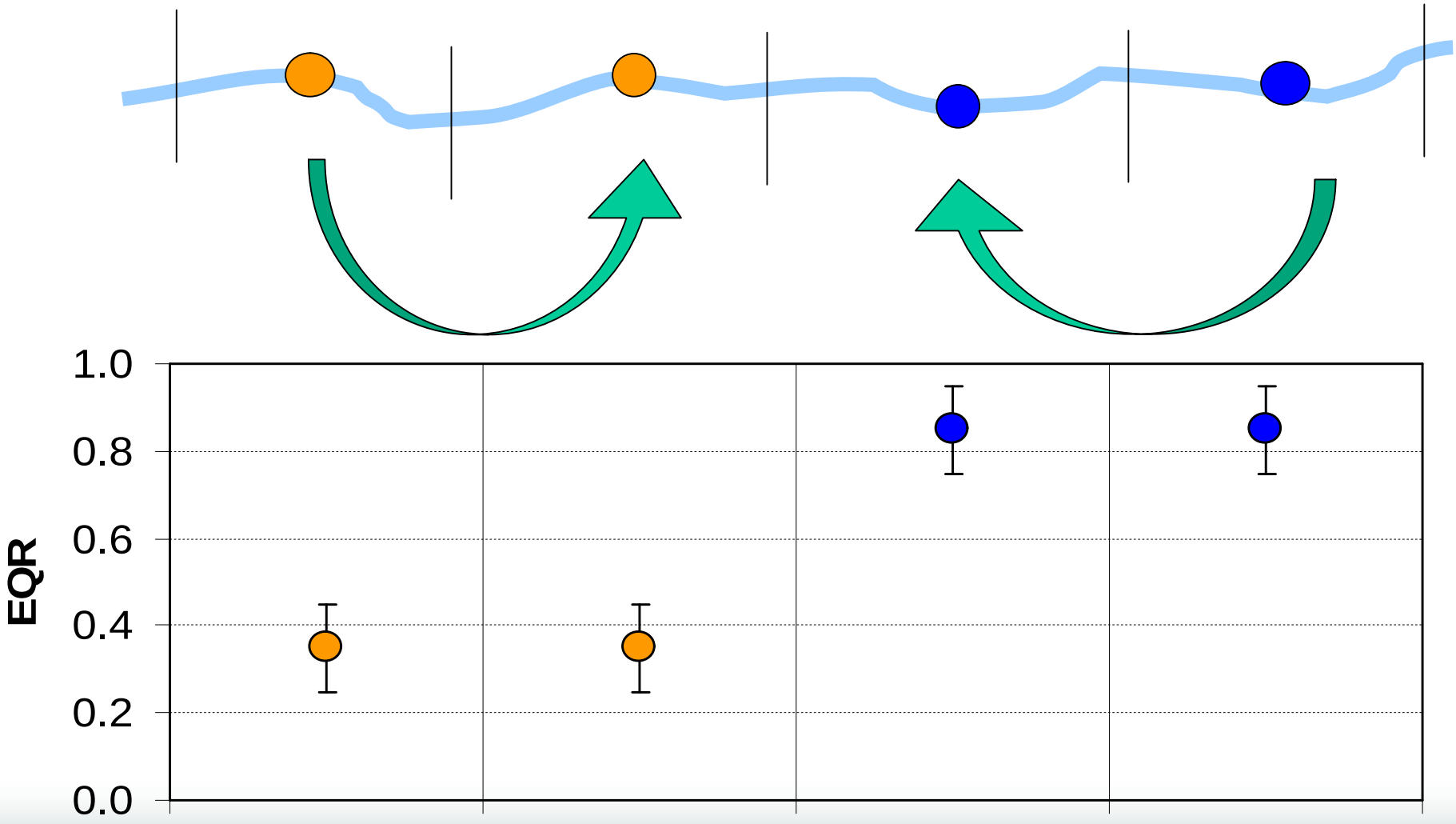
Classifying unmonitored water bodies



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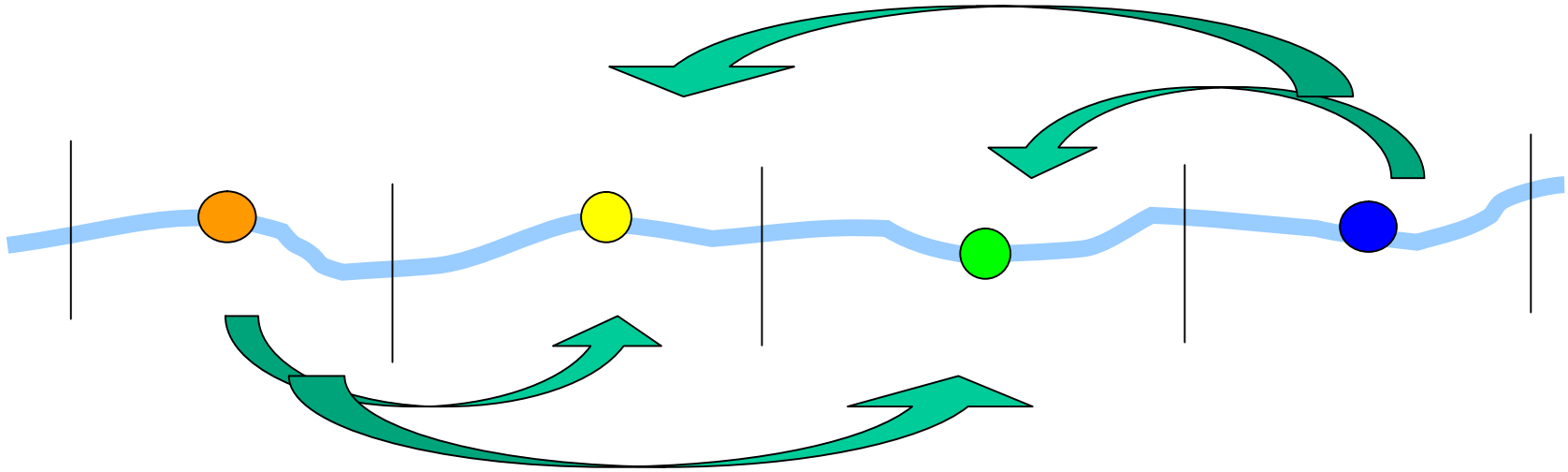
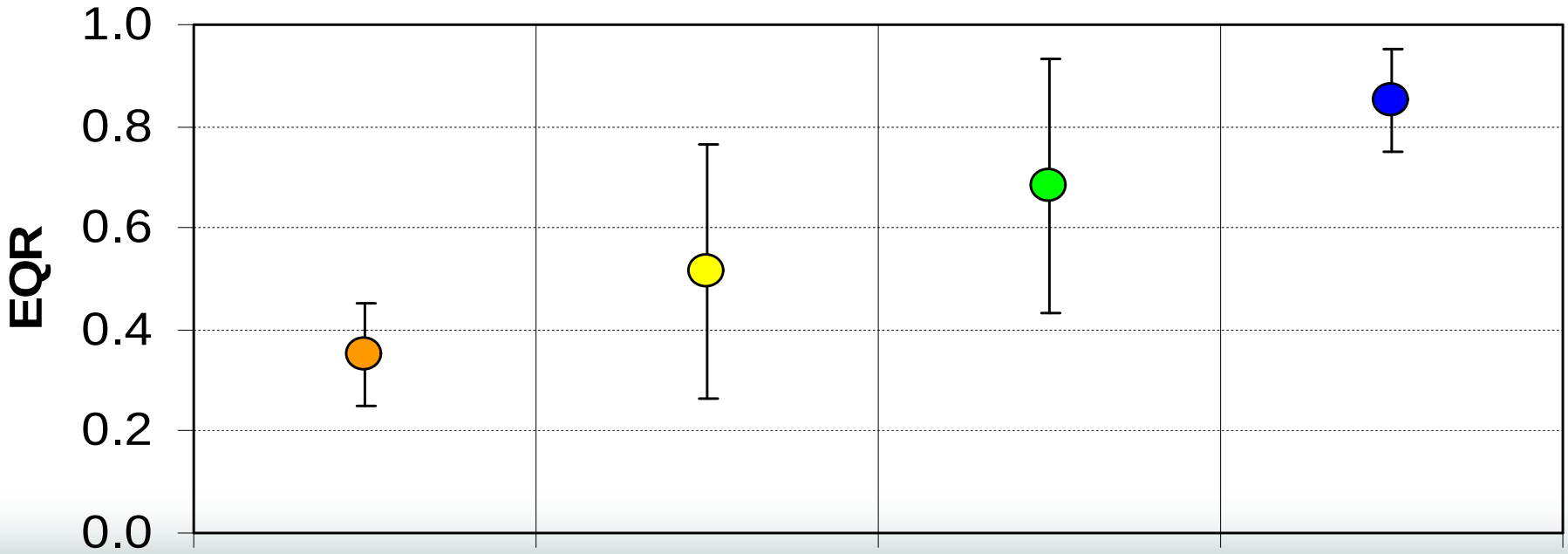
Classifying unmonitored water bodies





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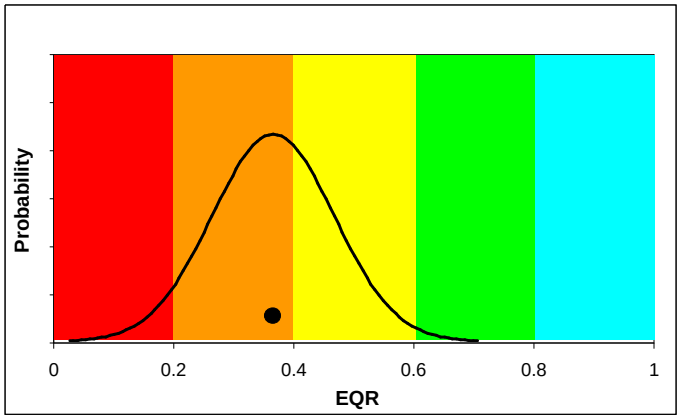
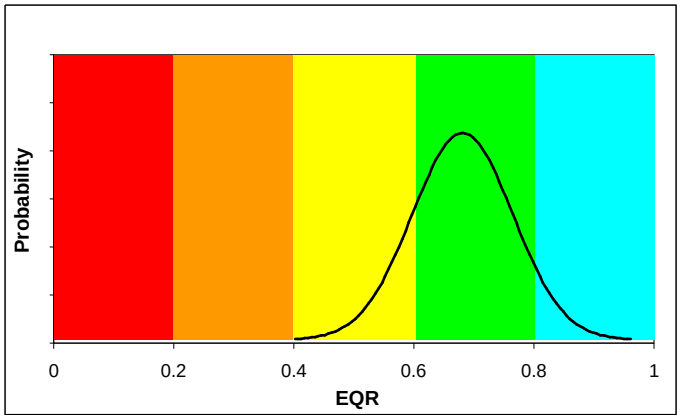
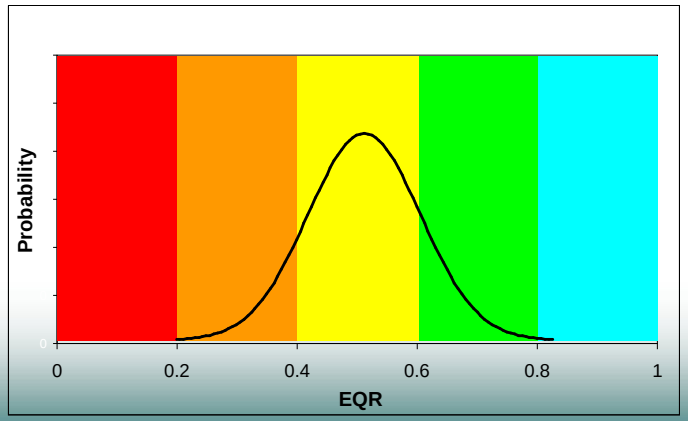
Improved classification of monitored WBs







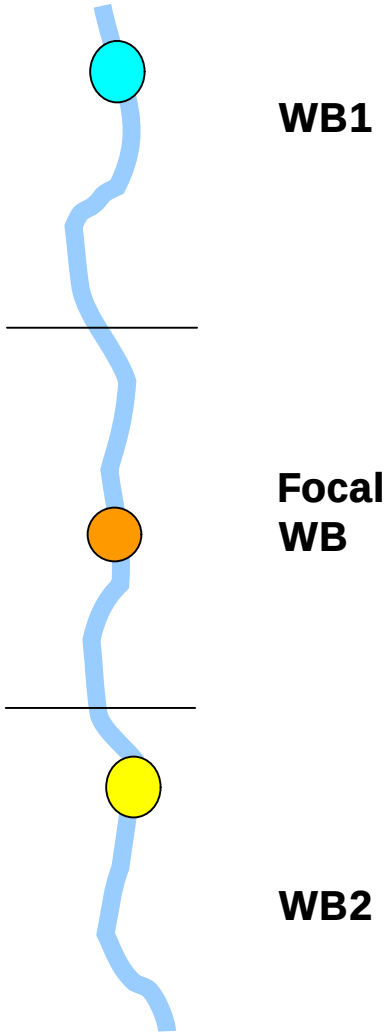
DATA

+

MODEL

=

IMPROVED CLASSIFICATION



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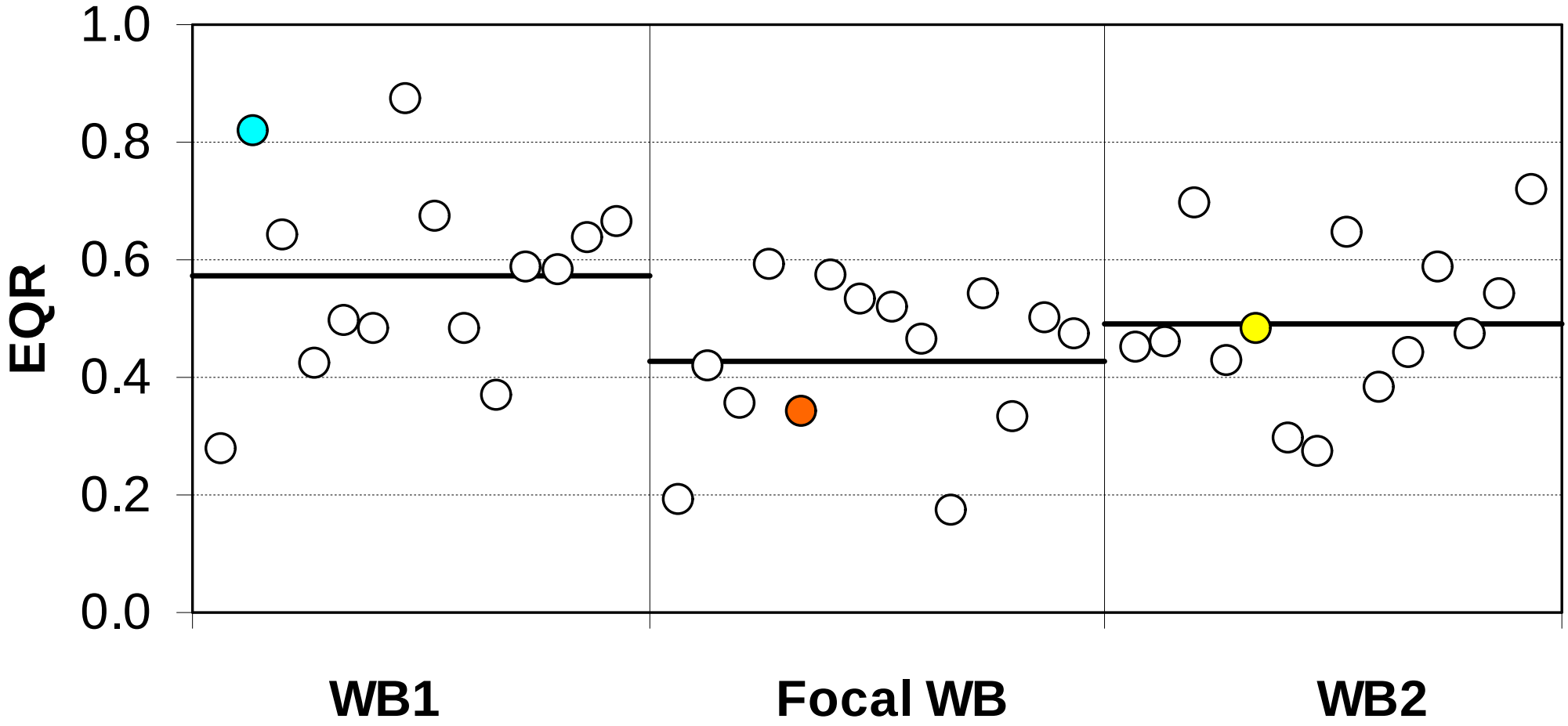
Information needs (1)

Hierarchical model of spatial variation



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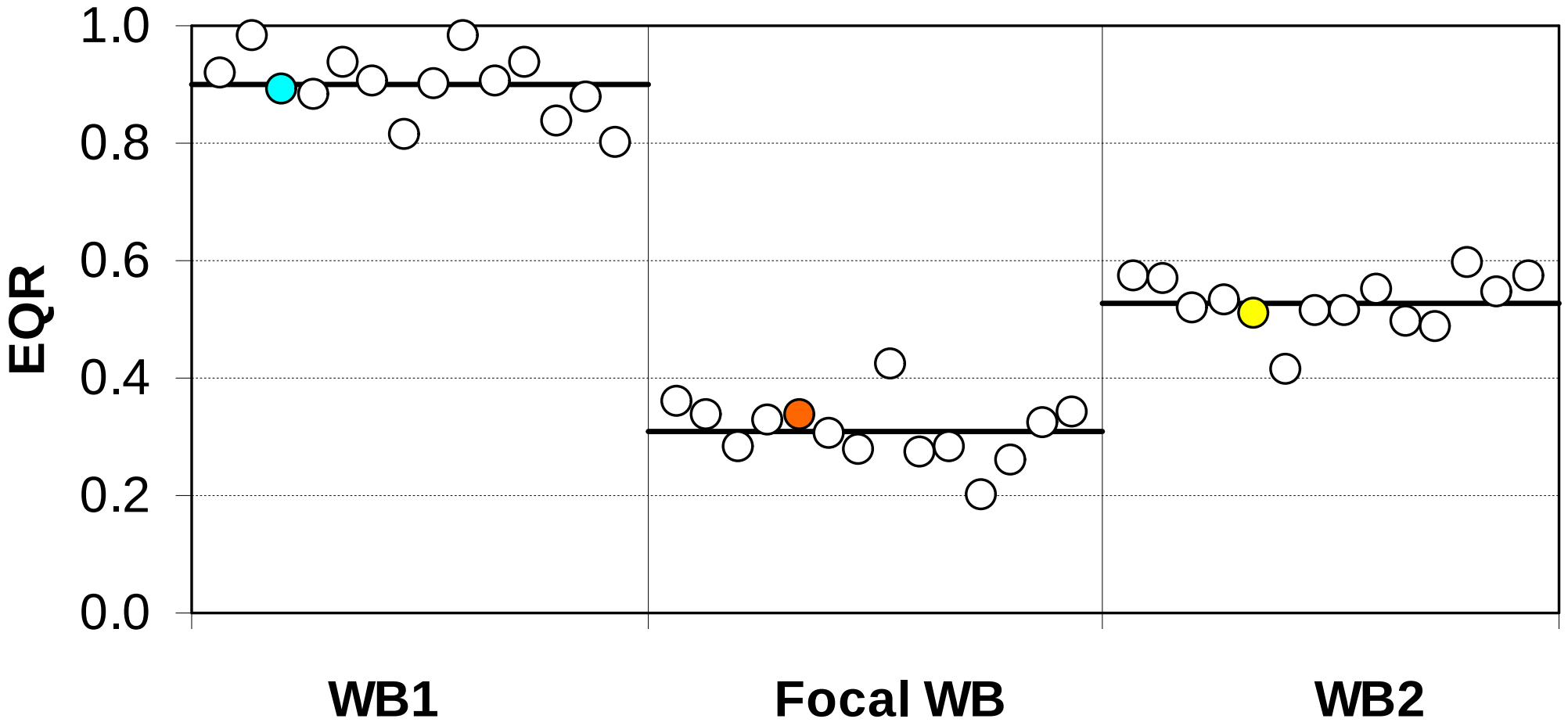

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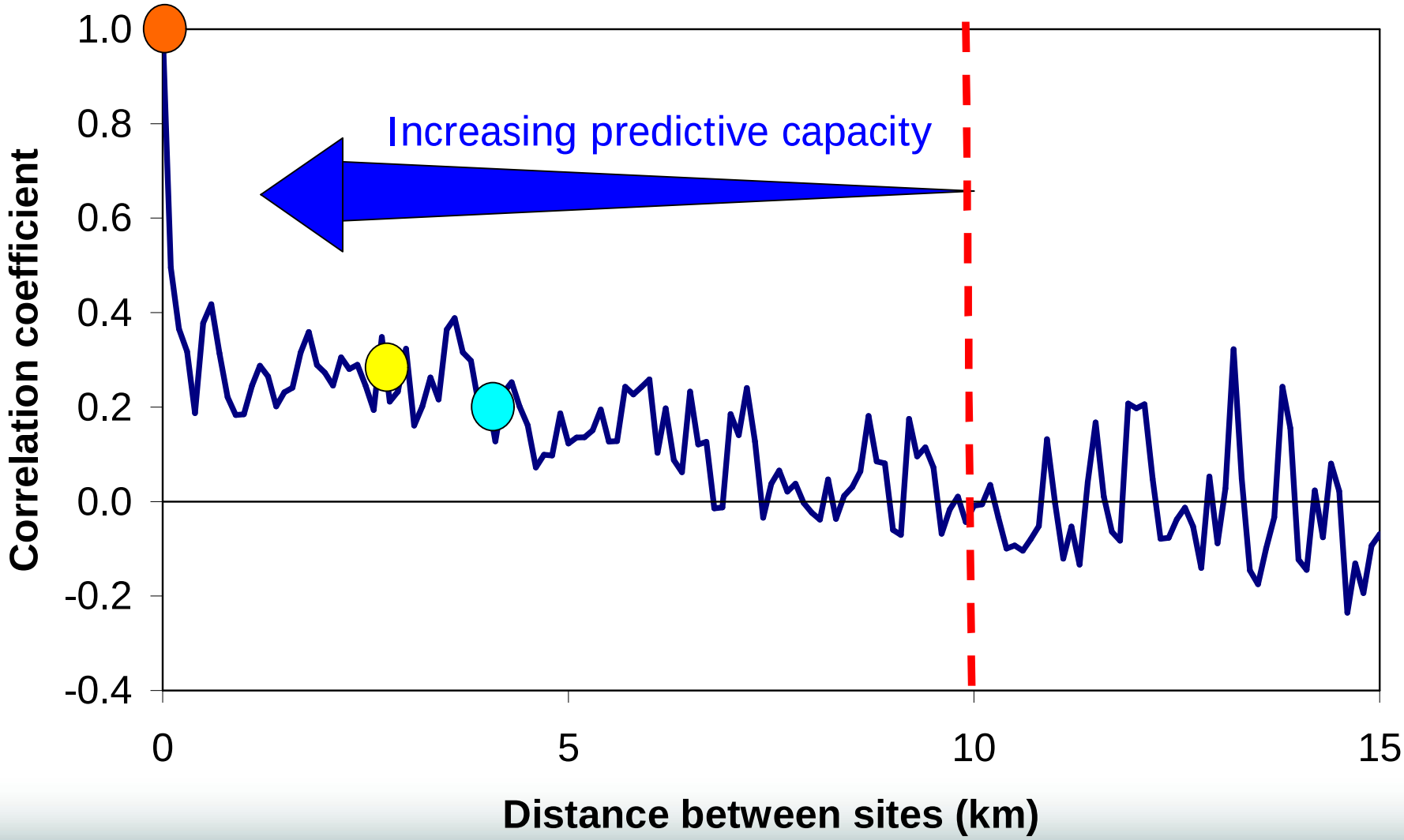
Information needs (2)

Geostatistical models of spatial variation



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Four steps to reducing uncertainty

1. Understand and quantify sources of variation
2. Minimise measurement error
3. Optimise sampling strategy and sampling effort
4. Integrate monitoring data with modelled predictions

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The Final Word

"If you know, to recognize that you know;
if you don't know, to realize that you don't know:
that is knowledge." - *Confusius*

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