Hydromorphological Indices Models and Predictions

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1. Introduction

With increasing environmental pressure on rivers and their ecosystems, there is a need for simple, robust tools to support environmental management decision-making. the Water Framework Directive (WFD) requires member states to bring rivers to Good Ecological Status by reviewing existing activities and taking remedial action (European Union 2000).

Maps of habitats across river networks would help diagnose environmental problems and plan for the delivery of improvement work. Existing habitat mapping methods are generally time consuming, require experts and are expensive to implement.

In this paper, we describe an approach towards mapping hydromorphological elements across entire river networks that does not require continuous surveys of river catchments, but makes use of existing semi-quantitative survey data, GIS, linear regression and geostatistical techniques. The paper briefly covers the indices derivation and their significance. Another paper will cover applications.

2. Methods summary

The principle of the method is to identify and define habitat indices representing major dimensions in habitat distribution using multivariate statistical analysis applied to existing habitat data taken from the River Habitat Survey (RHS). The habitat indices are predicted using standard linear regression models using GIS map-derived covariates such as altitude, slope, distance from source, discharge and geology which represent known drivers of habitat/geomorphological change. The model outputs are then analysed using geostatistical techniques to identify and explain any remaining spatial variance and patterns not explained by the regression. The final model is then applied to the entire river network by deriving GIS covariates at regular intervals on the network (e.g. 500 m). For more information on methods see Naura et al (2016). A link to the paper is available online here: link. Two sets of models were produced, one based on all existing RHS data and the other on a subset of sites with little or no modifications (i.e. semi-natural sites).

3. Hydromorphological indices

Four indices were derived using RHS semi-quantitative spot-check data, the

- Channel Substrate Index (CSI), the
- Geomorphic Activity Index (GAI), the
- Flow Regime Index (FRI), and the
- Channel Vegetation Index (CVI).

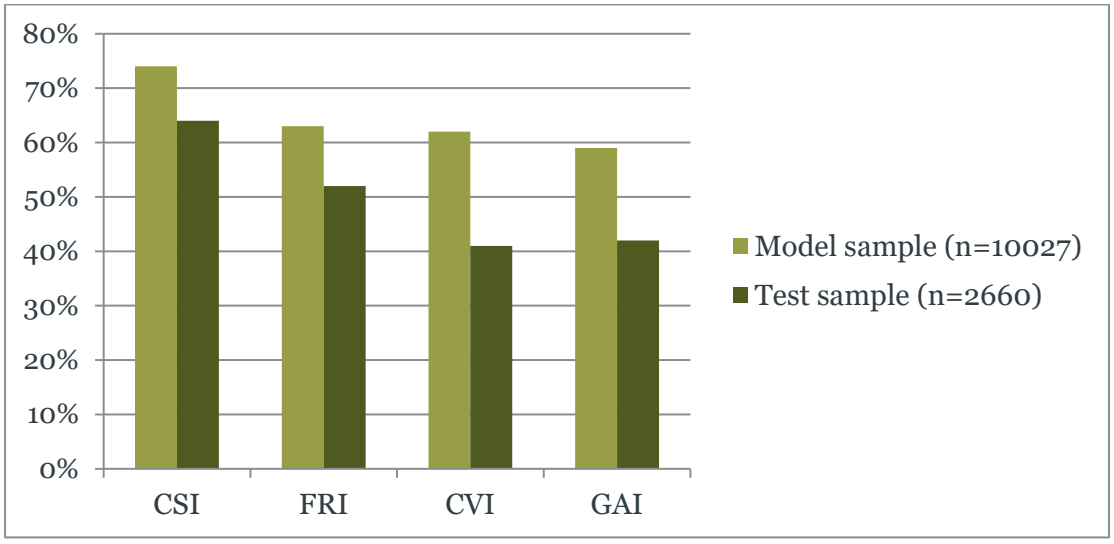
Calculation can be performed using an Excel spreadsheet (FTT089b) or by hand using the equations provided in FTT089c.

The indices represent major dimensions in the distribution of hydromorphological features. The following figures illustrate, for each index, the relative occurrence of constituting hydromorphological features along the indices scales. The indices and figures were built using RHS semi-natural sites with little or no signs of channel/bank modification.

4. Models

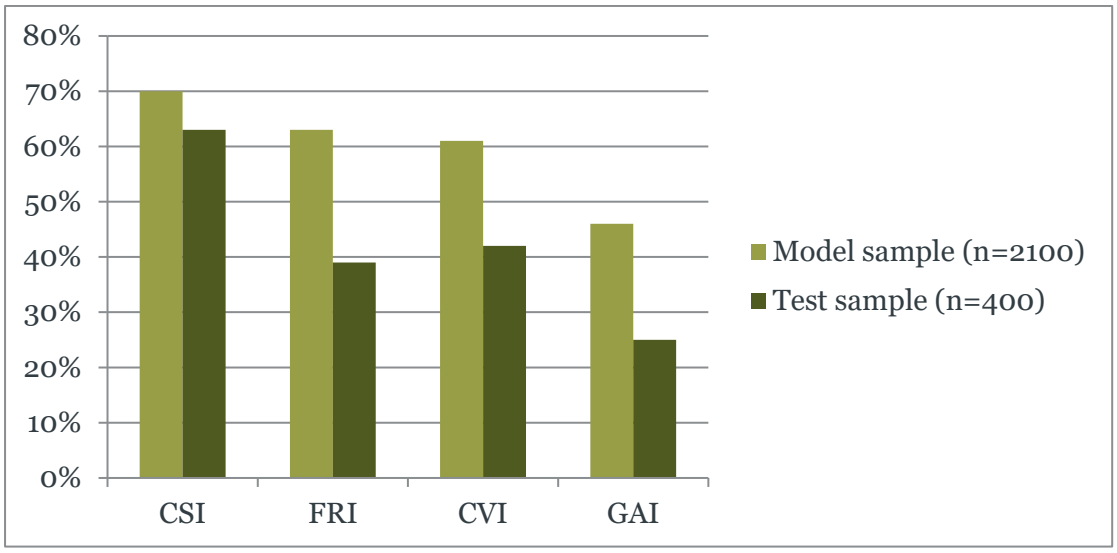
Predictive models results for all RHS sites (including modified sites) and semi-natural sites are displayed in the following two figures. All models were tested on an independent set of RHS sites from the 2007-2009 baseline survey for their predictive ability in space and time.

Prediction of index values for four hydromorphological indices using all RHS sites. Amount of variability explained by the models on the validation and test samples (R^2).



Altogether, the model predictions were satisfactory with marked improvements in predictive power achieved through spatial correction. Model R^2 were generally high for all indices across samples. The model performance on a separate sample of sites were comparable with some decrease in predictive power that could be attributed to differences between years and time of survey as well as changes in sampling strategy (the 2007-9 baseline survey included sites from the 1/50,000 scales network less than 1m wide not present in the original sample). Best results were achieved for CVI and FRI predictions with higher levels of residual variability observed for CVI and GAI.

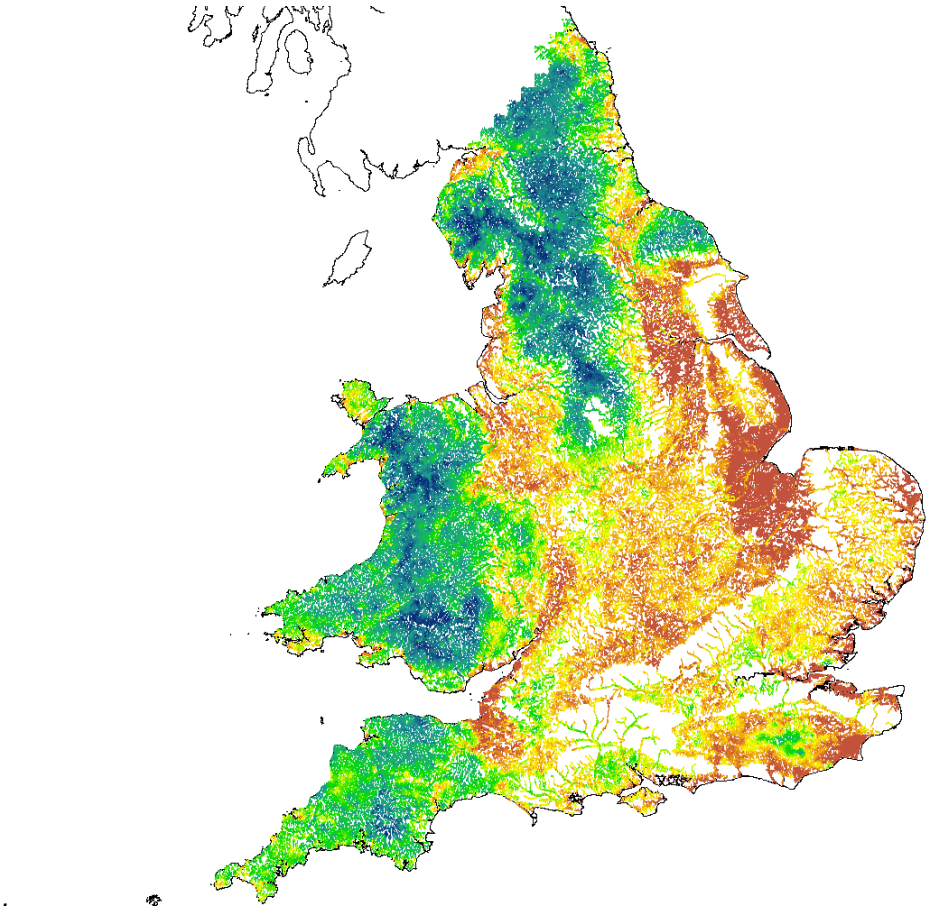
Prediction of index values for four hydromorphological indices using RHS semi-natural sites. Amount of variability explained by the models on the validation and test samples (R^2).



5. Maps

The models were implemented across the entire river network. The following figure shows the map for the Channel Substrate Index (all sites) across England & Wales.

Map of predicted values of CSI using regression kriging at every 500m across the 1/50,000 river network on a gradient from bedrock/boulder (blue) to gravel-pebble (green) and silt-sand-clay (brown). White reflects areas of low drainage density where fewer streams are present.



6. Conclusion

We proposed an approach for mapping habitat elements across *entire* river networks that makes use of existing semi-quantitative survey data, GIS map-based covariate data and geostatistics. A set of new national scale indices were developed, which are accurate from 500m up to national scales. Models predicted observable hydomorphological as well as semi-natural conditions with adequate accuracy. This application shows the potential of using spatially explicit techniques for modelling river attributes at the national scale for assessing hydromorphological conditions and departure from natural state.

7. References

Collins, A.L., Jones, J.I., Sear, D.A., Naden, P.S., Skirvin, D., Zhang, Y.S., Gooday, R., Murphy, J., Lee, D., Pattison, I., Foster, I.D.L., Williams, L.J., Arnold, A., Blackburn, J.H., Duerdoth, C.P., Hawczak, A., Pretty, J.L., Hulin, A., Marius, M.S.T., Smallman, D., Stringfellow, A., Kemp, P., Hornby, D., Hill, C.T., Naura, M. and Brassington, J. (2012). Extending the evidence base on the ecological impacts of fine sediment and developing a framework for targeting mitigation of agricultural sediment losses. Final report to Defra, Defra project WQ0128.

European Union (2000) *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*.

Naura, M., Clark, M.J., Sear, Atkinson, P.M. Hornby, Kemp, P., England, G., Peirson, G., Bromley, C., Carter, M.G. (*2016*) Mapping habitat indices across river networks using spatial statistical modelling of River Habitat Survey data. Ecological Indicators. 66, 20-29. Doi:10.1016/j.ecolind.2016.01.019

Information on how to calculate indices can be found on the river habitat survey website: http://www.riverhabitatsurvey.org/manual/rhs-indices/

Additionally, you can download an Excel spreadsheet to calculate indices by hand: www.riverhabitatsurvey/RHSfiles/RHSHydromorphologicalIndicesCalculation.xlsx