Predicting physical habitat sensitivity to abstraction

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Overview

New version of the Rapid Assessment of Physical Habitat Sensitivity to Abstraction (RAPHSA) model

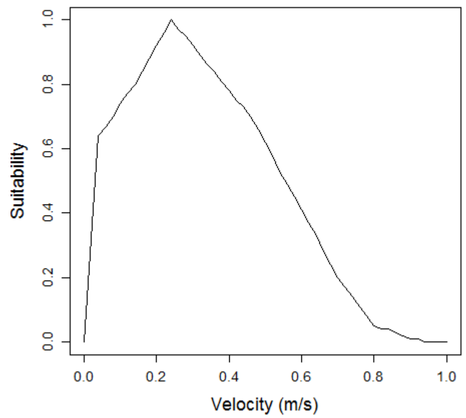
Original RAPHSA completed in 2006 for the Environment Agency; defined sensitivity to abstraction as the change in physical habitat with changes in river discharge

Several development needs identified in order to deploy the model operationally

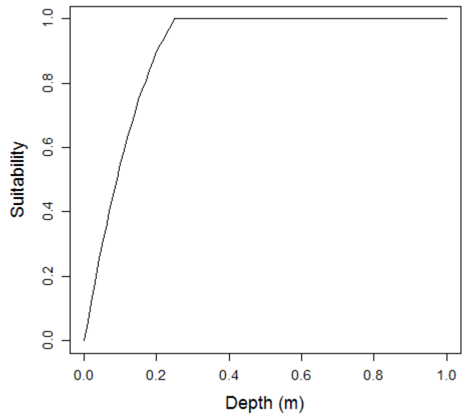
Original and current version: ‘RAPHSA 1’
Alternative version: ‘RAPHSA 2’

Hydrology, hydraulics, habitat

- Discharge has indirect effect on river ecosystems
- River organisms respond to hydraulics, either directly (e.g. shear stress), or via physical habitat (i.e. depth and velocity)
- Habitat created by interaction between flow and channel morphology
- Discharge–habitat association provides way to asses ecological impacts of abstraction/flow change in a river
- Several habitat–discharge models based on these concepts (for example PHABSIM)
- Depth and velocity suitability for various species or life stages collated (e.g. field observation, experiments, expert knowledge)
- Suitability of 1 for depth or velocity means that any parts of the river with such depths or velocities are suitable as habitat
- At a given cross-section, depth and velocity suitability indices are combined to give the proportion of the cross-section that is usable as function of discharge



Suitability curves for juvenile trout (0–7cm)



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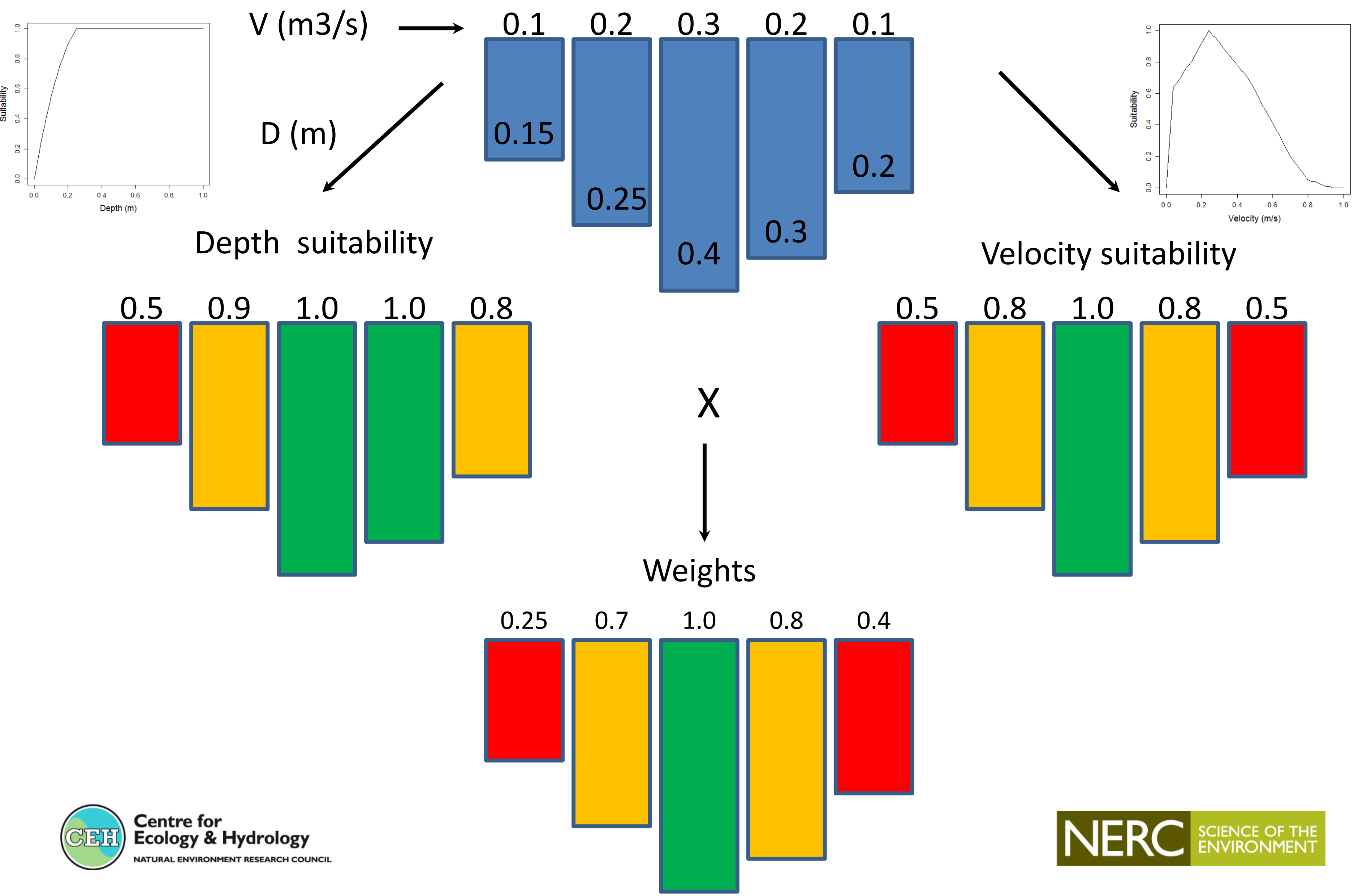
Weighted usable area



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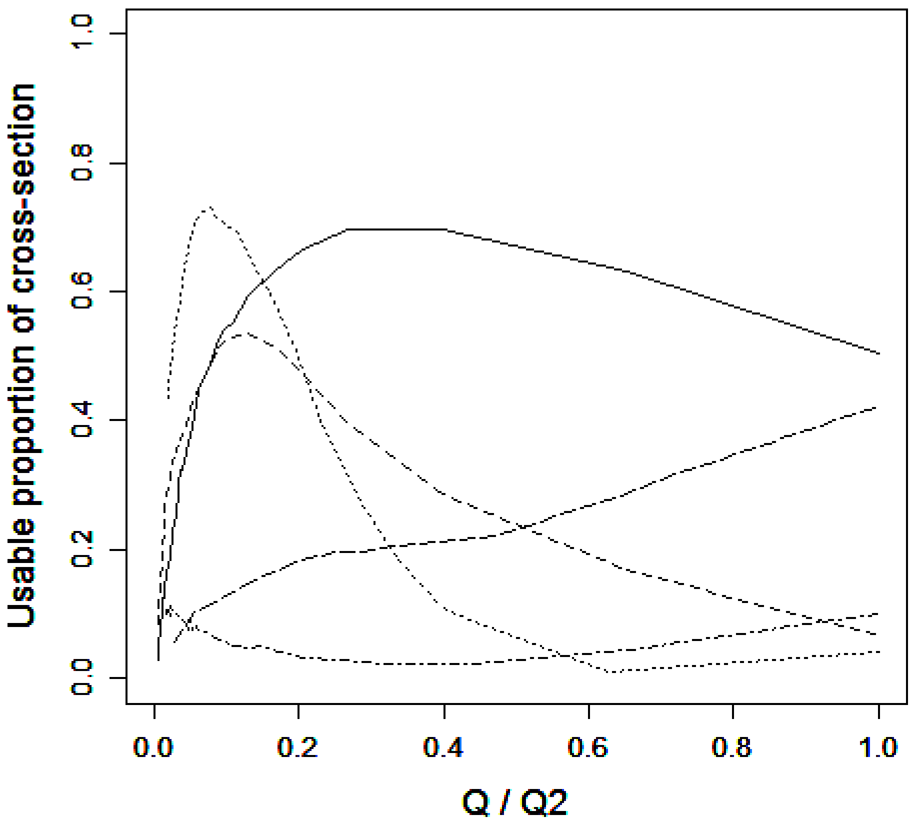
Sensitivity to abstraction



Juvenile trout (0–7cm); selected UK sites (each curve corresponds to a different transect)

- Steeper curve = habitat more sensitive to abstraction/flow change
- Shapes of curves are controlled by the site hydraulic characteristics
- Same abstraction can lead to different impacts depending on transect and on flow percentile

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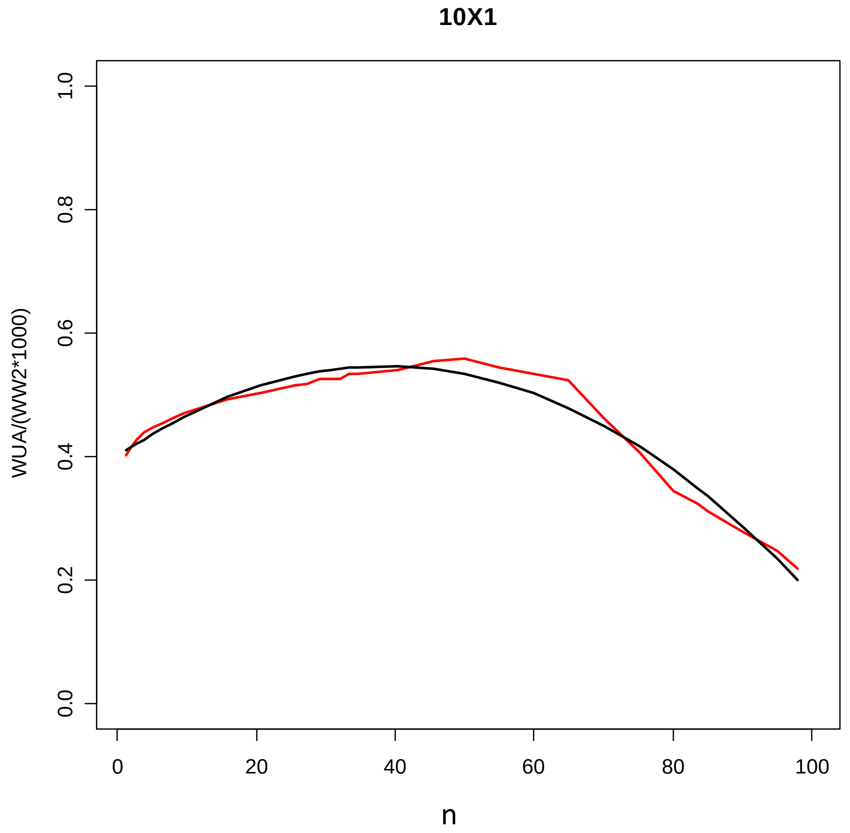
RAPHSA 1

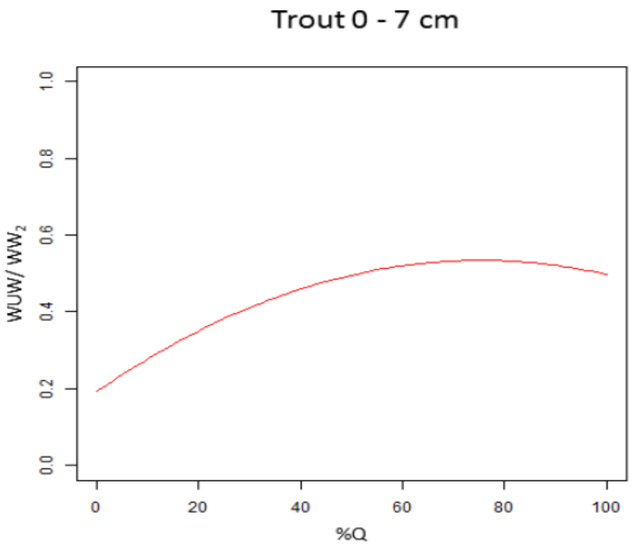
- Predicted variable:
  weighted usable area (WUA) standardised by bankfull wetted width (WW2) ie WUA/WW2

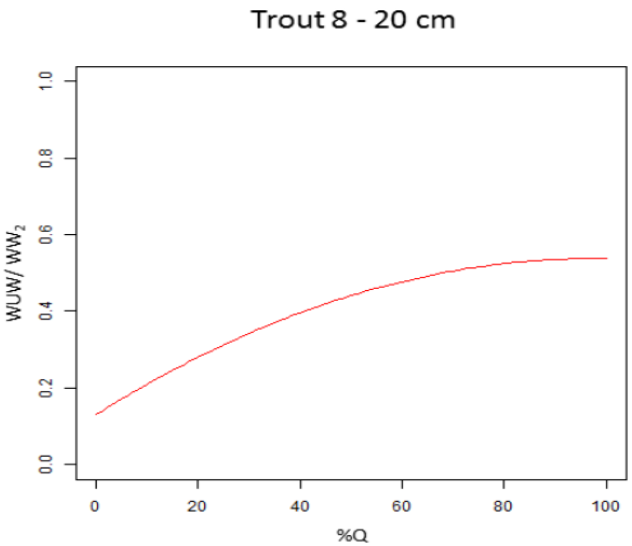
- *WUA/WW2* = a + b*n* + cn^2
  with *n* flow percentile rank (ie n^{th} flow percentile)



RAPHSA 1

- One survey/gauging at a given *n* (eg 40 = Q60)
- Coefficients modelled using flow-dependent variables taken at the same *n* for a pool of reference sites (PHABSIM studies; 516 transects in 64 river stretches)
- 10 species/life stages modelled





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Operational development needs

(1) Improving representativeness of calibration dataset

- Original model using collection of PHABSIM studies totaling 516 transects at 64 river sites
- Limited geographical coverage
- Biased towards lowland permeable rivers

(2) Simplifying model

- To standardise information across sites, RAPHSA 1 uses flow percentile rank *n*
- Requires derivation of flow duration curve
- Requires numerous input variables (14)
- Outputs as function of *n*; need back-transformation to be expressed as function of discharge

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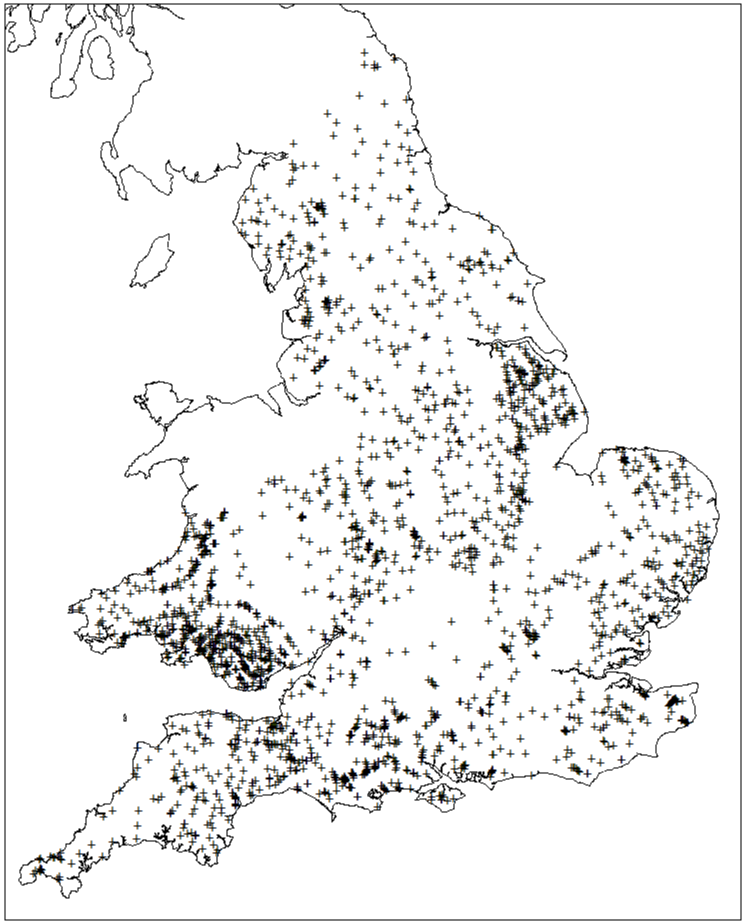
Selection of new calibration sites



- c. 4,000 sites with detailed panel data up to 2006 (EA)
- Matched against gauging stations => 645
- Filtered for good hydraulics => 210
- Filtered to keep sites capturing whole WUA & flow range => 90

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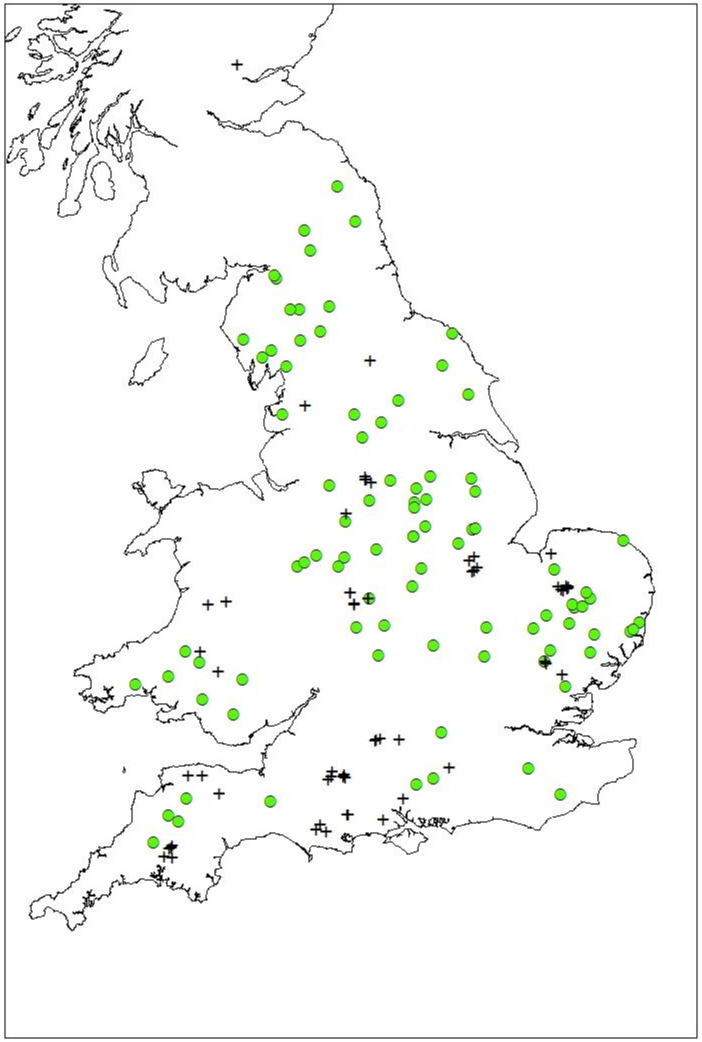
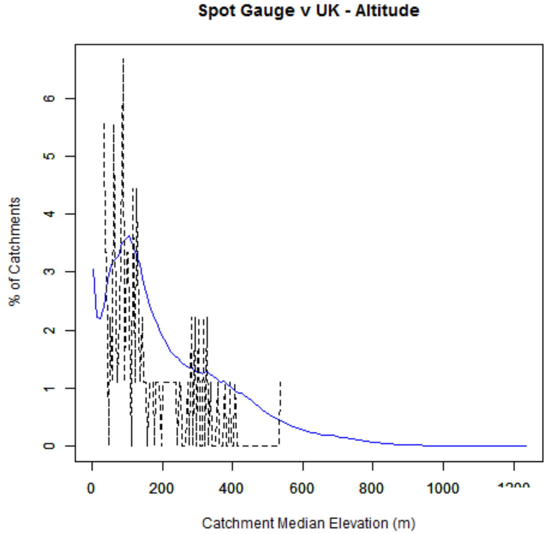
Improved representativeness



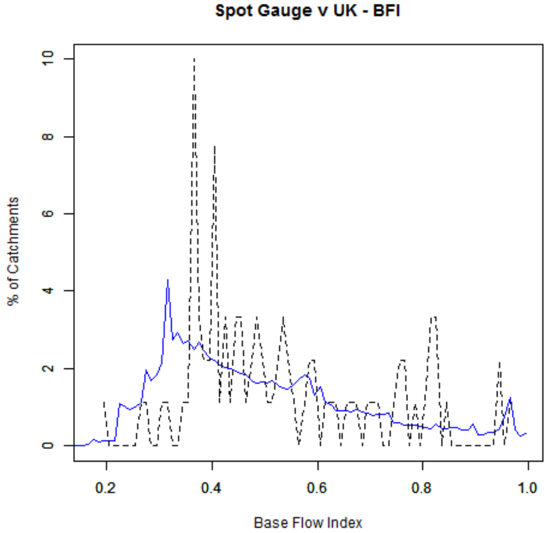


River types

RAPHSA 2 - dash black
UK rivers - solid blue

Geographical coverage

RAPHSA 1 - black crosses
RAPHSA 2 - green dots



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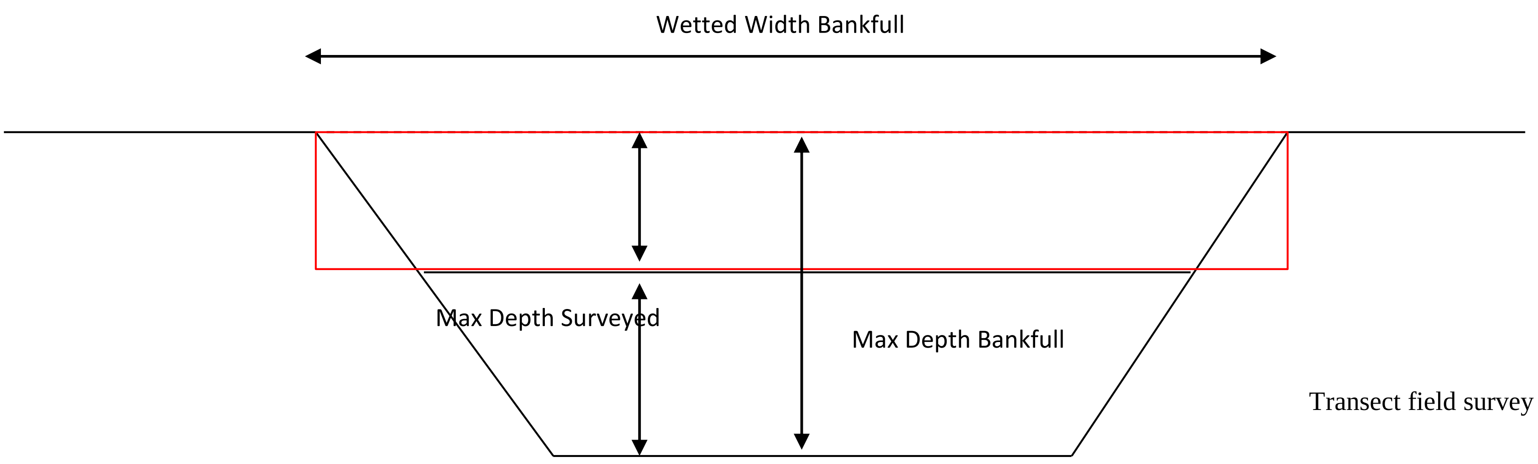
Simplified model

- To avoid using flow duration curves, relation between ln(Q) and n approximated as linear; Q standardised with bankfull flow (approximated as Q2)
- $WUA/WW2 = a' + b' \ln(Q/Q2) + c' (\ln(Q/Q2))^2$
- Q/Q2 = 0 means no water; Q/Q2 = 1 (or 100%) means bankfull flow
- Q2 (and additional variables at Q2) can be estimated from one field survey only by using Manning-Strickler (providing the gauging does not occur at low flows)
- Similar model structure but simplified formulation (fewer explanatory variables; 9)
- Output habitat curves as function of Q/Q2 (no back-transformation needed)



Model testing: MSEs

- Jackknifing procedure on RAPHSA 1, RAPHSA 2 with original sites only, RAPHSA 2
- Similar performance
- RAPHSA 2: slightly higher mean squared errors partly because of wider range of river types

	Min	5%	25%	50%	75%	95%	Max
RAPHSA 1	0.0002	0.0012	0.0033	0.0067	0.0139	0.0365	0.9400
RAPHSA 2 with RAPHSA 1 sites only	0.0001	0.0014	0.0046	0.0100	0.0213	0.0527	0.6100
RAPHSA 2	0.0003	0.0013	0.0048	0.0112	0.0253	0.0610	0.4700

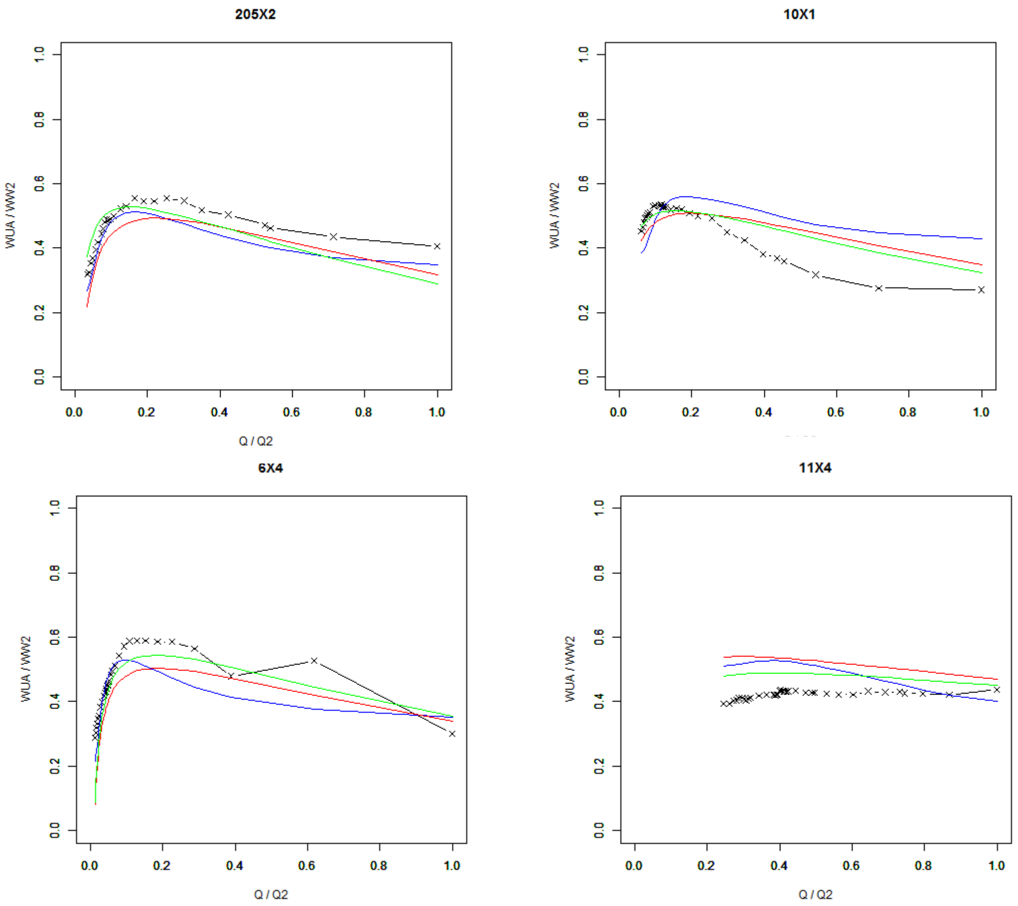
Model testing: (some) habitat curves

Observed data - black line with X

RAPHSA 1 - blue

RAPHSA 2 with original sites only - red

RAPHSA 2 - green



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Thank you for your attention!

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