

Abstract

Rethinking Species Distribution Modelling for Freshwater Fish Under Environmental Changes [†]

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Abstract

Introduction: Species Distribution Models (SDMs) are widely used to infer environmental drivers of freshwater fish distributions and to project biodiversity responses to climate and land-use change. However, freshwater ecosystems present specific conceptual and methodological challenges, including dendritic network structure, strong spatial autocorrelation, dispersal constraints, and scale mismatches between biological processes and environmental predictors that remain insufficiently addressed. At the same time, emerging data sources such as environmental DNA (eDNA) and high-resolution remote sensing offer new opportunities to improve data coverage and ecological realism in SDMs. **Methodology:** Focusing on Iberian systems as illustrative case studies, here, we synthesize the following recent advances and challenges in SDM applications to freshwater fishes: (i) the implications of using presence–absence versus abundance data; (ii) the integration of hydrological and connectivity metrics as predictors; (iii) approaches to explicitly account for spatial structure and biotic interactions; and (iv) the contribution of novel datasets, including eDNA and remote sensing. Furthermore, we examine the performance and transferability of correlative models under analogue and non-analogue climate conditions. **Results:** Our synthesis highlights the importance of incorporating network topology, seasonality, dispersal constraints, and novel data sources to improve ecological realism and predictive performance. The integration of emerging biodiversity and environmental data can substantially reduce data gaps and improve model calibration and validation, particularly in poorly sampled systems. Nonetheless, model transferability remains a challenge, particularly for endemic and range-restricted species. Advancing freshwater SDMs through the integration of hydrologically explicit frameworks and novel data sources will strengthen their capacity to support evidence-based management of freshwater fish assemblages facing accelerating environmental changes.



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