Biological Invasions (2006) 8: 241–254
DOI 10.1007/s10530-004-5573-8

Boats, pathways, and aquatic biological invasions: estimating dispersal potential with gravity models

Brian Leung[1,2,]*, Jonathan M. Bossenbroek[1] & David M. Lodge[1]
[1]*Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556, USA;* [2]*Present Address: Department of Biology & McGill School of Environment, McGill University, Montreal, QC, Canada H3A 1B1;* **Author for correspondence (e-mail: brian.leung2@mcgill.ca)*

Received 23 March 2004; accepted in revised form 28 October 2004

Key words: dispersal, exotic, invasive species, gravity model, non-indigenous, risk

Abstract

Biological invaders can have dramatic effects on the environment and the economy. To most effectively manage these invaders, we should consider entire pathways, because multiple species are dispersed through the same vectors. In this paper, we use production-constrained gravity models to describe movement of recreational boaters between lakes – potentially the most important pathway of overland dispersal for many aquatic organisms. These models are advantageous because they require relatively easily acquired data, hence are relatively easy to build. We compare linear and non-linear gravity models and show that, despite their simplicity, they are able to capture important characteristics of the recreational boater pathway. To assess our model, we compared observed data based on creel surveys and mailed surveys of recreation boaters to the model output. Specifically, we evaluate four metrics of pathway characteristics: boater traffic to individual lakes, distances traveled to reach these lakes, Great Lakes usage and movement from the Great Lakes to inland waters. These factors will influence the propagule pressure (hence the probability of establishment of invasive populations) and the rate of spread across a landscape. The Great Lakes are of particular importance because they are a major entry point of non-indigenous species from other continents, hence will act as the origin for further spread across states. The non-linear model had the best fit between model output and empirical observations with $r^2 = 0.80$, $r^2 = 0.35$, $r^2 = 0.57$, and $r^2 = 0.36$ for the four metrics, respectively. For the distances traveled to individual lakes, r^2 improved from 0.35 to 0.76 after removal of an outlier. Our results suggest that we were able to capture distances traveled to most but not all lakes. Thus, we demonstrate that production-constrained gravity models will be generally useful for modeling invasion pathways between non-contiguous locations.

Introduction

Invasions by non-indigenous species are a major driver of global environmental change. Invasive species have the potential to reduce global biodiversity, affect entire ecosystems (Sala et al. 2000; Lodge 2001) and impose high economic damages (Pimentel et al. 2000). Thus, it is critical to forecast where invasions will take place and to identify areas that act as major sources for further invasions to focus our management efforts and to reduce the probability of invasion or the rate of spread.

To identify areas to focus management, we need models of species dispersal – one of the major components of the invasion process. Arguably, we should focus on pathways. While analyses of specific single species are important and