Freshwater Science

The Modular River Survey and its application in ecological studies

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The Modular River Physical (MoRPh) survey was developed to enable river enthusiasts and citizen scientists to get involved with recording and assessing physical habitat and hydromorphological processes in their local rivers and streams. Its open-data outputs are of interest to anyone working in or with catchment partnerships, or local groups with an interest in monitoring and understanding how rivers function and change over time. Here the authors outline their experience in developing and using MoRPh in ecological assessments.

Assessing the quality of physical habitat and functioning of river systems is vital for informing appropriate management to sustain our water-dependent wildlife. To build understanding of how the characteristic shape and physical features of rivers and streams sustain and are influenced by biotic communities, we need to document the range of these features and how they change over time, at the same spatial scale at which biological data are collected.

The MoRPh survey (Shuker et al. 2017; Gurnell et al. 2019) provides a standardised observation-based field survey that allows trained surveyors to record hydromorphological elements in both wet and dry rivers. Data gathered across short patch or longer sub-reach spatial scales record local habitats plus indicators of morphological function, generating outputs that summarise patch and sub-reach character and quality. An extended reach-scale assessment can also be applied to support interpretation of patch/sub-reach data and to determine habitat condition in relation to the geomorphic river type.

At the patch scale, a single MoRPh 'module' provides the foundation unit: a short section of river or stream whose length is defined by the width of the active channel bed (comprising the wet or dry bed width plus marginal physical features). Field observations are recorded for the bank top (to 10 m), bank face and bed (Fig. 1). For the sub-reach scale, 5 or 10 side-by-side modules generate a MultiMoRPh survey and additional data, capturing the increased physical diversity and geomorphic process indicators that occurs at this scale.

The raw field data are used to calculate a series of publicly available MoRPh metrics, which can be analysed by trained surveyors to support bespoke investigations, for example, to explore biotic or other interrelationships with physical attributes.

MoRPh focuses on morphological diversity and interactions between flow, sediment and vegetation. Aquatic and terrestrial plant presence are recorded as morphotypes rather than species, to capture their functional roles and process-interactions between their physical properties e.g., the influence of riverine vegetation on sediment transport and deposition.

Developed collaboratively with expert geomorphologists and ecologists, including those in the Riverfly Partnership, one of the aspirations for developing MoRPh was to collect river habitat data on a scale comparable with biological surveys. One MoRPh module equates to an invertebrate kick sample area and 2–10 side-by-side surveys to macrophyte or fish surveys. MoRPh metrics can be used in ecological assessments, for example, to characterise relationships between stream biota and habitat diversity (England et al. 2017; Finn Leeming et al. 2019), and in river restoration appraisal (England et al. 2019).

MoRPh has recently been updated to include recording of in-channel terrestrial vegetation, improving characterisation of drying and dry channels (Fig. 2). This means MoRPh can now be better applied to characterise habitat changes and wet refuges during droughts, and to assess temporary rivers. We present two case studies that illustrate these applications.

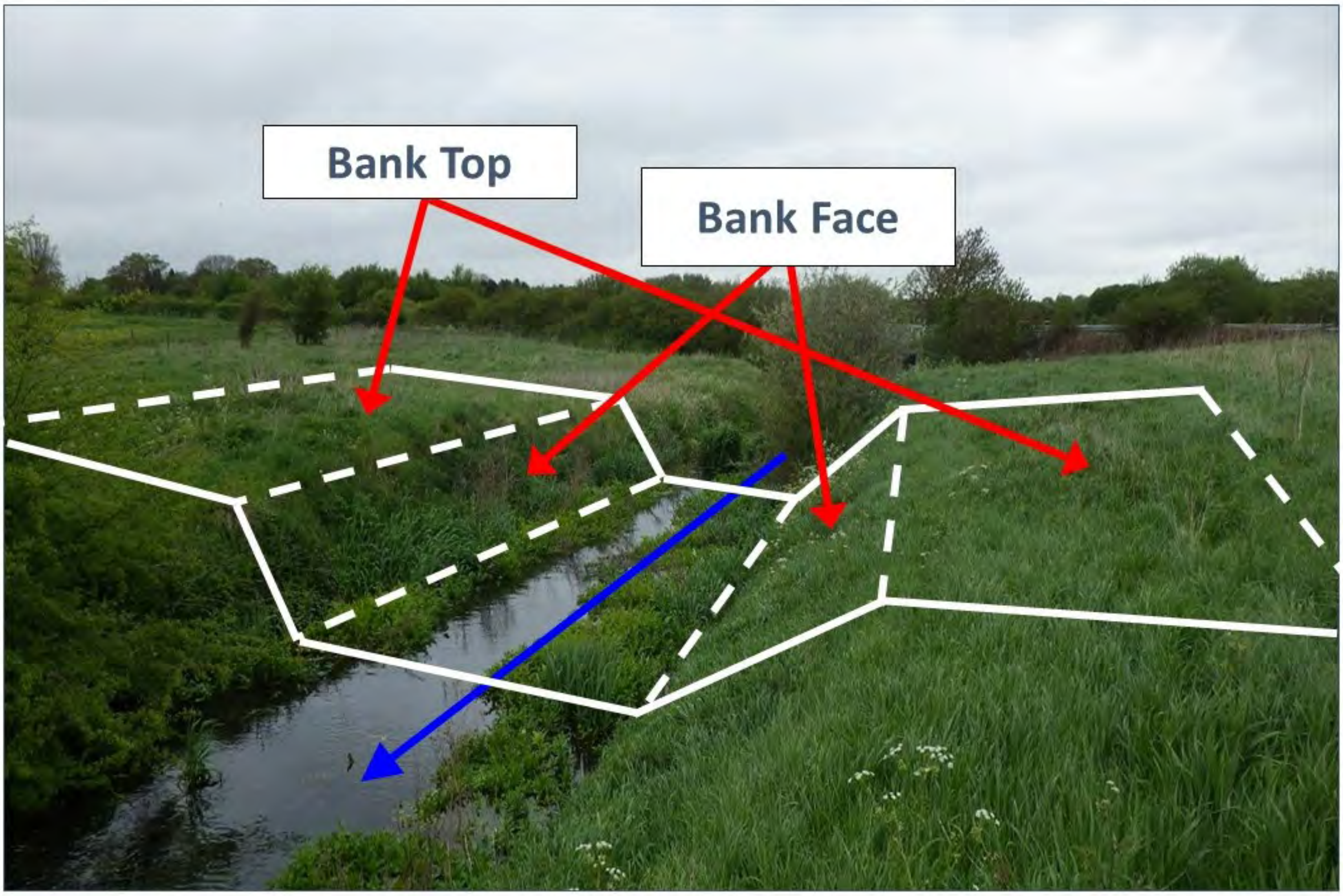

Figure 1: The area characterised by a Modular River Physical (MoRPh) survey.

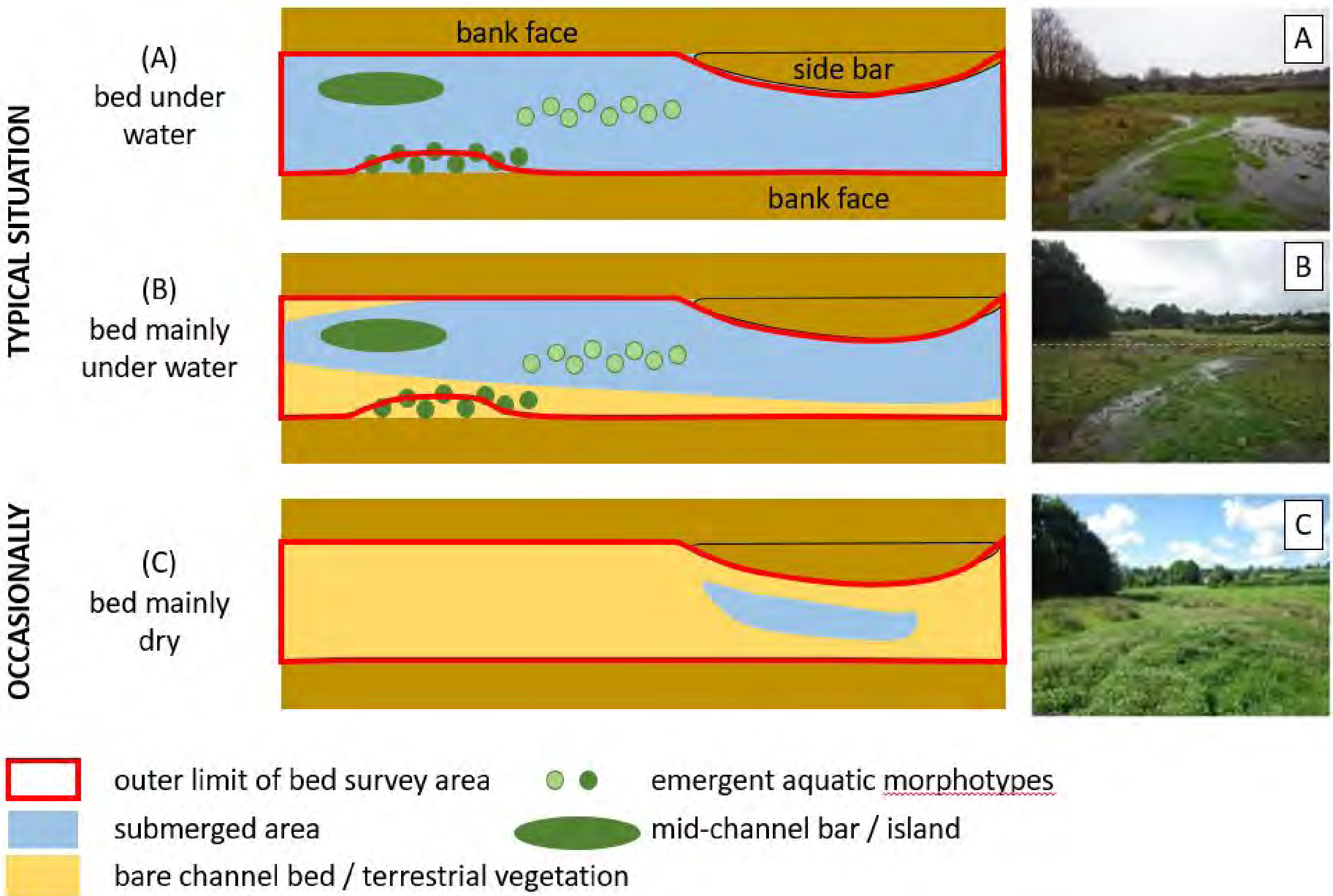

Figure 2: The application of MoRPh for flowing (A), drying (B) and dry (C) rivers and streams. In each phase, MoRPh records the diversity and extent of features on the channel bed including: flow habitats, aquatic and/or terrestrial vegetation and bare sediment types.

Case study 1 - Assessments in wet and dry rivers

We investigated the responses of aquatic macroinvertebrates and terrestrial plants and invertebrates to environment variables including flow, sediment, nutrients and vegetation in both wet and dry conditions in rivers of the Colne and Upper Lee catchments, Hertfordshire. We used MoRPh to characterise 62 sites, with flow regimes ranging from perennial (Fig. 3a) to seasonally intermittent (Fig. 3b), including 12 sites that were dry during the survey. We used a large dataset of previously collected MoRPh data (supplemented with our own surveys) to investigate spatial and temporal variability in macroinvertebrate, plant and terrestrial invertebrate communities.

Across all sites, the MoRPh metric highest energy flow type was a key influence on aquatic invertebrate communities, as indicated by responses in taxonomic richness and the biotic index WHPT ASPT (Fig. 4; Paisley et al. 2014), regardless of flow regime. Additionally, vegetation morphotypes influenced these community metrics at perennial and, in particular, at intermittent sites. MoRPh metrics characterising sediment, vegetation morphotypes, and also shade and leaf litter, influenced terrestrial plant and invertebrate communities. Plants predominantly responded to nutrients, and also to the MoRPh metric shading, with overall richness peaking at the present shading category (Fig. 5a) and grass richness (Fig. 5b) at trace levels of shading. Terrestrial invertebrate communities responded to sediment complexity, leaf litter and vegetation complexity.

These results show how MoRPh can characterise responses of both aquatic and terrestrial communities to habitat conditions in wet and dry rivers.

Figure 3: A flowing perennial (A) and dry intermittent (B) stream in the Colne and Upper Lee catchments, Hertfordshire.

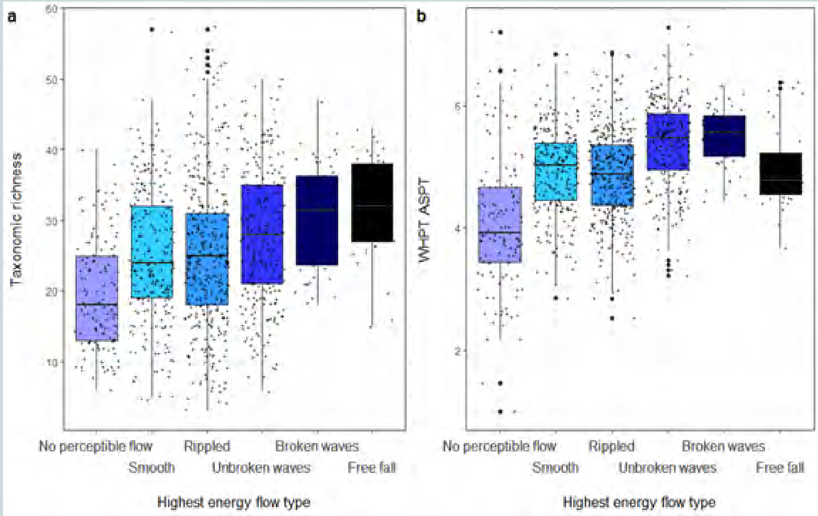

Figure 4: The median values plus upper, lower, minimum and maximum quartiles, with individual sample points (jittered), for (a) taxonomic richness and (b) WHPT ASPT responses to the highest energy flow type.

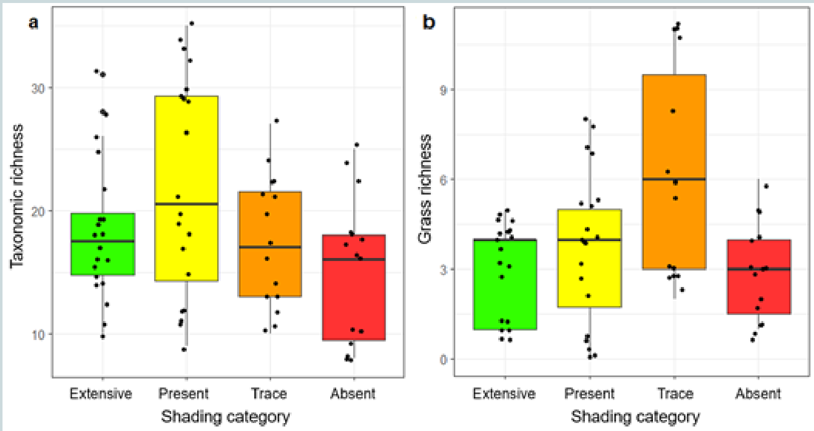

Figure 5: (a) Taxonomic richness and (b) grass richness in each shading category with individual sample points (jittered).

Case study 2 - Predicting beetle richness in dry temporary streams

Many groups of terrestrial invertebrates that inhabit dry river channels respond predictably to the habitat features summarised by MoRPh metrics, and thus may be used to assess ecosystem health. We used a dataset comprising MoRPh surveys paired with terrestrial beetle assemblage samples collected from five sites on a dry temporary stream, in an attempt to predict beetle taxonomic richness using MoRPh metrics.

Before predicting richness, the predictive model required training. For this we use a larger dataset of paired MoRPh surveys and beetle assemblage samples collected from exposed riverine sediments (ERS), which were considered a good candidate for training the model because – like temporary rivers – they transition between wet and dry states. The predictive model used the ERS dataset to 'learn' the relationship between three MoRPh metrics (habitat complexity, vegetation complexity and anthropogenic land cover) and beetle richness. The model was then given the MoRPh metrics for the temporary stream samples and asked to predict the richness of these sites. We assessed the model's predictions by correlating them with the actual richness observed in the dry temporary stream.

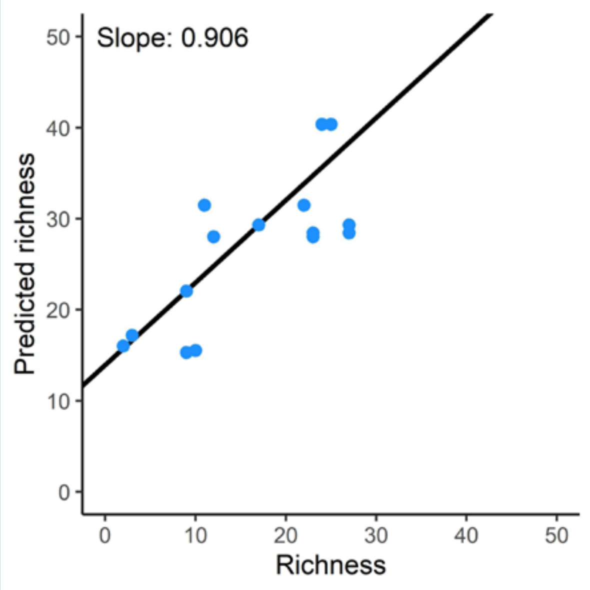

Figure 6: The relationship between observed taxonomic richness of beetle assemblages and richness predicted by MoRPh metrics for a dry temporary stream.

Model predictions were 90.6% correlated with the actual beetle richness of the dry temporary stream (Fig. 6), with scatter around the trendline likely reflecting variability in beetle responses to environmental conditions between ERS and the dry temporary stream. The over-estimation of richness (i.e. the trendline crossing the y-axis above 0; Fig. 6) likely reflects the higher resolution of taxon identification in the ERS dataset. The strength of the correlation between observed and predicted richness suggests that, with a training dataset comprising habitat metrics and beetle occurrences, MoRPh may be used in ecological assessments of temporary rivers. This approach may enable quantitative assessment of terrestrial invertebrate assemblages even when they cannot be sampled (e.g. when channels are inundated; Fig. 7a), and may allow comparisons of sampled assemblages with those expected at a site with certain habitat characteristics (e.g. exposed in- channel tree roots: Fig. 7b). Finally, many terrestrial invertebrate groups (e.g. ants, true flies) respond predictably to the habitat conditions summarised by MoRPh metrics, and thus MoRPh has the potential to inform holistic ecological assessments of the fauna of dry temporary rivers.

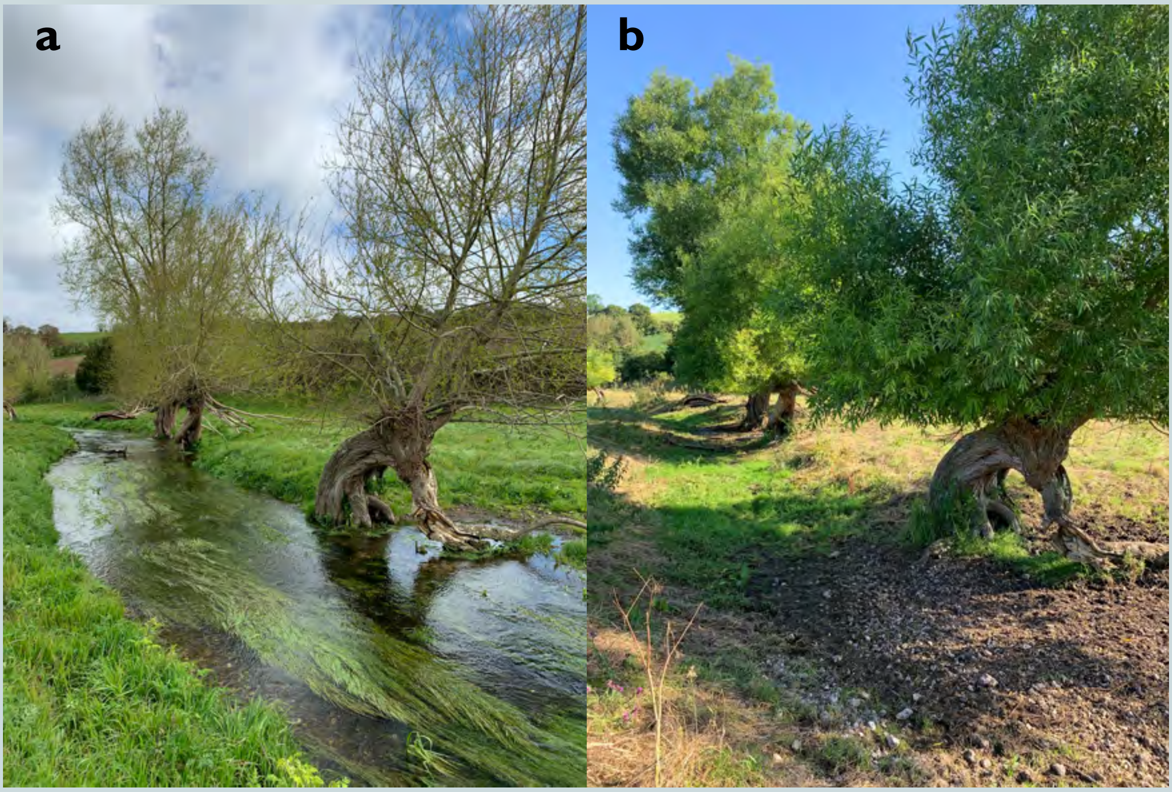

Figure 7: MoRPh metrics calculated during (a) the flowing phase may allow prediction of (b) dry-phase terrestrial communities. Photo credits: Tim Sykes.

Conclusions

Previous studies have shown how MoRPh metrics can be successfully used in ecological assessments, and to characterise relationships between biota and habitat diversity. Here we present case studies which demonstrate how the metrics can be readily applied to rivers with temporary flow regimes. As river drying increases with climate change, we encourage citizen scientists and researchers to record and assess how habitat conditions change and biota respond. For those interested in being trained in MoRPh surveys please contact: lucy@cartographer.io.

References

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