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Conference Abstract

Hit them where it hurts: Spatial management prioritisation of pondscape invasions using graph theory

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Abstract

Pondscapes, networks of ponds and the landscape matrix surrounding them, fulfil ecological, economic, and socio-cultural roles. Their integrity, however, is threatened by a variety of stressors, including biological invasions. Managing widespread non-native invasive species (NIS) in pondscapes is challenging due to interacting ecological, spatial, and logistical factors. Efficient resource allocation is essential, yet often hindered by an incomplete understanding of how landscape configuration shapes pond connectivity. We investigated the potential value of graph theory for informing the spatial prioritisation of widespread NIS management in pondscapes, using the American bullfrog (*Lithobates catesbeianus*) invasion in the Grote Nete river valley (Belgium) as a case study. Here, bullfrogs occur in a pondscape metapopulation with the hydrographic network acting as a permeable matrix for dispersal. Specifically, we asked whether a network-informed allocation outperforms a random allocation in disrupting pondscape connectivity, and how such an approach can inform management across objectives (overall containment, front-based containment, and site-level eradication), approaches (reactive and proactive), and scales (local and regional). We constructed an undirected

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distance-based graph of the invasion, with edges (connections) weighted by land use-informed resistance cost. Node attributes (bullfrog absence, presence, breeding) were assigned using 1,164 occurrence records along with catch effort data and environmental DNA data from 123 and 315 ponds, respectively. We then simulated sequential targeted versus random node removal to assess network robustness across three node-specific network metrics: betweenness centrality, degree, and eigenvector centrality. Based on these results and the properties of these metrics, we developed a decision tree to guide management across strategies, approaches, and scales, and empirically demonstrate its utility for prioritising bullfrog management in Belgium. We found that the invaded pondscape was highly modular and susceptible to network-informed management. Betweenness centrality-informed node removal was most effective in disrupting the network, outperforming random approaches by 21%. As overall network fragmentation may not be desired nor feasible in certain contexts, we show that other metrics can nevertheless be valuable in helping to guide node removal across management objectives, approaches, and spatial scales. Graph theory offers a practical and straightforward approach to improve the spatial allocation of management effort in pondscapes with minimal data requirements. The decision tree presented here facilitates its application by invasion biologists, decision-makers, and practitioners.

Keywords

American bullfrog (Lithobates catesbeianus), decision tree, management prioritisation, network ecology, non-native invasive species

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Conflicts of interest

The authors have declared that no competing interests exist.