Bioeconomics of Invasive Species

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1 Overview of the Field

Over the last seven years the National Science Foundation funded Integrated Systems for Invasive Species (ISIS) research group has worked to integrate economic, ecological and mathematical theory for responding to the risks from biological invasions. One of the products of this work will be an edited book, to be published by the Oxford University Press, titled "Bioeconomics of Invasive Species: integrating ecology, economics, policy and management". The four workshop attendees are the editors of this book, and the workshop at BIRS was to review and respond to draft chapters from other authors, and to write introductory and conclusion chapters. The workshop met each of these aims.

2 Background to project

Biological invasions occur when species are introduced to regions beyond their native range, establish large populations, and cause undesirable impacts to human health, the environment, or economic systems. Recent research reveals that biological invasions are one of the strongest drivers of global environmental change. Invasive species are now often in the public discourse. At the same time, economists have begun to take a real interest in determining how invasive species interact with economic systems, and how invaders should be controlled to optimize societal welfare. Although each of these bodies of work has greatly expanded our understanding of the impacts of invasions, little integration between economics and ecology has occurred that would allow managers and policy-makers to identify the optimal expenditures on, for example, prevention and control of invasive species. Because the level of effort expended on invasive species management is intricately linked to the costs and projected benefits of that management, there is an urgent need for greater synthesis between ecology and economics.

The ISIS group came together largely as a result of our common interest in the bioeconomics of invasive species in freshwater ecosystems. Many of us have worked in the Laurentian Great Lakes region, which is arguably the most studied ecosystem in the world with respect to the ways that economics and ecology combine to determine both the impacts of invasive species on society, and the responses of society to the risks and impacts from invaders. The first serious invader to enter the Great Lakes was the sea lamprey, which gained access after the Welland Canal was constructed. This new waterway was built in response to the economic imperative to allow oceangoing ships access to the lakes. Sea lamprey parasitize larger fish, and this led to the devastation of lake trout populations, which led in turn to declines in opportunities for recreational anglers, and the almost complete loss of the commercial fishery. Government agencies responded by searching for methods to limit the sea lamprey population, and poisons specific to sea lamprey have been developed. These are now applied to lamprey breeding streams at a cost of roughly $16million per year, paid by the U.S. and Canadian governments. In addition to sea lamprey, over 180 other species have invaded the Great Lakes, and their pathways of introduction can be linked to, for example, the aquarium, live food and nursery trades, ballast water of intercontinental ships and intentional release to enhance commercial and recreational fisheries. It is impossible to understand the invasion history of the Great Lakes without considering the economic history of the region. Indeed, the invasion history of all ecosystems is intricately linked to economic factors. Our

book will be the first to present a unified bioeconomic approach for researching and addressing the problems of invasive species.

Our aim throughout the ISIS project has been to develop a synthetic 'bioeconomic' research program for addressing the risks from invasive species. Mathematical biology has been at the heart of this effort for at least three reasons. First, mathematicians have conducted much of the most productive research on invasive species over the last several decades. For example, the development of integro-difference equation applications for predicting the spread of invasive species has contributed greatly to our understanding of species dynamics. These methods are thus essential to any genuinely synthetic approach. Second, although economists and ecologists routinely use complicated modeling approaches, members of either group are generally only familiar with the paradigms of their field. Hence, combining these models into a synthetic approach requires the broader perspective of mathematicians. Finally, both ecological and economic data contain large amounts of uncertainty, and there is a need for more advanced mathematical methods for explicitly dealing with this uncertainty.

We have a number of interconnected aims in preparing and publishing this book. First, we want to cement the role of bioeconomic research as the best approach to designing policy and management systems for invasive species. As society becomes more aware of the problems associated with global environmental change there is an increasing need for environmentally sound, and economically rational, responses. We present such a framework in this book for addressing the impacts of invasive species. No other book that we are aware of presents such an integrated framework for addressing an environmental problem. Hence, we believe that our book will inspire bioeconomic research on issues both within, and beyond, biological invasions.

Second, as well as providing the tools for bioeconomic research, we aim to show scientists how that research can be conducted so that it results in realistic and acceptable policy recommendations. Because the field of bioeconomics is relatively young, there has not yet been a great deal of development beyond theoretical applications. The authors of this book are an exception to this, and we see this book as an opportunity to expand our results, and those of others, more fully into a context that is useful to researchers and society.

Third, we recognize that the greatest potential for encouraging additional bioeconomic research is to make it accessible to junior graduate students and policy-makers. Our book will be written at such a level, and contains sufficient introductory material that ecologists, economists, mathematicians and interested policy-makers and managers will be able to see the merits of and adopt our approach.

2.1 Proposed Table of Contents for "Bioeconomics of Invasive Species" book

Chapter 1: Introduction to Biological Invasions: Biological, Economic, and Social Perspectives.
Chapter 2: Integrating Ecology and Economics to Guide Risk Management.
Chapter 3: Trait-Based Risk Assessment for Invasive Species.
Chapter 4: Forecasting Suitable Habitat for Invasive Species Using Ecological Niche Models and the Policy Implications of Forecasts.
Chapter 5: Propagule Pressure and Establishment.
Chapter 6: Estimating Dispersal and Predicting the Distribution of Invasive Species.
Chapter 7: Uncertain Invasions: A Biological Perspective.
Chapter 8: Uncertain Invasions: A Bioeconomic Perspective.
Chapter 9: Risk Perception and Communicating the Risk of Invasive Species.
Chapter 10: Modeling Integrated Decision-Making Responses to Invasive Species.
Chapter 11: Bioeconomics of Species Invasions in the Laurentian Great Lakes.
Chapter 12: A Case Study on Rusty Crayfish: Interactions Between Empiricists and Theoreticians.
Chapter 13: Advances in Ecological and Economical Analysis of Invasive Species: Zebra Mussel as a Case Study.
Chapter 14: Putting Bioeconomic Research Into Practice.