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Impact of Dispersal on Total Equilibrium Biomass in Patch-Structured Logistic Models.

Understanding how dispersal asymmetry influences total equilibrium biomass in spatially structured populations remains a key challenge in mathematical ecology. This study extends classical two-patch logistic models by incorporating a mixed dispersal strategy that combines random and density-dependent movement. The dispersal rate from each patch is governed by a fitness function parameterized by dispersal strength and asymmetry ratio. Using geometric phase-plane analysis, specifically the intersection of an ellipse and a hyperbola derived from the equilibrium conditions, we characterize the unique positive equilibrium and prove its global asymptotic stability via Dulac's criterion and the Poincaré–Bendixson theorem. Our results reveal four distinct dispersal regimes based on the position of a limiting hyperbola relative to three critical points on the ellipse. These regimes determine whether total equilibrium biomass increases, decreases, peaks at an intermediate dispersal strength, or crosses the isolated baseline. The framework resolves the so-called Perfect-Mixing Paradox by showing that asymmetry fundamentally alters the relationship between connectivity and total biomass, offering a more complete picture than previous symmetric or purely nonlinear models.