Influence of multiple scale environmental features on stream invertebrate community structure

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ABSTRACT

Most ecological studies concerning stream invertebrates consider that patterns in local communities are determined by local processes. In this study we hypothesise that local invertebrate diversity is determined by a combination of factors occurring at multiple spatial scales in the environment. This hypothesis was tested using environmental data collected at 97 sampling sites dispersed throughout the Taieri River catchment, New Zealand. We used artificial neural networks (ANN), which are known to be able to deal with complex and non-linear features, to model invertebrate diversity according to environmental data collected at various spatial scales (bedform, riparian zone and sub-catchment respectively). Models were trained on the data from 97 sites to define the relationships between the environmental variables and diversity, and then tested using the leave-one-out cross-validation procedure to estimate the generalisation ability of the models (i.e. the ability to predict new and independent samples). Models run using each specific spatial sampling scale were highly significant in training ($p<0.01$) with correlation coefficients between observed and estimated values ranging from 0.61 and 0.85 for equitability and from 0.56 and 0.89 for species richness. However, the models were never able to match the predictions on new data in testing ($p>0.01$). Even if the diversity of each sample can be explained using one spatial sampling scale, information was not consistent between independent samples. New models using combined data for the three spatial scales were highly significant in both training and testing procedures ($p<0.01$, r (training) = 0.86 and 0.90, r(test) = 0.55 and 0.64 for measures of diversity. Considering the contribution of the variables, using specific algorithms at each scale, bedform median particle size, the presence of pasture within the riparian scale and relief ratio of the sub-catchment were found to be most important. The representation of the sensitivity of these variables revealed complex non-linear relationships between diversity features and environmental variables, which were found consistent with both river continuum and habitat templet theories. However, we found that stream invertebrate diversity is accounted for by several variables acting mainly in a non-linear way and belonging to different scales of survey of the environment. This means that patterns and processes observed in local assemblages are not only determined by local mechanisms acting within assemblages, but also result from processes operating at larger spatial scales. Hence, the integration of different spatial scales can be considered as a key component for increasing model predictability and understanding the factors that determine the structure of invertebrate communities in streams of different states.

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