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Meso-scale resolution for the definition of environmental flow standards in Mediterranean streams

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The prediction of fish presence related to habitat characteristics is fundamental for the definition of environmental flows and habitat restoration measures. Meso-scale habitat models have been widely used in the context of water resources planning and management and demonstrated interesting potentials to assess freshwater fish distribution at a large spatial scale. In particular, the meso-scale approach allows rivers to be surveyed for longer stretches with a considerable representation of river habitats in comparison with more detailed models, and involves a large range of habitat descriptors. Moreover, machine learning techniques, such as random forest (RF), can be used to define multivariate habitat suitability criteria and capture the confounded effect of biotic and abiotic environmental variables. Data from three catchments located in the Mediterranean area (i.e. Júcar, Po and Nestos river basins located in Spain, Italy and Greece respectively) were used to develop habitat suitability criteria for threatened and endemic fish species. Fish data for model constructions were collected in reference sites, which were selected for their natural conditions of flow regime and habitat characteristics, and the resulting models described the habitat use by fish during their diurnal routine. Dataset dimension varied from 110 to 240 mesohabitat observations depending on the considered fish species. The RF algorithm provided an indicator of variables' importance and, using the variables' ranking, the best and the most parsimonious model was selected to define the lowest number of variables to be surveyed for future model applications. Our results indicated that RF performed well in both model calibration and validation phases and can be considered a valuable tool to predict fish distribution at meso-scale. Overall, the habitat suitability models had high model-fit accuracy (ranging from 75% to 94%). Cohen's kappa statistics were assessed over 0.52 and all models showed high sensitivity/specificity values, indicating substantial predictions with low cross-classification errors. In addition, the area under the ROC curve (AUC) was over 0.81 in all cases, indicating from good to excellent model performance. Finally, examples of model applications in regulated sites were also presented in order to quantify the available habitat under specific environmental conditions and to define environmental flow standards. The meso-scale approach showed its potential in modelling habitat for fish and the presented statistical techniques can be considered a promising tool for river restoration and ecological management of Mediterranean streams.