Invasive Species

With climate change and increasing globalisation of trade and travel, the risks presented by invasive pests and pathogens to natural environments, agriculture and economies have never been greater, and are only increasing with time. Governments world-wide are responding to these increased threats by strengthening quarantine and biosecurity. This book presents a comprehensive review of risk-based techniques that help policy makers and regulators to protect national interests from invasive pests and pathogens before, at and inside national borders. Selected from the research corpus of Australia and New Zealand's Centre of Excellence for Biosecurity Risk Analysis, this book provides solutions that reflect scientific rigour coupled with practical, hands-on applications. Focussing on surveillance, stochastic modelling, intelligence gathering, decision making and risk communication, the contents combine the strengths of risk analysts, mathematicians, economists, biologists and statisticians. The book presents tested scientific solutions to the greatest challenges faced by quarantine and biosecurity policy makers and regulators today.

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Invasive Species

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Foreword

Towards Evidence-Based and Risk-Weighted Strategies for Biosecurity

Globalisation has radically increased the magnitude and scale of the human-mediated movement of species. Species' ranges are no longer defined by natural dispersal mechanisms and biogeographical barriers. International travel and commerce have developed new trade routes, markets and products, and rapid climate change and associated factors continue to shape existing pathways and open new ones (Essl et al., 2015). The overall extent and magnitude of impacts is increasing rapidly, as is the diversity of types of impact and problems associated with the framing of issues and implicit assumptions regarding impacts of biological invasions (Essl et al., 2016).

The interest in understanding and managing the phenomenon of biological invasions has exploded in recent decades. Charles Elton's 1958 book *The Ecology of Invasions by Animals and Plants* is widely acknowledged as the starting point for focussed scientific attention on biological invasions (Richardson & Pyšek, 2007). In the 1980s, a major international programme under the auspices of the Scientific Committee on Problems of the Environment (SCOPE) was the impetus for a major upsurge in interest in invasions. Substantial progress has been made in understanding the 'nuts and bolts' of biological invasions (Richardson, 2011b). Despite many advances in invasion science, however, the magnitude and complexity of problems associated with biological invasions continue to escalate in all parts of the world (Richardson, 2011a).

The applied side of invasion science has morphed into the domain of *biosecurity* in which biogeography and ecology are important but where economic and socio-political issues increasingly dominate agendas (Figure 1). Biosecurity is a relatively new term, entering the scientific lexicon only in the late 1980s and the *Oxford English Dictionary* in 2005 (Hulme, 2012a). Various definitions exist, but in its broadest sense biosecurity covers 'all activities aimed at managing the introduction of new species to a particular region and mitigating their impacts should they become established…, [including] the regulation of intentional (including illegal) and unintentional introductions and the management of weeds and animal pests by central and local government, industry and other stakeholders' (Hulme, 2012a, p. 304). Emerging biosecurity strategies typically include international treaties and standards, cooperative efforts, inspections in host countries and at ports of entry, quarantine, intelligence and treatment of shipments (Elferink & van der Weijden, 2011).

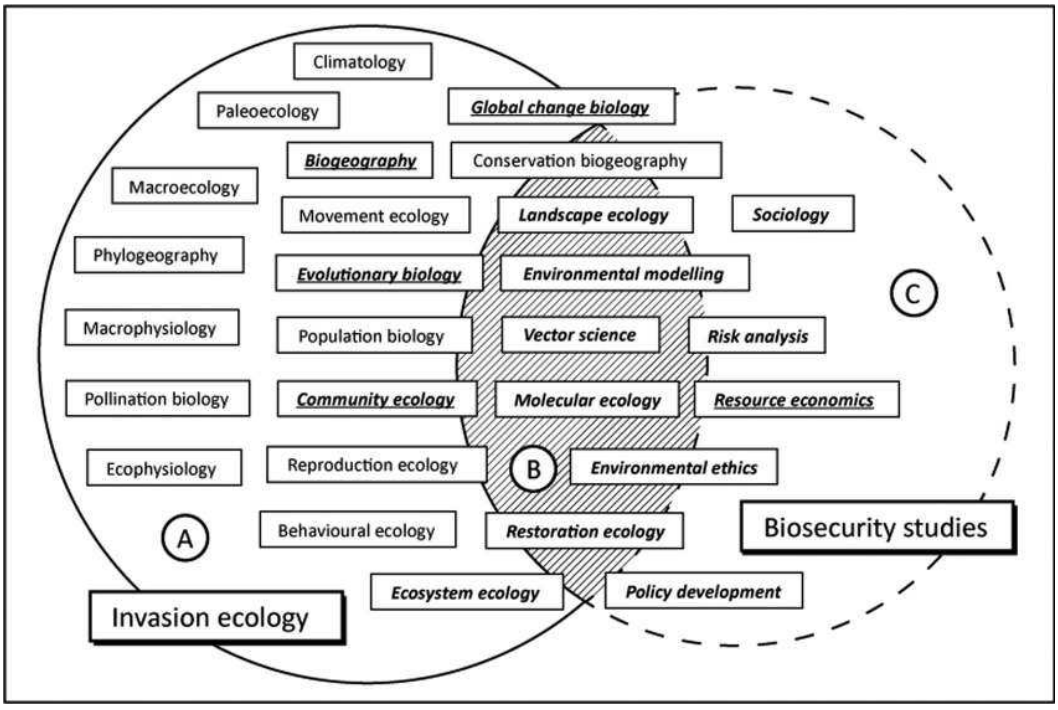

Figure 1. Fields of research on issues relating to biological invasions (the main fields are underlined). Research in fields at the left of the diagram (zone A) are largely those that produce systems knowledge; those closer to and within zone B produce target knowledge; and those within zone B and into zone C largely comprise transformation knowledge. Boundary management occurs towards the right of the diagram (see text for details). Zones A, B and C together define the domain of invasion science.
[Reproduced, with permission, from Richardson (2011b).]

Most countries have legislation and policies aimed at biosecurity, but the magnitude of the problem is so large and the challenges of dealing with all the many interacting drivers of biological invasions are so daunting that only a few wealthy countries are devoting anything near the resources required to systematically reduce the rate and impacts of biological invasions. How much should a country spend to reduce problems associated with invasive species? The economics of preventing invasions is receiving much attention. Results of several studies suggest that expensive interventions are justified (e.g. Leung et al., 2002; Keller et al., 2007; Williams et al., 2010), but other authors question whether currently applied risk assessment methods are accurate enough to achieve their aim (e.g. Hulme, 2012b). A key aspect of the complexity relates to pathways of introduction and dissemination of non-native species. In most cases, we simply know too little about introduction pathways to apply effective management (Essl et al., 2015). Even where we do know the most important pathways, implementing effective interventions is becoming increasingly complicated. For example, the World Trade Organization requires that any trade

restrictions invoked for biosecurity purposes must be science based, and should be 'least trade restrictive' (Shine et al., 2000). The science on which to base decisions on achieving a balance between 'least trade restrictive' and what is most effective to protect people and the environment is still under development. Countries are free to set their own levels of acceptable risk. Substantial work has been done recently to apply the latest advances in risk assessment methods in the biosecurity arena, but major advances in this sphere are in many cases being thwarted by the inherent complexity of the many interacting processes that mediate progress along the introduction–naturalisation–invasion continuum (Blackburn et al., 2011). The lack of objective criteria for assessing the risk of different categories of impacts has also hindered the formulation of robust policies and protocols (Blackburn et al., 2014). A promising approach in this regard is the Environmental Impact Classification for Alien Taxa (EICAT) framework which proposes using a scheme for evaluation impacts of invasive species that is similar to that applied by the International Union for Conservation of Nature (IUCN) to evaluate the threat of extinction of native species in *The IUCN Red List of Threatened Species* (www.iucnredlist.org/; Hawkins et al., 2015). Widespread adoption of this scheme could pave the way for a standardised approach for reporting impacts, thereby alleviating some of the current problems in the implementation of standards.

This book presents a timely and authoritative review of the fundamental challenges that face us in implementing effective and sustainable biosecurity measures, drawing largely on the particular challenges facing Australia. Contributions deal with state-of-the-art methods that are available to inform objective decision making. These include fundamental assessments to evaluate the quality and value of information, options for predicting distributions of non-native species, models for understanding the dynamics of diseases, cost–benefit analyses for biosecurity decisions, and key requirements for surveillance and monitoring. Of huge importance, and well covered in the book, is the key challenge of ensuring that risks and potential options for biosecurity are accurately communicated to all stakeholders.

I greatly enjoyed reading the chapters in this volume. I have no doubt that the contributions will result in improved management of one of the most challenging problems of our time.

David M. Richardson

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