Resource and Energy Economics 32 (2010) 566–585

Contents lists available at ScienceDirect

Resource and Energy Economics

journal homepage: www.elsevier.com/locate/ree

Spatial economic analysis of early detection and rapid response strategies for an invasive species

Brooks A. Kaiser [a,b,*], Kimberly M. Burnett [c]

[a] Dept of Economics, Gettysburg College, Box 391, 300 N Washington Street, Gettysburg, PA 17325, United States
[b] Dept of Economics, University of Hawaii, 2424 Maile Way Saunders Hall 542, Honolulu, HI 96822, United States
[c] University of Hawaii Economic Research Organization, University of Hawaii, Manoa, 2424 Maile Way Saunders Hall 540, Honolulu, HI 96822, United States

ARTICLE INFO

Article history:
Received 15 November 2007
Accepted 2 April 2010
Available online 18 April 2010

JEL classification:
Q20
Q51
Q57

Keywords:
Invasive species
Spatial analysis
Early detection and rapid response
GIS
Brown treesnake
Hawaii

ABSTRACT

Economic impacts from invasive species, conveyed as expected damages to assets from invasion and expected costs of successful prevention and/or removal, may vary significantly across spatially differentiated landscapes. We develop a spatial–dynamic model for optimal early detection and rapid response (EDRR) policies, commonly exploited in the management of potential invaders around the world, and apply it to the case of the Brown treesnake (*Boiga irregularis*) in Oahu, Hawaii. EDRR consists of search activities beyond the ports of entry, where search (and potentially removal) efforts are targeted toward areas where credible evidence suggests the presence of an invader. EDRR costs are a spatially dependent variable related to the ease or difficulty of searching an area, while damages are assumed to be a population-dependent variable. A myopic strategy in which search only occurs when and where current expected net returns are positive is attractive to managers, and, we find, significantly lowers present value losses (by $270 m over 30 years). We find further that in the tradeoff between search costs and damages avoided, early and aggressive measures that search some high priority areas beyond points of entry even when current costs of search exceed current damages can save the island more ($295 m over 30 years). Extensive or non-targeted search is not advised however.

* Corresponding author. Tel.: +1 717 337 6670.
E-mail address: bkaiser@gettysburg.edu (B.A. Kaiser).

0928-7655/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.reseneeco.2010.04.007

1. Introduction

Management of invasive species presents spatial and temporal analytical challenges that require integrated biological and economic modeling. An invasive species may be intercepted or treated across the invasion timeline: before entry to a new location (prevention), shortly after introduction but before establishment (early detection and rapid response, EDRR), by restricting it to a location smaller than the potential host range after establishment (containment), by restricting a population through harvest (control), or by allowing it to become part of the ecosystem (adaptation). Clearly, there are certain complementary and substitutable activities across this spectrum, but hitherto, applied research integrating optimal management of invasive species generally has not accounted for EDRR or spatial variation. This has kept the focus clearly on the important intertemporal tradeoffs in invasive species management (Burnett et al., 2006, 2008; Finnoff et al., 2007; Olson and Roy, 2005). However the addition of a spatial dimension has been shown to change optimal policy for control efforts when marginal costs of control include a cost of search, increasing the steady state level of a controlled invader as the spatial unit of analysis decreases (Burnett and Kaiser, 2007), and therefore must be explicitly included in any EDRR analysis.

In this paper, we exploit the significant biological and economic research to date on the potential ecological and economic damages and costs of a particularly well-studied species of significant concern, the Brown treesnake (*Boiga irregularis*).[1] The Brown treesnake's imminent arrival in Hawaii (Rodda et al., 1992, 1999; Burnett et al., 2006; Shwiff et al., 2010) provides an excellent case study to develop a spatially explicit, comprehensive dynamic EDRR management strategy to minimize the expected impacts of a potential invader. We contribute to the current literature in several respects, with a chief goal being to evaluate real-world invasive species management decisions in a bioeconomic framework. First, we consider EDRR, a real-world policy instrument commonly exploited in the management of potential invaders around the world, although not explicitly analyzed as a policy option in the literature to date. Second, we attempt to mimic real decisions facing managers with long-run dynamic consequences by examining decisions made across brief time horizons and assessing the impact of this constraint. Finally, our work expands, using real world data, the findings of Finnoff et al. (2007) that managers should prefer prevention to control even when their risk preferences lead them to wait for an invasion before treating. To do this, we ask whether a myopic policy under which only locations where the expectation is that current benefits outweigh current costs are searched is preferable to a strategy where more aggressive EDRR occurs so that certain locations are searched even when current net benefits may be negative.

EDRR, defined here as intervention that occurs shortly after introduction but before there is a known population in a new location, consists of search activities beyond the ports of entry, where search (and potentially removal) efforts are targeted toward areas where credible evidence suggests the presence of an invader. EDRR should not be simply considered either ex-post prevention[2] or low-population control (though both are components of EDRR) and deserves much greater analytical attention. This is due to the need to make decisions based on the possibility that a specimen is present across many possible locations.

Our paper is a first step in formally modeling EDRR as an invasive species management tool. In order to concentrate on the combination of spatial and temporal components and the comparison of real-world myopic policy to optimal policy, we set aside virtually all uncertainty, using a deterministic representation of expected outcomes of a new invasion based on estimated population growth, costs of search treatments, and damages. As such, we can concentrate on the benefit EDRR adds to the management strategies of prevention and/or control, given a new invasion. Inspection, barriers around ports of entry, or any other action taken to avoid invasion is typically thought of as prevention. Prevention differs from EDRR particularly as the opportunities for reaping high returns are foregone once a species has successfully

[1] The Brown treesnake is one of fewer than ten species causing damage outside its home range that has specific US Federal Legislation passed to fund efforts to prevent its spread (Public Law 108–384, the Brown Tree Snake Control and Eradication Act of 2004). The focused nature of its current 70-year invasion in Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and more than 10 years of interdisciplinary conversations between economists, ecologists, herpetologists and land managers provides a wealth of scientific data about potential damages and control methods.

[2] We use the term ex-post prevention to describe interception of newly arrived specimens outside the purview of standard interceptions at points of entry.