# FOREWORD
# Special Issue on Invasive Species

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Invasive species are non-native organisms that can cause economic, environmental, or human harm. Invasive species can alter the ecosystem balance, threatening the survival of indigenous species and impairing the ability of natural and managed ecosystems to provide services of significant economic value. Damage from just six exotic invasive species has been estimated at $74 billion. Mitigation often requires increased use of pesticides, which may adversely affect beneficial organisms, water quality, and human health. The cost of mitigation measures can also be high and often is paid with tax dollars. For example, USDA's Animal and Plant Health Inspection Service increased its annual spending on emergency eradication programs more than twenty-fold during the 1990s—to $232 million from $10.4 million. Due to these impacts, trade instruments and other border measures are often used to avoid the introduction of such species.

This special issue of the *Agricultural and Resource Economics Review* contains papers from a workshop focused on invasive species issues that was held in Annapolis, Maryland, on June 14–15, 2005, following the annual meetings of the Northeastern Agricultural and Resource Economics Association. The U.S. Environmental Protection Agency, USDA's Economic Research Service, and the Farm Foundation co-sponsored the workshop. Current theoretical models and research findings were presented with an emphasis on understanding the relationship between trade, exotic species invasions, and natural and managed ecosystem functioning; developing methodologies that connect biology, ecology, and economics so that the complexity of agricultural or natural systems is recognized in the evaluation of existing and potential preventive, mitigation, and eradication policies; assessing the potential benefits and costs of alternative institutional arrangements for establishing and implementing invasive species policies at the national and international levels; and identifying key research needs and future research collaborations. In addition to the workshop papers, this special issue includes two literature reviews covering terrestrial and aquatic invasive species.

Ecologist Daniel Simberloff explains how difficult prevention is as biological organisms move autonomously, reproduce, evolve, and interact with other organisms. Estimating the impacts is difficult due to the lack of data about these factors. He argues that the blacklist policy of the United States is not working. He concludes that to stem the flood of invasive species into and within the United States would require blacklists, a white-listing procedure, and tighter regulation of pathways.

Jason Shogren provides an overview of his work on the biological and economic problems of managing invasive species. Issues include prevention versus control, uncertainty and investment in control measures, dynamics, risk aversion, economic growth, and the political economics of trade policy. He and co-authors David Finnoff, Chris McIntosh, and Chad Settle review integration (combining biological and economic models) and valuation (assigning value to non-market phenomena). They argue that valuation should be based on the integration models.

Several papers explore issues related to the prevention and control of invasive species, drawing implications for policy decisions and resource allocations. The paper by Kimberly Burnett investigates the level and funding of invasive species prevention and control as a "weaker link" public good given incomplete information. She finds that there will be underinvestment in prevention

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unless complete information about the cost of provision and other factors are known. C.S. Kim, Ruben Lubowski, Jan Lewandrowski, and Mark Eiswerth explore factors that affect the optimal allocation of resources between exclusion and control given an uncertain discovery date. Before invasion, prevention is favored. After discovery, if the pest population is below a threshold level, both control and exclusion measures should receive resources; if the pest population is above this threshold, then control activities are more efficient. Joe Moffitt and Craig Osteen also look at resource allocation issues given uncertainty about invasion threats between prevention and control. They examine decision rules based on the minimax and relative cost criteria in order to express a cautious approach for decisions regarding severe, irreversible consequences. They also apply a simple rule to develop a list of priority plant pests. Erik Lichtenberg and Lori Lynch examine pest-free status certification and how this impacts exclusion, eradication, and control decisions for a region. Pest free status certification is desirable if the demand-side impacts (increased export revenue) and supply-side impacts (lower pest damage and decreased ongoing control costs) exceed the compliance monitoring and eradication costs. Certification is more likely for regions facing costly treatment requirements (i.e., bans on exporting) or possessing geographic traits that lower monitoring costs and infestation probabilities than it is for those regions exporting higher valued products.

Many of the papers in this issue use models and simulation techniques to examine an existing or threatening invasive issue. The paper by Kimberly Burnett, Brooks Kaiser, Basharat Pitafi, and James Roumasset examines policy outcomes for an existing invasive plant in Hawaii that reduces biodiversity, soil cover, and water quality, and they examine an imminent threat of an invasion by the Brown treesnake which could result in native bird extirpations, power outages, and health costs. The optimal level of prevention and/or control is simulated under assumption of prevention and control costs and lost ecosystem services given assumed population levels. Their results coincide with the theoretic results in the paper by Kim, Lubowski, Lewandrowski, and Eiswerth cited above. Marjolaine Frésard and Jean Boncoeur use a bioeconomic model to study the common scallop fishery of the Bay of St-Brieuc (in France), where a slipper-limpet invasion is competing for space. Their model combines the dynamics of the two competing stocks and finds that when an industry begins a control program has a large influence on the overall economic results. The paper by Zishun Zhao, Thomas Wahl, and Thomas Marsh develops a conceptual bioeconomic framework that integrates dynamic epidemiological-economic processes to analyze the effects of invasive species introduction on decision making in a livestock sector (e.g., production and feeding). They simulate different scenarios of foot-and-mouth disease to demonstrate the usefulness of the framework in facilitating invasive species policy design. Robert Johansson, Michael Livingston, John Westra, and Kurt Guidry simulate the impact of different Asian soybean rust treatment options, as Asian soybean rust had invaded nine U.S. states by 2004. Give new farm survey data on management practices and geographic distribution of the fungus, they find larger economic impacts than previous research has indicated. Rust infestations will likely result in reduced soybean production, reduced exports, and higher prices. Jeffrey Prestemon, Shushuai Zhu, James Turner, Joseph Buongiorno, and Ruhong Li examine the consequences of a widespread, successful Asian gypsy and nun moth invasion in U.S. forests under current policies and of trading partner responses. Trade liberalization is found to have a negligible effect on U.S. imports of Siberian logs, the possible source of the moths, and thus, on the risk of a pest invasion. Although unlikely, a successful and widespread pest invasion is found to have large effects on producers and consumers. Alexander Macpherson, Rebecca Moore, and Bill Provencher use a different dynamic modeling approach (principal-agent model) to examine the invasion of Eurasian watermilfoil spread by boaters. They find that the optimal management policies vary by the designated management objectives: maximizing boater welfare (economic objective) and minimizing milfoil spread (ecological objective).

Two papers use data to assess the impacts of invasive species on housing prices in a New Jersey community and on land use decisions in southern Mexico. Thomas Holmes, Elizabeth Murphy, and Kathleen Bell find a negative effect on housing prices in a New Jersey community due to an exotic forest insect—the hemlock woolly adel-

gid. In addition, negative spillover impacts from hemlock decline were found on neighboring properties. The results give some indication of the benefits of potential control programs and strategies. Laura Schneider and Jacqueline Geoghegan focus on the linkages between an invasion of bracken fern and land use decisions in an agricultural frontier in southern Mexico using data from a small household survey performed in the region in 2002. An agricultural household model of land use choices examines the decision of a subsistence farmer to either continue cultivating an invaded agricultural plot or permanently abandon the plot and cultivate elsewhere.

Lars Olson reviews the literature on the economics of terrestrial invasive species. He summarizes a number of recent studies that assign values to the economic impact of terrestrial invasive species on a national scale. He also examines the economics literature on control and prevention of a biological invasion and the literature on international trade and trade policy with invasive species. Sabrina Lovell, Susan Stone, and Linda Fernandez review the literature on the economics of aquatic invasive species. They review both empirical papers that present cost estimates as well as theoretical papers on preventing and mitigating the impacts of aquatic invasive species. Species-specific estimates are included for both animals and plants.

## Where Do We Go from Here?

At the end of the workshop, a brief discussion ensued as to the gaps, further research needs, and challenges in this area of research. In short, workshop participants agreed that significant challenges remain for economists and other researchers in expanding models and analytic tools to address this complex topic. Research extensions mentioned include the following:

- expand models from single species to multiple species
- include spatial and dynamic dimensions, i.e., rate and extent of spread
- incorporate the simultaneity of policy instruments available for prevention and control
- expand trade models to include a matrix of pathways from infested to noninfested areas/countries and compare the best-case scenario with the Nash equilibrium
- address differences within the research community regarding alternative objectives, such as maximizing welfare versus minimizing threat or spread
- incorporate more complex ecological systems into economic models
- enhance understanding of the behavioral reaction to low probability but high loss events
- design models to address decision making under uncertainty
- assess the impact of human behavior on the spread of invasive species
- incorporate research from other disciplines, such as public health and epidemiology, into economic models
- identify characteristics that define "successful versus unsuccessful" control and/or eradication programs