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Population persistence in river networks using metric graphs

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Freshwater scientists are increasingly demonstrating that the branching structure of river networks has substantial ecological consequences. Most previous models that explicitly considered network geometry artificially discretized river habitat into distinct patches. Differential equation models have largely ignored the global geometry of river systems and the effects of tributary junctions by using intervals to describe the spatial domain. Here, we explore the effects of a continuous network structure and the distribution of habitat within the network on the persistence of a hypothetical, highly mobile population. Our model uses a reaction-diffusion-advection equation on a metric graph, which unlike a traditional graph, encodes a continuous branching system where edges represent actual domain rather than simple connections among discrete nodes. Graph edges are connected by junction conditions that represent river confluences. This continuous network structure usually has a significant impact on persistence, and occasionally leads to dramatically altered predictions. Persistence analysis of the reaction-diffusion-advection equation is connected to a more complex 'two-stage' integro-differential equation via simple analytic formulas.

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