Developing ecological assessment systems for rivers in Cyprus along a gradient of hydrological stability

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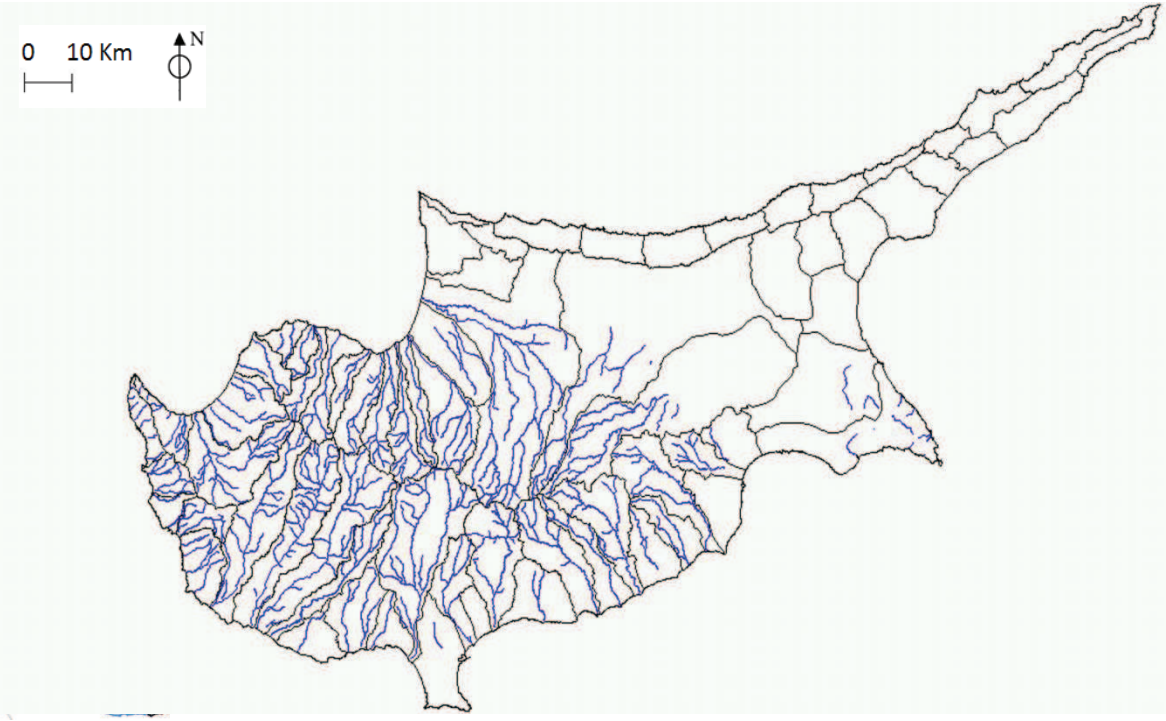
Study area

- Ca. 100 biomonitoring stations are annually monitored in Cyprus
- More than 500 samples collected between 2005 and 2011
- AQEM multi-habitat, proportional biological sampling of benthic communities; pool and riffle were kept separated
- Monthly characterization of physico-chemical condition



Hydrological characterization

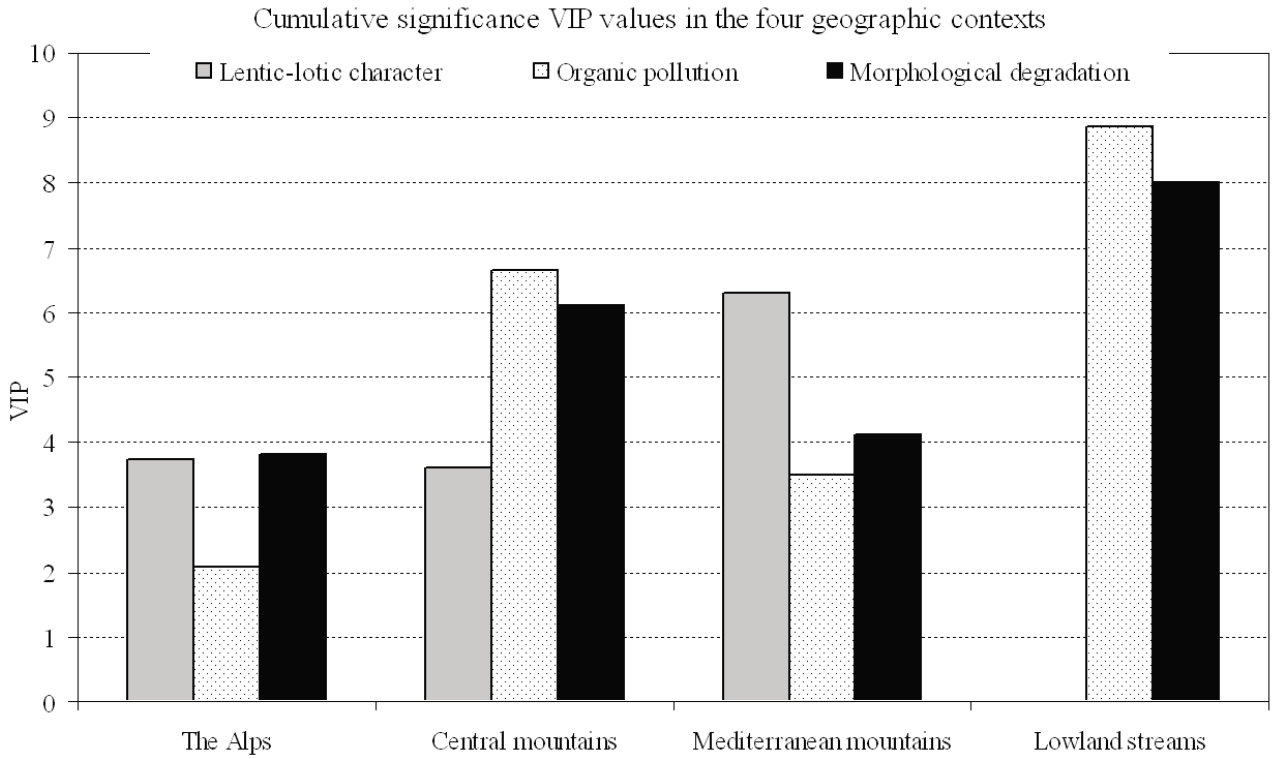
- Hydrological measuring stations and the biomonitoring networks are usually paired across the country
- WDD has performed a preliminary hydrological classification based on the Indicators of Hydrological Alteration (IHA) and Oueslati et al. (2010)

Type Code	Type name	Type characteristics
1a	PERENNIAL	less than 4 dry weeks
1b	PERENNIAL HIGHLY PREDICTABLE	less than 4 dry weeks, Colwell's predictability around 0.6
1c	PERENNIAL (ARTIFICIAL PERENNIAL)	non-natural perennial flow (sewage outfall u/s, ...)
2a	INTERMITTENT	Dry period 1-4 ½ months, R-B index <0.4
2b	INTERMITTENT FLASHY	Dry period 1-4 ½ months, R-B index 0.4-0.8
3a	PROLONGED INTERMITTENT	Dry period 4 ½ - 8 months, R-B index <0.4
3b	PROLONGED INTERMITTENT FLASHY	Dry period 4 ½ - 8 months, R-B index 0.4-0.8
4a	HARSH INTERMITTENT	Dry period 8-11 months, R-B index <0.4
4b	HARSH INTERMITTENT FLASHY	Dry period 8-11 months, R-B index 0.4-0.8
4c	HARSH INTERMITTENT HIGHLY FLASHY	Dry period 8-11 months, R-B index 0.8-1.2
5	EPHEMERAL/EPISODIC HYPERFLASHY	Flow period < 1 month, R-B index >1.2

- Issue: natural regime modelling of impaired sites currently not available

Habitat characterization: CARAVAGGIO method

- The CARAVAGGIO method (Buffagni et al., 1995), the adaptation of the River Habitat Survey (Raven et al., 1998) to Mediterranean streams, was applied
- Between others, the Lentic-lotic River Descriptor (LRD) was derived



Buffagni A., Erba S. & Armanini D.G. 2010. The lentic–lotic character of Mediterranean rivers and its importance to aquatic invertebrate communities *Aquatic sciences*.

Current ecological assessment method

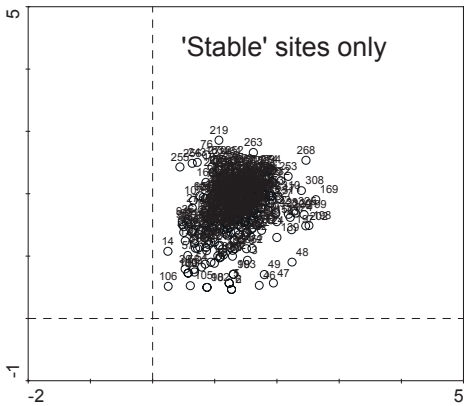
- As part of the Inter-calibration exercise for the WFD, Intercalibration Common Metrics (ICMs) and the STAR ICMi were used (Buffagni et al., 2005, 2006, 2007)
- Such method was selected for both Permanent (R-M4) and Temporary rivers (R-M5)

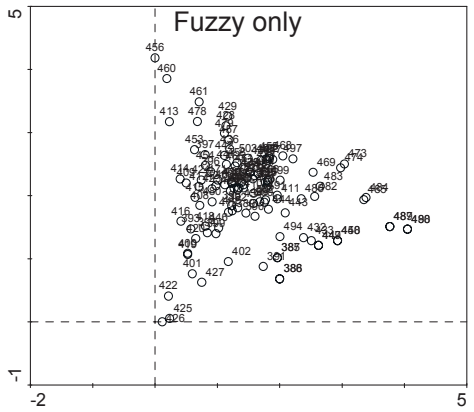
Intercalibration Common Metrics (ICMs) used in the STAR ICMi

Type	Metric type	Metric name	Taxa considered in the metric	Literature reference	weight
Tolerance	Index	ASPT	Whole community (Family level)	e.g. Armitage et al., 1983	0.333
Abundance/ Habitat	Abundance	Log_{10} (Sel_EPTD +1)	Log(sum of Heptageniidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae, Limnephilidae, Odontoceridae, Dolichopodidae, Stratyomidae, Dixidae, Empididae, Athericidae & Nemouridae)	Buffagni et al., 2004; Buffagni & Erba, 2004	0.266
	Abundance	1-GOLD	1 - (relative abundance of Gastropoda, Oligochaeta and Diptera)	Pinto et al., 2004	0.067
	Taxa number	Total number of Families	Sum of all Families present at the site	e.g. Ofenböch et al., 2004	0.167
Richness and Diversity	Taxa number	number of EPT Families	Sum of Ephemeroptera, Plecoptera and Trichoptera taxa	e.g. Ofenboch et al., 2004; Böhmer et al., 2004.	0.083
	Diversity index	Shannon-Wiener diversity index	$D_{S-W} = -\sum_{i=1}^{s}\left(\frac{n_i}{A}\right)\cdot\ln\left(\frac{n_i}{A}\right)$	e.g. Hering et al., 2004; Böhmer et al., 2004.	0.083

Typology: Fuzzy areas

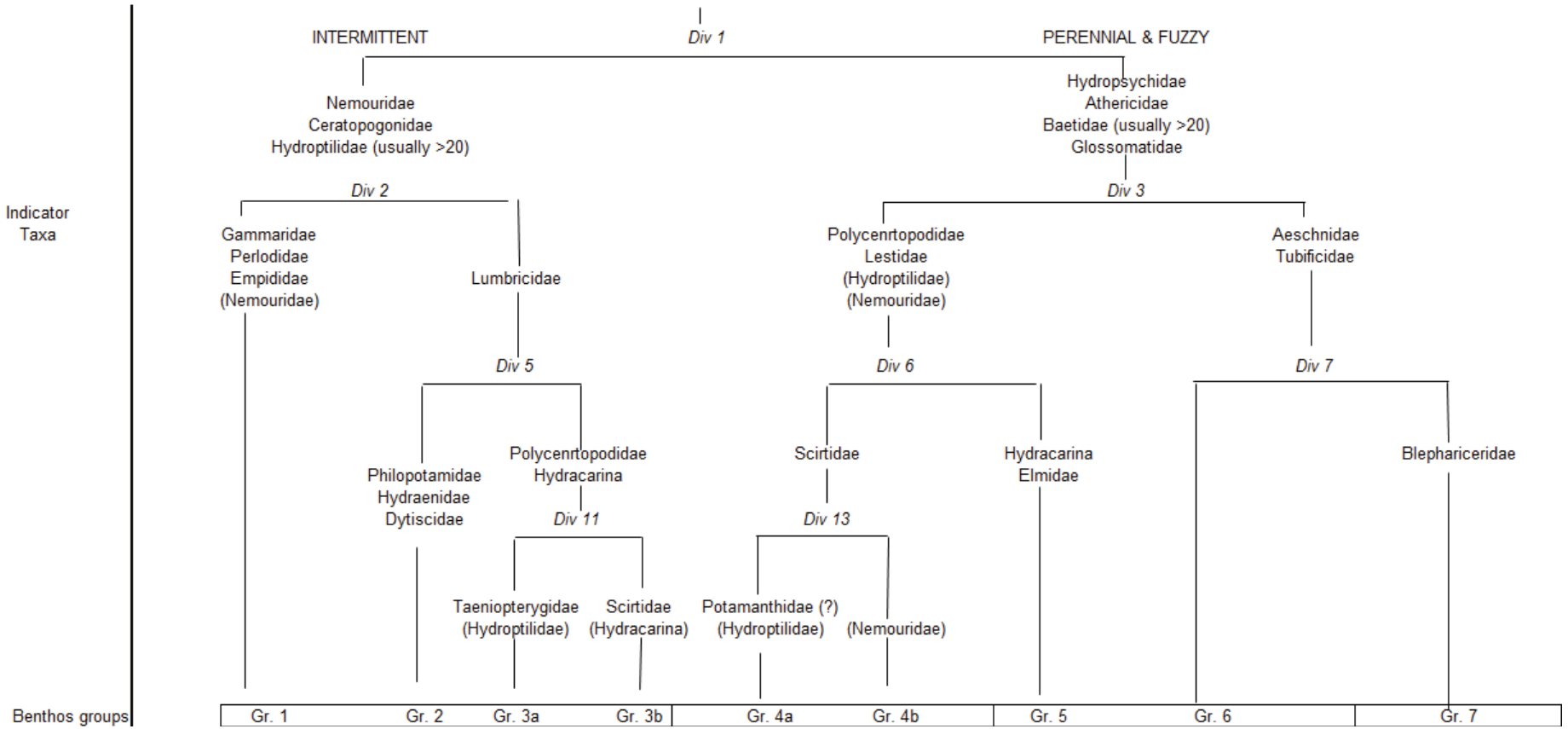
- A simple temporary vs. perennial type is an over-simplistic classification of Cyprus river. *Fuzzy zones/areas* (Uys & O'Keeffe, 1997), i.e. the flow character of rivers changes seasonally and yearly, are an important component of the system.
- Preliminarily, Baetidae abundances were used to classify stable vs. fuzzy sites
- By mean of multivariate analyses, a series of ordination has shown that clear relationship between environmental drivers and biological communities were observed only when accounting for this typological difference





Typology

- Can we develop a biologically valid typology that account for the hydrological gradient experienced in Cyprus rivers?



By mean of a TWINSPAN analysis, the main biological clusters were identified

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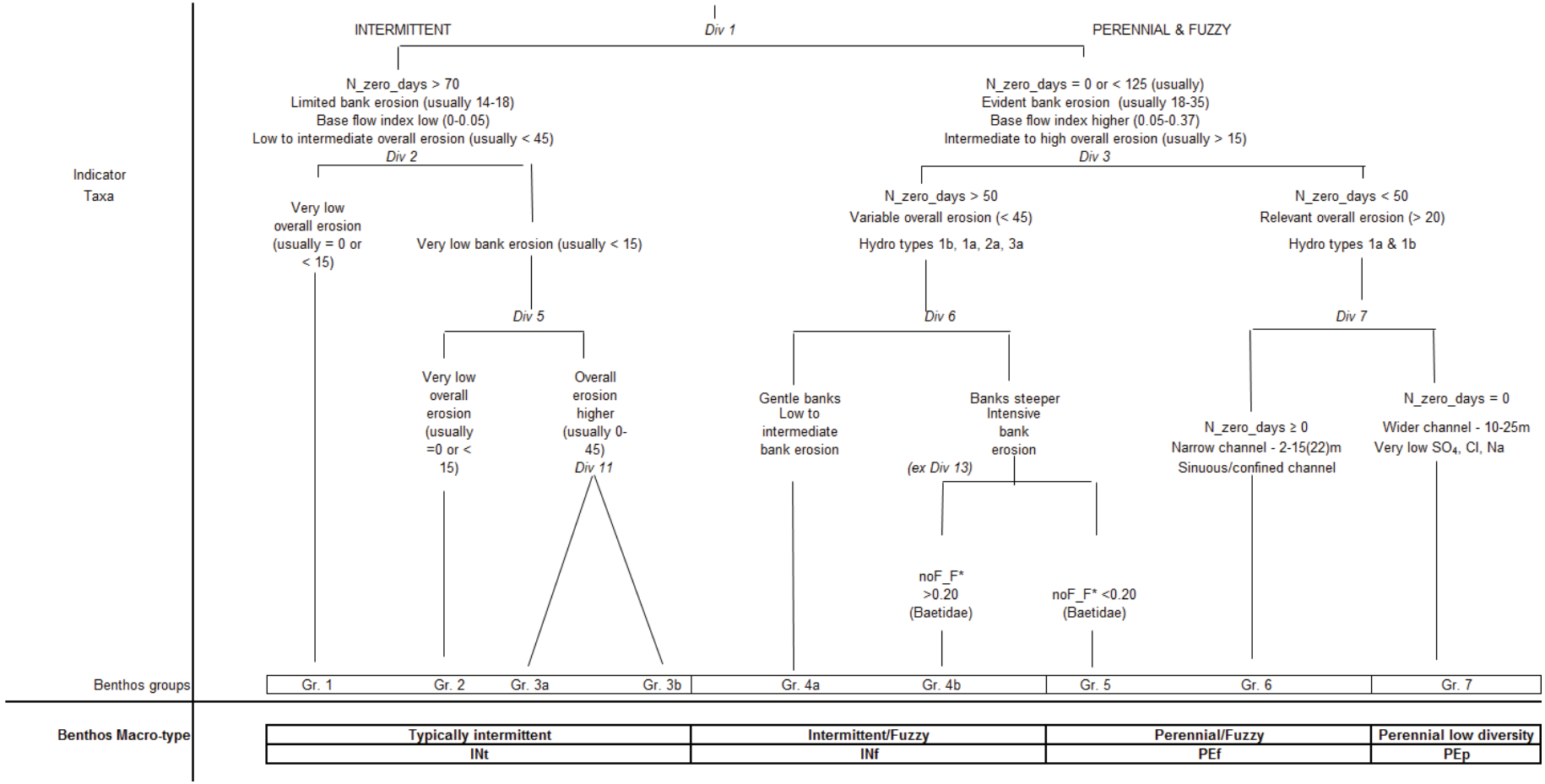
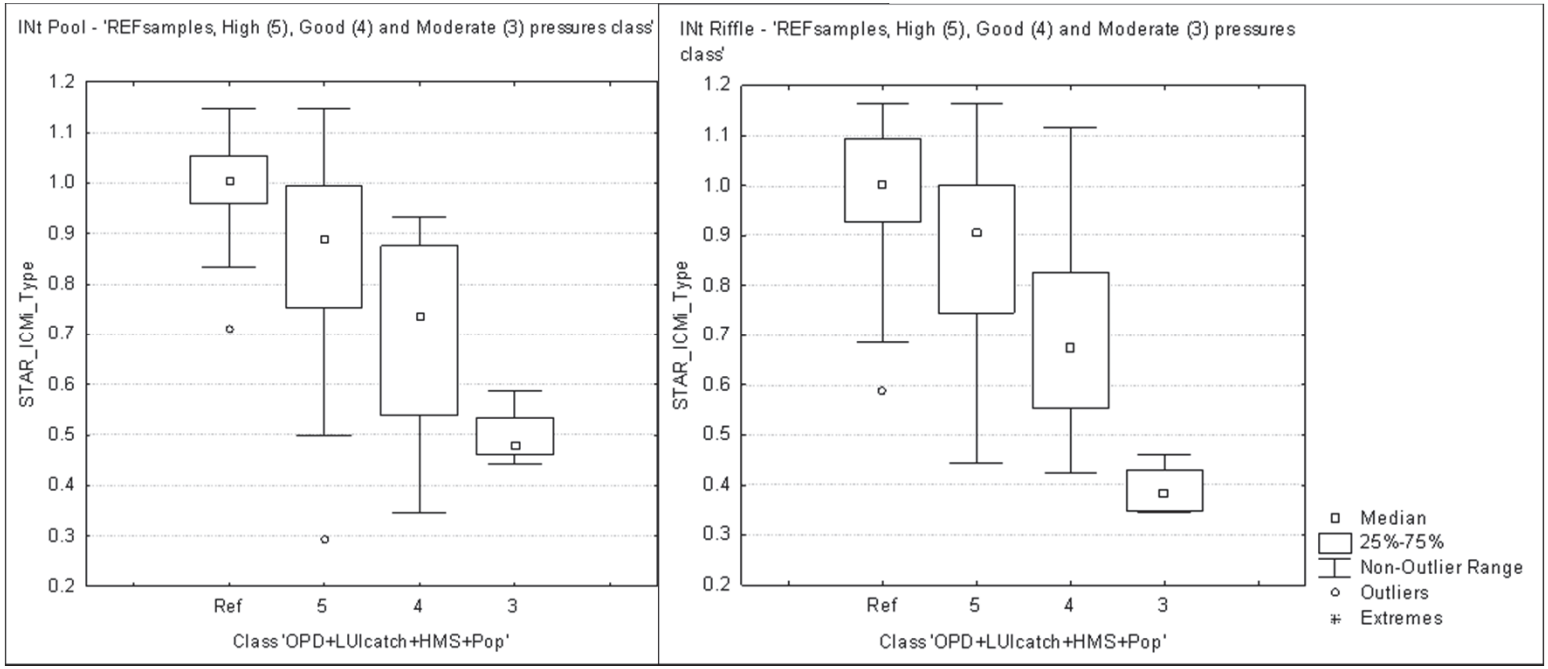


Biological clusters were interpreted by mean of a range of environmental information

Typology

- Can we implement an ecological assessment system that can detect anthropological change in an hydrological driven environment?
- Clear separation between environmental pressure classes was observed in the distribution of the STAR_ICMi in the different river types



Typology

- A potential approach to address hydrological uncertainty in ecological assessment is currently under development in the LIFE IN-Habitat project
- A correction factor for benthic metric values can be derived based on the LRD index

LRDp	STAR_

Coefficient and Fit Statistics

From scipy.odr.odrpack and http://www.scipy.org/Cookbook/OLS

Degrees of freedom (error): 8

Degrees of freedom (regression): 2

Chi-squared: 0.023995464455

R-squared: 0.810097452088

R-squared adjusted: 0.762621815109

Model F-statistic: 17.0634351354

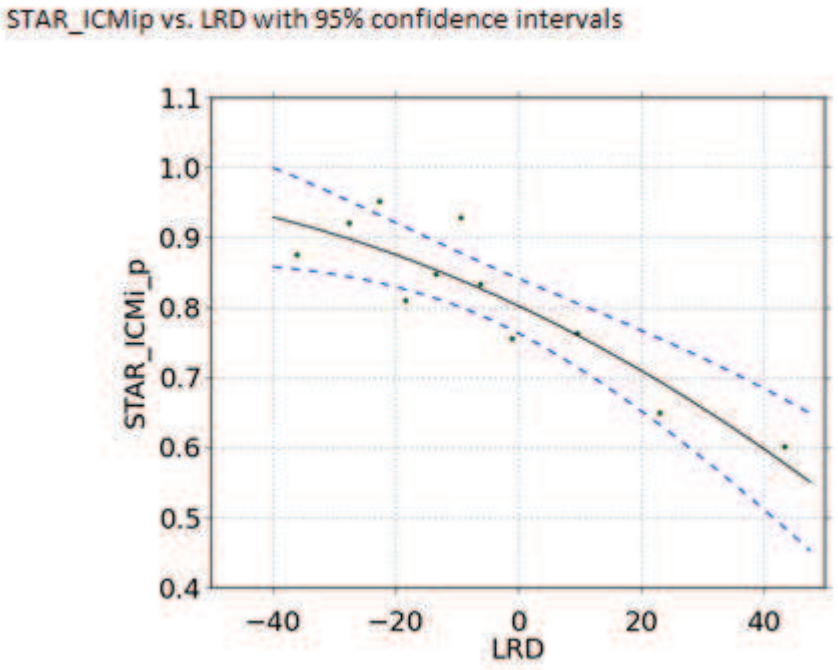
Model F-statistic p-value: 0.001

Model log-likelihood: 18.0944975966

AIC: -2.74445410847

BIC: -2.63593721589

Root Mean Squared Error (RMSE): 0.0467055227949



Polynomial fitting ($y = a + bx + cx^2$) of STAR_ICMi as a function of LRD for POOL samples

Conclusion

- Typological classification needs to account for hydrological variability and particularly for the fuzzy character of rivers

- Once accounted for typological differences, the STAR-ICMi resulted as a valuable tool to assess ecological quality in Cyprus

- Improved results can be obtained by employing hydromorphological information to account for local hydrological conditions

Future research

- Natural regime modeling of impaired sites should be implemented to support quantification of the effects of hydrological alteration

- A flow regime classification (e.g. Monk et al., 2012) should be implemented to improve the understanding of hydrological pattern in the country

- Detailed and type-specific correction factors should be developed to minimize hydrologically driven uncertainty in classification

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THANKS FOR YOUR ATTENTION:
QUESTIONS?

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