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How spatial heterogeneity affects transient behavior in reaction-diffusion systems for ecological interactions

Most studies of ecological interactions study asymptotic behavior, such as steady states and limit cycles. The transient behavior, i.e., qualitative aspects of solutions as and before they approach their asymptotic state, may differ significantly from asymptotic behavior. Understanding transient dynamics is crucial to predicting ecosystem responses to perturbations on short time scales. Several quantities have been proposed to measure transient dynamics in systems of ordinary differential equations. Here, we generalize these measures to reaction-diffusion systems in a rigorous way and prove various relations between the non-spatial and spatial effects, as well as an upper bound for transients. This extension of existing theory is crucial for studying how spatially heterogeneous perturbations and the movement of biological species involved affect transient behaviors. We illustrate several such effects with numerical simulations.