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Global dynamics of a competition model with non-local dispersal I: The shadow system

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ABSTRACT

Equations with non-local dispersal have been widely used as models in biology. In this paper we focus on logistic models with non-local dispersal, for both single and two competing species. We show the global convergence of the unique positive steady state for the single equation and derive various properties of the positive steady state associated with the dispersal rate. We investigate the effects of dispersal rates and inter-specific competition coefficients in a shadow system for a two-species competition model and completely determine the global dynamics of the system. Our results illustrate that the effect of dispersal in spatially heterogeneous environments can be quite different from that in homogeneous environments.

1. Introduction

Dispersal of organisms, by which a species expands its range, is a central topic in biology and ecology. The evolution of dispersal has attracted attentions from both theoretical and empirical biologists for several decades. There are many forms of dispersals. The simplest type of dispersal is probably random diffusion, which describes the movement of organisms between adjacent spatial locations. Random dispersal can be approximated by reaction–diffusion models; see [1,25,26,32] and references therein. However, random dispersal is too simplistic to describe the movement of many organisms. Another type of dispersal, assuming that organisms can travel for some distance, is called non-local dispersal. Non-local dispersal describes the movements of organisms between non-adjacent spatial locations. We refer [2–5,7,11,15,16,19,20,30,31] and references therein for more details.

The purpose of this paper is to understand the population dynamics of both single and two competing species models with a simplified non-local dispersal in heterogeneous environments, which is mathematically more tractable.

1.1. Motivations

To motivate our discussions, consider the non-local dispersal operator [13]

$$\mathcal{L}u := d\left[\frac{1}{L}\int_{-\infty}^{\infty} k\left(\frac{x-y}{L}\right)u(y)\,dy - u(x)\right], \tag{1}$$

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