Assessing the spatio-temporal dynamics of hydraulic habitats

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Background

- Decline of natural heterogeneity (Søndergaard & Jeppersen, 2007)
- EU Water Framework Directive (2000/60/EC)
  - "Good ecological status"
  - Biological relevance of hydromorphology
- Importance of quantitative habitat assessment
  - Evaluating ecological health (Maddock, 1999)
  - Tool for ecohydromorphic research (Vaughan et al., 2009)

Physical Habitat Assessment

Scope for improvement?

1. Improve representation of fluvial continuum (Legleiter & Goodchild, 2005)
2. Develop a spatio-temporal approach (Newson & Newson, 2000; Wiens, 2002; Thoms, 2006)
3. Bridge ecological-physical scales of assessment (Vaughan et al, 2009)

Research Objectives

PHASE 1

Develop a protocol for spatio-temporal hydraulic habitat assessment

- Data-driven habitat delineation
- Reflect the quasi-discrete nature of hydraulic habitats
- Quantify spatio-temporal variability

PHASE 2

Test the framework in UK rivers

River Arrow

Catchment

- Triassic sandstone and red clay
- 333.92km^2
- 4% urban land cover (2000)

Flow Regime (1980-2008)

- mean daily flow 0.830m^{3}s^{-1}
- Q95 0.133m^{3}s^{-1}
- Q10 1.681m^{3}s^{-1}
- BFI 0.38

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Study Reach

Methods: Data Collection

- 4 discharges (Q13-70)
- High resolution point sampling (0.5x1m)
- Depth and streamwise velocity
- Current meter/ StreamPro ADCP
- Interpolated to 0.5m resolution (IDW, ArcGIS)

Data Analysis

Habitat Delineation

- Fuzzy Cluster Analysis, MATLAB (Balasko et al., 2001)
  - Validated
  - Defuzzified

Habitat Structure

- FRAGSTATS v3.3 (McGarigal & Marks, 1995)
  - 15 measures of composition and configuration computed

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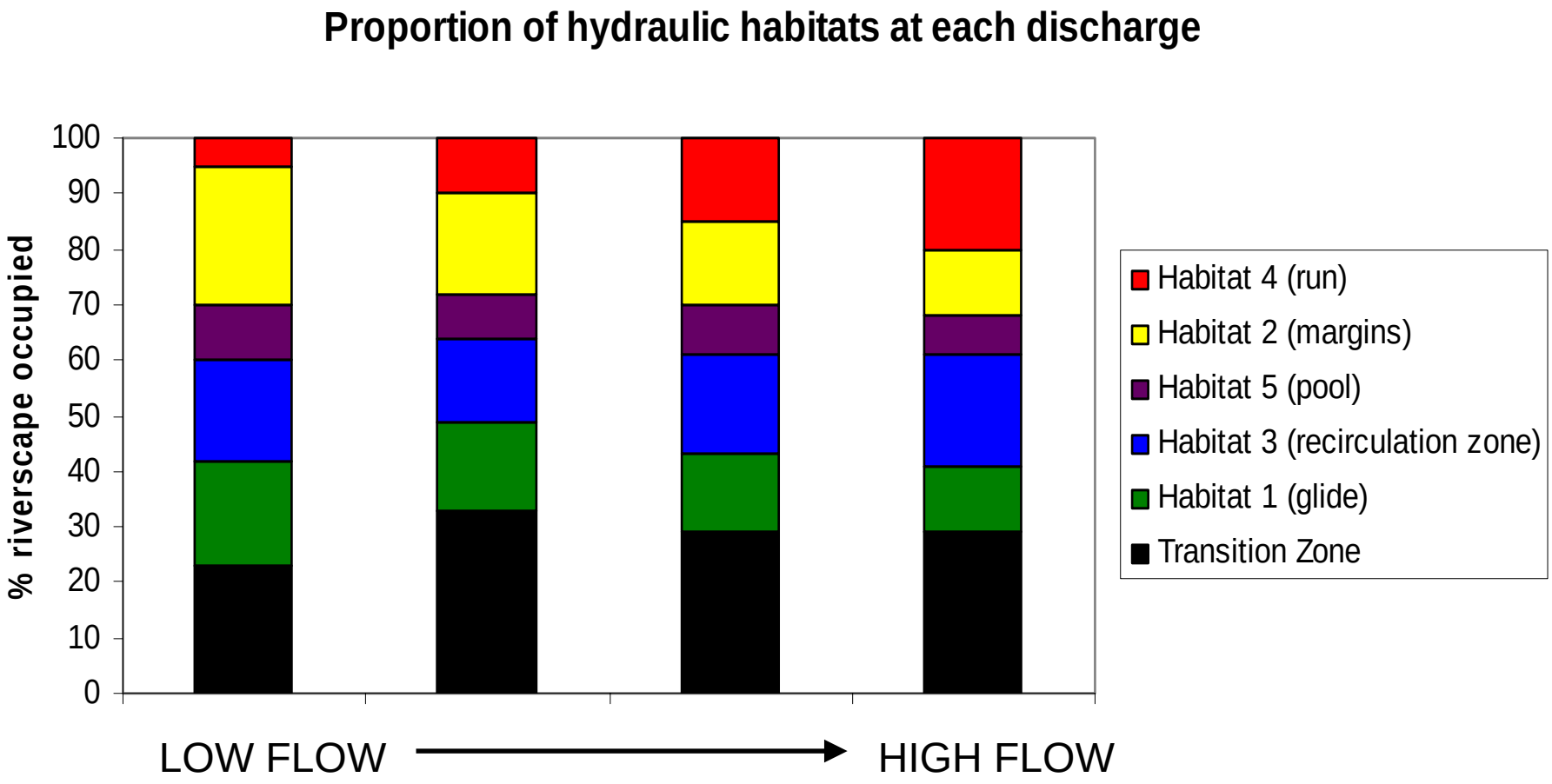
Results: River Arrow

- 5 hydraulic habitats at each discharge
- 23-33% transitional zone
- Reflect mesoscale geomorphic units
  - ~ Glide-type
  - ~ Run-type
  - ~ Pool-type
  - ~ Margins
  - ~ Recirculation zone

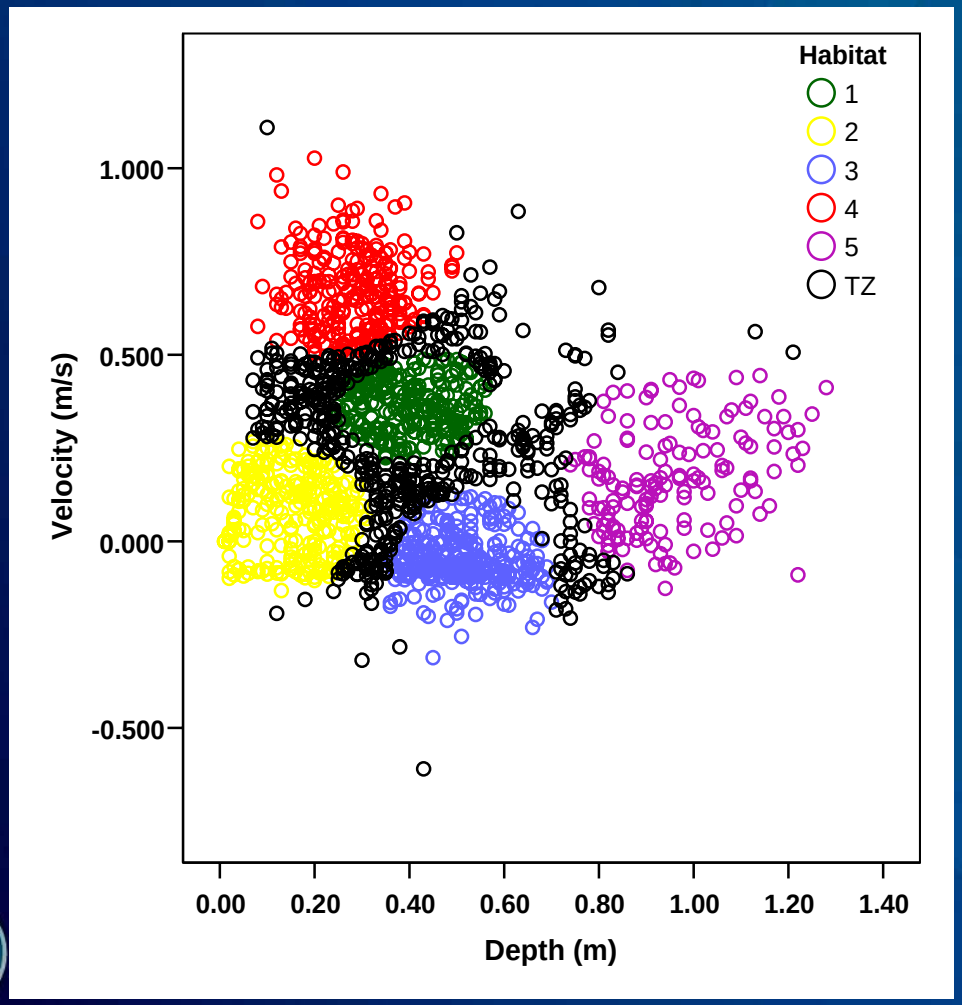
	D_{mean} (m) (st dev)	V_{mean} (m/s) (st dev)	CGU
1	0.36 (.17)	0.360 (.19)	Glide
2	0.16 (.10)	0.119 (.17)	~
3	0.49 (.11)	-0.022 (.07)	~
4	0.27 (.10)	0.676 (.16)	Run
5	0.96 (.15)	0.153 (.18)	Pool

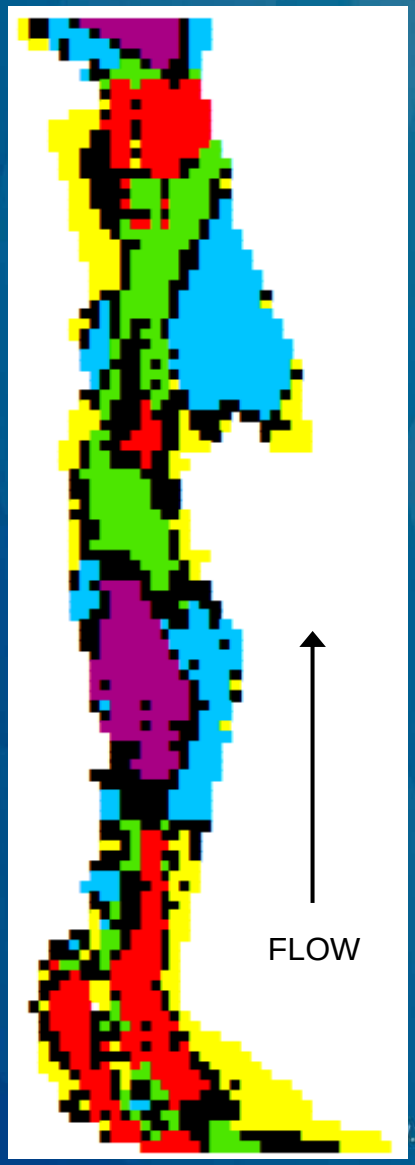
Habitat Composition



Results: River Arrow

Crisped fuzzy cluster partition at Q22 (0.866m^{3}s^{-1})



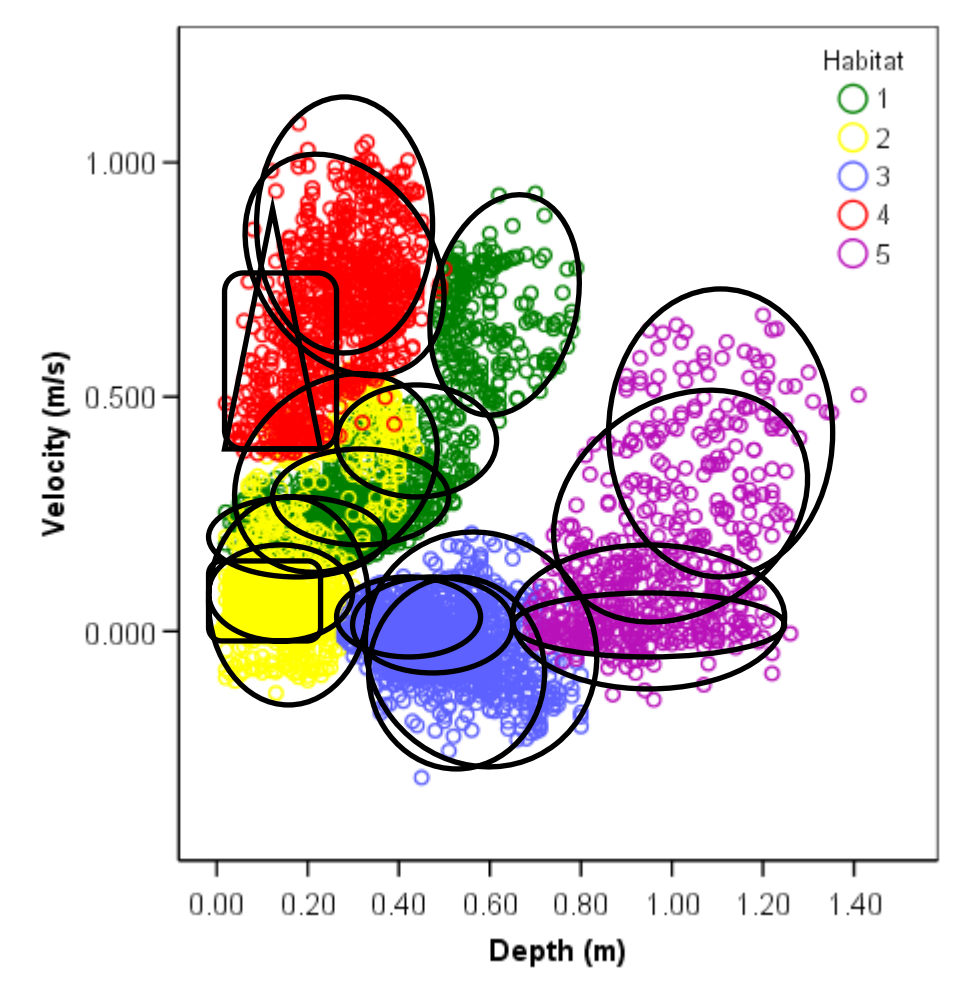


Location and extent of hydraulic habitats, Q22

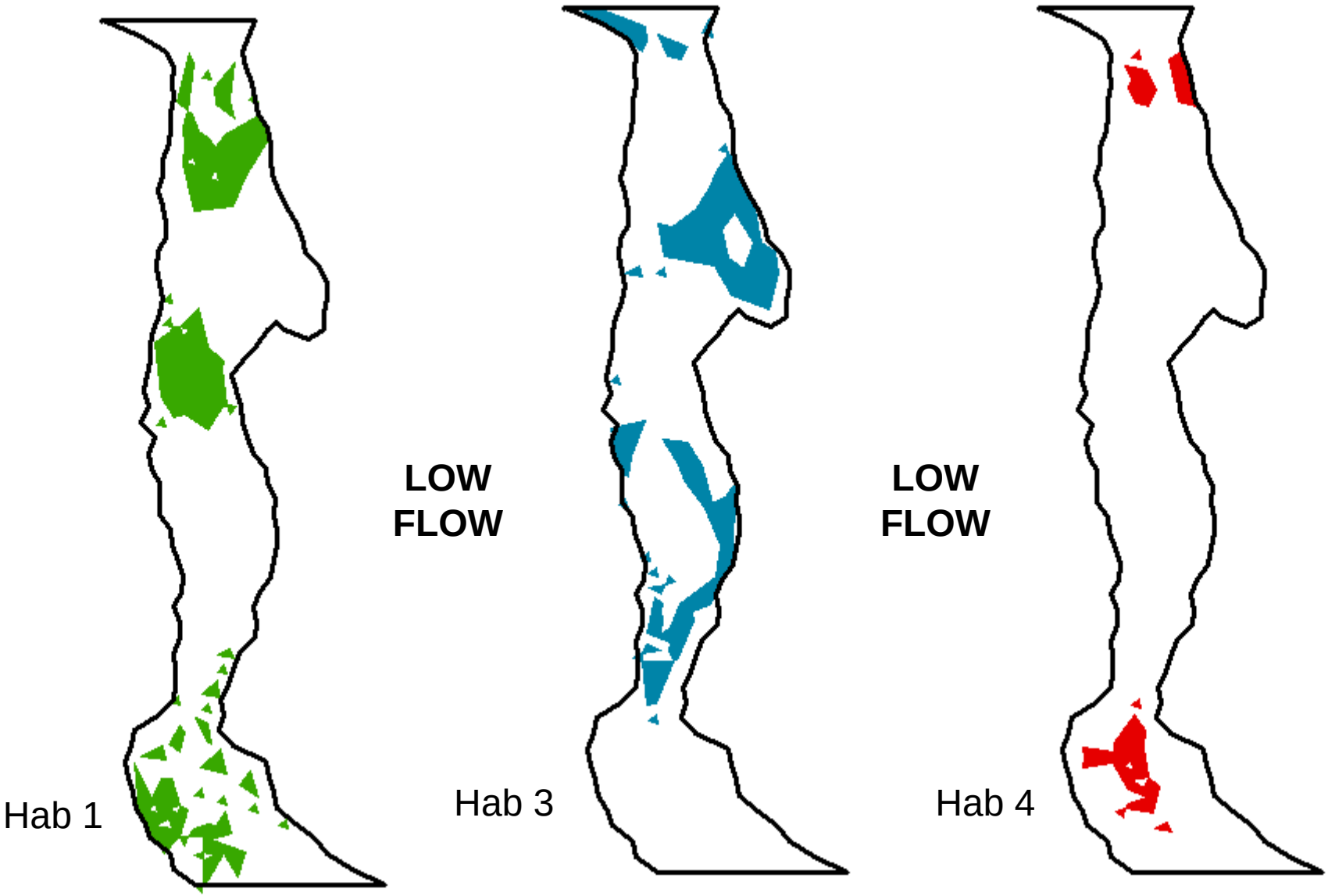
Hydraulic variability

How do hydraulic habitats vary with discharge?

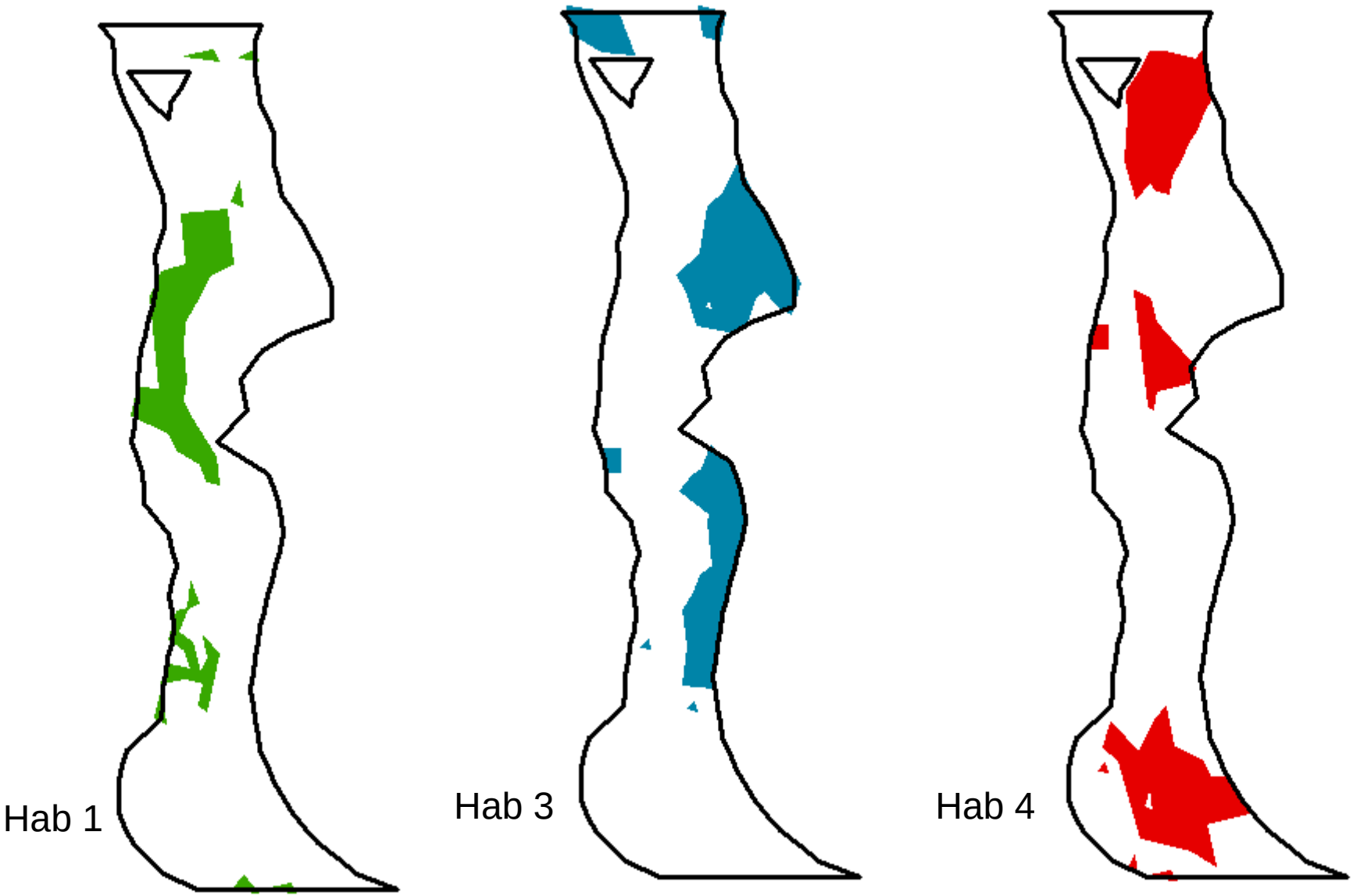
Are changes in depth and velocity significant? (MANOVA)



How do the location and extent of habitats vary with discharge?



HIGH FLOW



Habitat Configuration

Inter-flow habitat configuration similarities

	Q70	Q53	Q22	Q13
Q70	1	41.8	52.6	25.6
Q53		1	86.5	32.5
Q22			1	44.8
Q13				1

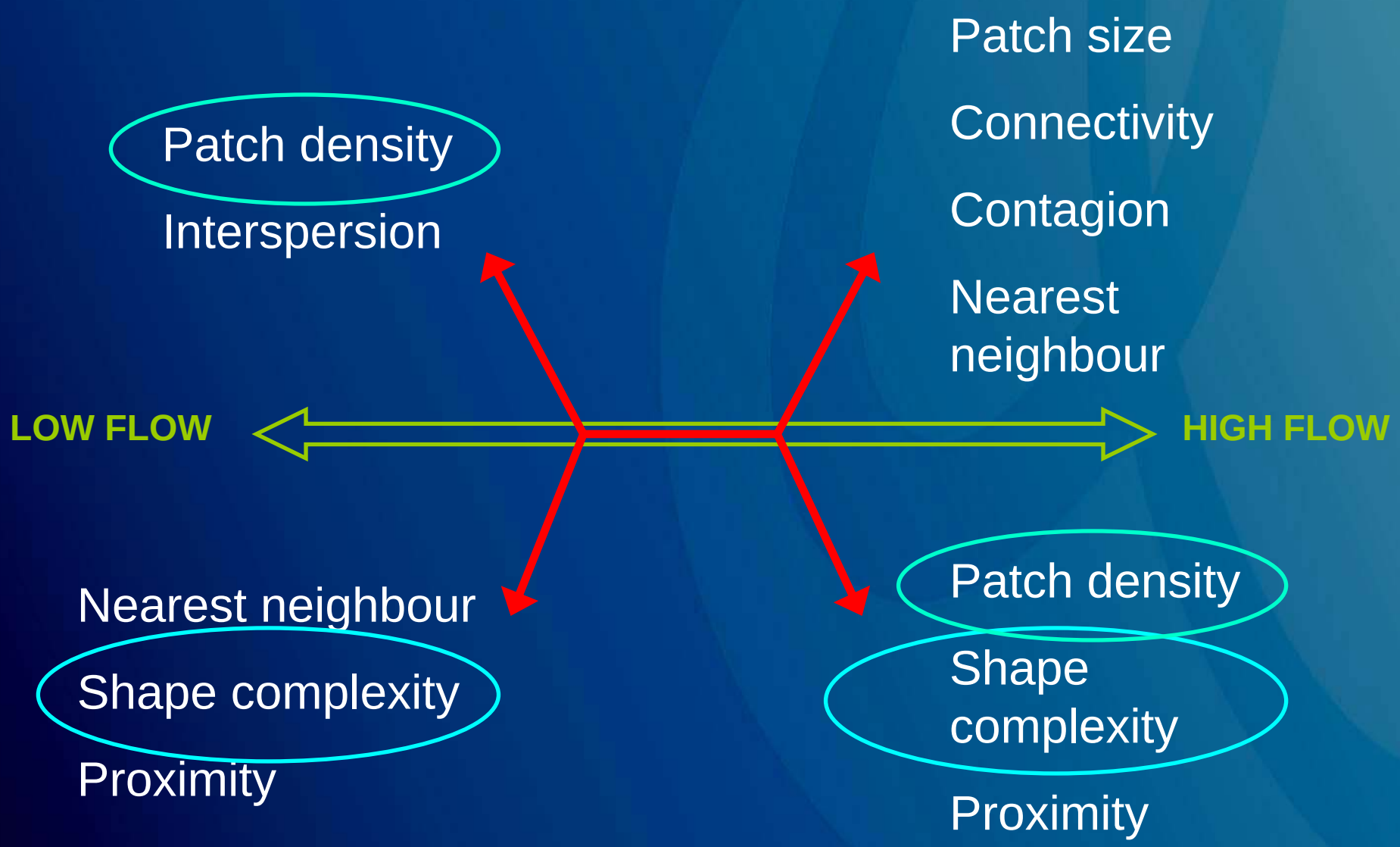
LOW FLOW

HIGH FLOW

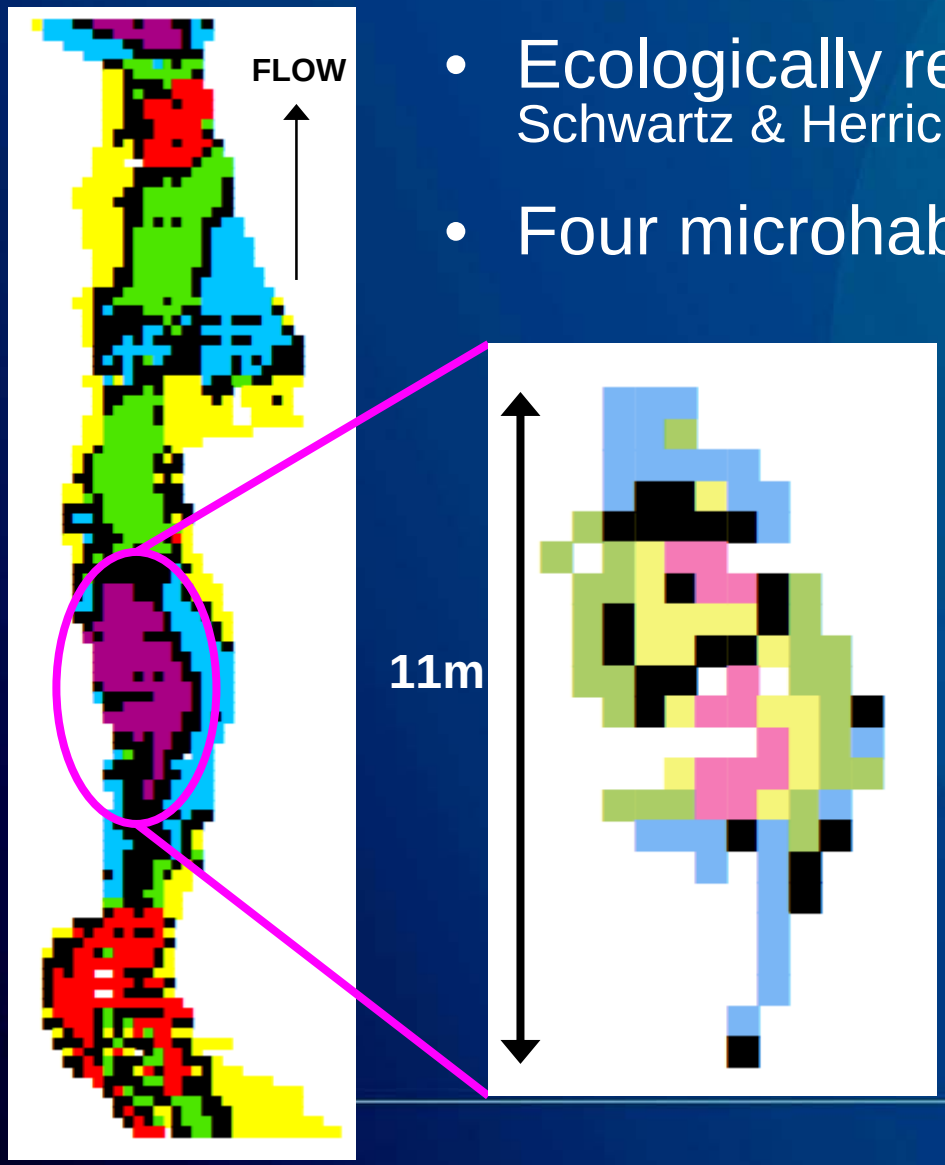
configuration similarity decreases

Primer: Gower environmental distance

Habitat Configuration



Microscale Habitats



- Ecologically relevant (Palmer et al., 2000; Schwartz & Herricks, 2008)
- Four microhabitats within Habitat 5 (pool)

	Dmean (st dev)	Vmean (st dev)
5a	1.09 (.05)	0.198 (.04)
5b	0.82 (.05)	0.127 (.04)
5c	1.03 (.06)	0.023 (.04)
5d	0.85 (.05)	-0.031 (.04)

Summary Discussion

HABITAT ASSESSMENT PROTOCOL

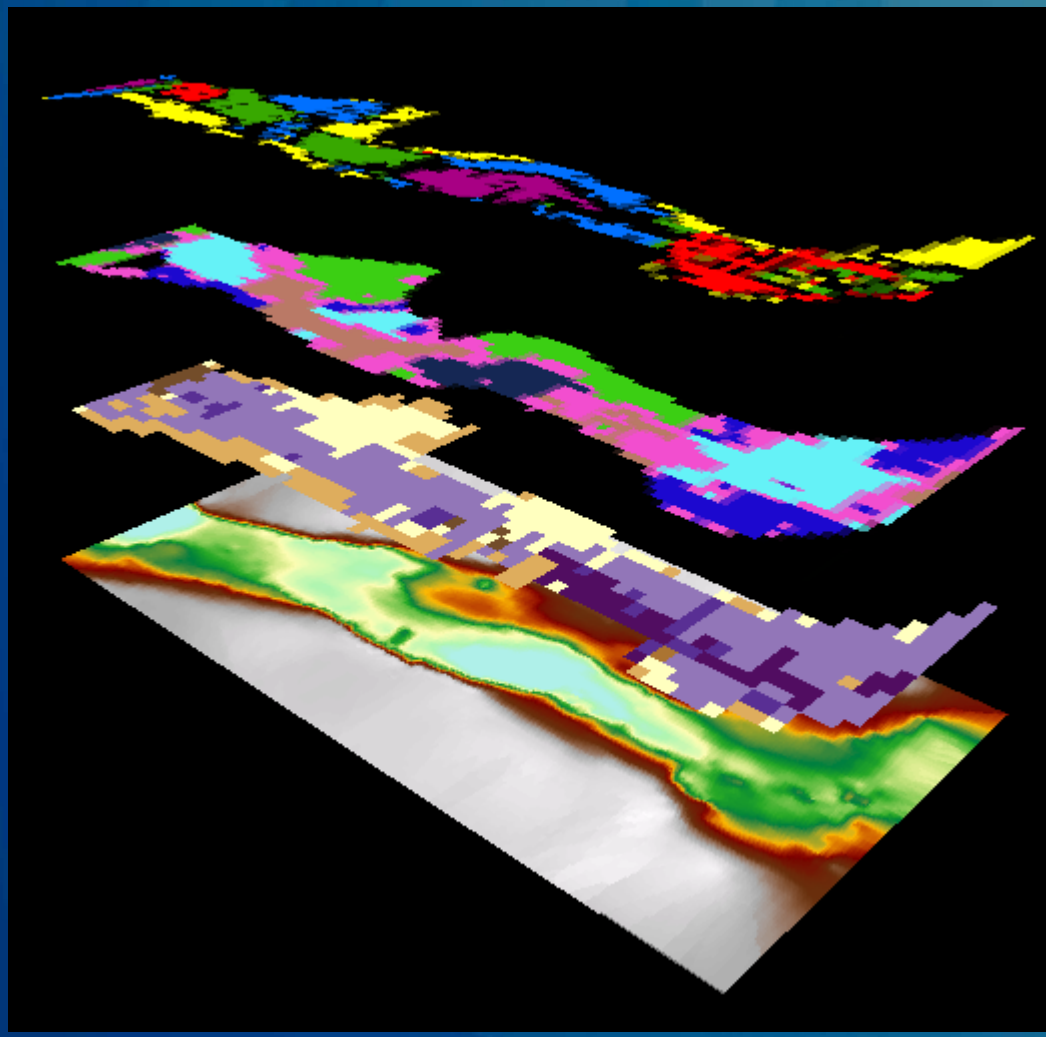
- Applicable at multiple scales and extents
- Reflects site-specific conditions and fuzzy habitat boundaries
- Flexible definition of habitat
- Careful selection and interpretation of spatial metrics required

Summary Discussion

APPLICATIONS

Tool for:

- Ecohydromorphic Research
- River Management



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Further Work

- Short-term (rest of PhD)
  - Apply to 2 more sites
  - Additional analysis
- Long term (post-doc)
  - Investigate biological response to habitat dynamics
  - Develop an index of habitat dynamics

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