



Invasive Plants: Ecological and Agricultural Aspects

Edited by Inderjit

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Invasive Species (S. D. County)

When I was young, these hills were grey and sere;
So few attractive bushes flourished here
But now wild mustard, blooming in the spring,
Provides a blaze of golden carpeting.

While in this valley, where was once a gleam
Of water, flowing in a wooden stream,
A vast, extending area is filled
With houses that we, new arrivals, build.

Where chapparal and streamlet once had been,
Invasive species dominate the scene.

Source: Mecking S, van Dunne F (2003) *Blue-green; a collection of poems by Ralph Lewin*. Kluwer Academic Publishers, Dordrecht, The Netherlands. Reproduced with permission from Professor Ralph Lewin, Scripps Institution of Oceanography, University of California, San Diego, CA, USA.

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Preface

The study of plant invasions is the science that attempts to understand causes and consequences of plant introductions outside their native areas. Invasive plants have an impact on global biodiversity and ecosystem function, and their management is a complex and formidable task. The applied aspects of this study include the health and economic impacts of invasions. Although research on plant invasions has progressed remarkably during recent decades, scientists are still looking for answers to basic questions.

This book is organized around the premise that general principles of ecology should be employed to understand invasions. Specifically, this volume attempts to answer the following questions: 1) What are invaders? 2) Can we predict invaders? 3) What are the mechanisms of exclusion of native species by invaders? 4) How can general principles in ecology be used to predict and understand plant invasions? 5) What makes a habitat susceptible to invasions? 6) What agricultural practices influence invasions? 7) What impact will invaders have on ecosystem processes and community structure? 8) What are the causes, mechanisms and consequences of plant invasions? 9) What are the environmental and economic costs of invasion? 10) What management strategies are needed to check invasion?

To answer these questions, contributing authors have provided up-to-date reviews and discussions of invasion-related research involving natural and agroecosystems. Chapter 1 discusses efforts by invasion ecologists to settle on a terminology that will enhance, not obstruct, efforts to understand and manage invasive species. Chapter 2 discusses the past achievement, present research and future directions of plant invasions with special reference to ecological and managerial aspects. Chapters 3–7 contribute towards the better understanding of ecological concepts in terms of predicting invaders, significance of residence time and replication in invasion, and the relationship between plant diversity and invasion. Chapter 8 discusses the invasion ecology with a specific example of *Centaurea diffusa*, an invader to the United States. Chapter 9 discusses the regional approach for the management of invasive plants and their management. Allelopathy as a mechanism for resisting plant invasion is discussed in Chapter 10. Chapters 11–14 discuss the agroecology and management of weed invasion. The economic, social and management aspects are discussed in chapters 15–17.

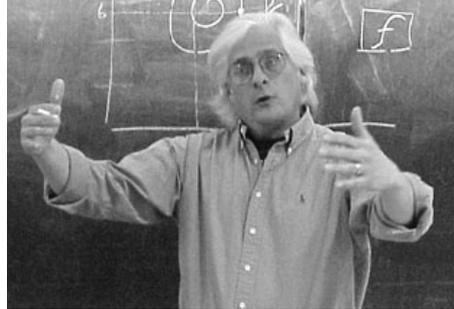
I am grateful to all authors for providing their valuable work to this volume. I appreciate the help and cooperation of Dr. Hans Detlef Klüber and Gabriele Poppen, Editorial Department Biosciences, Birkhäuser Verlag AG. It is my hope that book will serve the scientific community, particularly ecologists, well, and equally hope that the book will stimulate young students to pursue research on plant invasions.

Foreword

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Plant Invasions: Ecological and Agricultural Aspects **Editor: Inderjit**

Nature is comprised of both simple and complex systems. Simple systems are those that are reducible to their component parts, parts whose aggregate behavior fully describes the system. However, simple systems can be complicated, containing a dizzying array of parts. Complex systems, on the other hand, may have few or many parts but possess the salient property of irreducibility. The parts of such systems reveal limited information about the operation of the whole. Such is the case with ecological systems. Ecosystems are the result of a convoluted history driven by the physical environment, species interactions, the dynamics and rules directing those interactions, along with a healthy dose of chance. The nature of nature haunts the observer, making experimentation, prediction and policy difficult to implement, but all the more essential in the face of the ever-growing threat posed by biological invasions.

Yet biological invasions are a fundamental aspect of nature and have occurred ever since life first appeared on the Earth. While invasions typically engender thoughts of noxious creatures colonizing in real time, evolution also produces invaders – genes and phenotypes invade, as do the ecological properties, processes, rules and dynamics that accompany them. Invasion is as integral to the face of nature as any other mechanism or process. Ok then, so what is the problem? The problem is the unprecedented and accelerating rate of species invasions caused by the dissolution of natural impediments to dispersal, barriers subverted by human movement and enterprise. Many invasions are apparently innocuous, but others have devastated ecosystems and caused enormous economic damage. Vast landscapes across the Earth now host non-native species rivaling in number their native counterpart. Invasive plants comprise nearly half the flora of New Zealand and Hawaii and entire ecosystems in Northern California have been simply replaced by their alien counterpart. The threat to biodiversity is real.

Plant Invasions: Ecological and Agricultural Aspects is a welcome addition to the rapidly growing and essential invasions literature. Dan Simberloff (2004)¹ has amusingly noted that the number of recent invasion-oriented book volumes has actually eclipsed the number of some invading taxa; a sobering reflection of the ecological, economic and sociological problems posed by biological invasions. The present volume consists of 17 papers written by international cast of invasions biologists. The editor, Inderjit, a plant ecologist at the University of Delhi, has conceived a volume reflecting both ecological and agricultural aspects of plant invasions. This combination of fundamental ecology, theory and application, creates a powerful intellectual feedback loop that can be exploited to further understand the manner in which invasions are changing the Earth's biological operation.

Within the breadth of contributions presented here, several distinct but cogent themes emerge from the author's collective gestalt. A preeminent thread in this volume is the construction of an intellectual framework that integrates academic ecology and theory, with management approaches and societal realities. All too often interactions between academics, managers, and policy makers are adversarial – a function of perspective. To my mind, chapters in this volume suggest that this perceptual discord is readily mended.

Approaches to predicting invasion success across scales of observation, as a function of species characteristics, ecosystem properties, variation in species residence time before establishment, and anthropogenic effects, form a second theme. The authors clearly call for a mechanistic understanding of species invasions that will form the backbone of any operational and conceptual framework. At some scales of observation each invasion is so unique that generality is unlikely. As pointed out by several authors, including scale in invasions biology appears to be a partial solution to this dilemma. However, the case studies of invasions and control efforts presented here provide such profoundly rich detail that one cannot help but ponder devices to keep the details without losing generality and *vice versa*.

A particularly intriguing focus of several papers is that of modifying or engineering habitat vulnerability to invasion. While this cannot be accomplished on very large scales, it is feasible within the confines of agroecosystems, nature reserves, and particularly vulnerable, but local habitats. At the same time we must also observe the physicians credo – do no damage. Nevertheless, exploring community and ecosystem invasibility may provide that mechanistic, and at the same time phenomenological, substance needed to understand invasions.

Together the chapters presented here highlight the complexity of nature and tell us that we are in for a difficult struggle with respect to biological invasions. A struggle complicated by a growing human population, implicate societal needs and economic skews – all in the face of global change.

¹ Simberloff D (2004) A review of some recent books on biological invasions. *BioScience* 54: 247–253

From the editor

Each chapter included in this book is peer-reviewed by two or more experts in the field. I am indebted to referees for their constructive comments and suggestions, and extend my sincere appreciation for time and effort the following scientists have spent on evaluating each manuscript.

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About the symposium

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Biological invasion is a multidisciplinary field that includes concepts, ecology, conservation biology, sociology and economics to explore the determinants and consequences of the establishment, reproduction and spread of non-native invasive species. Biological invasions constitute a global environmental challenge that attracts the attention of scientists and policy makers across the world. Almost all countries have been actively engaged in evolving strategies that eradicate, prevent, control or contain the alien invasive species. India is invad-



From left to right: Prasanta C. Bhowmik, Hans Lambers, Leslie Weston, Inderjit, John Romeo, Neil Harker and Fakri A. Bazzaz

ed by several alien plant species, and some of them include: *Ageratum conyzoides*, *Chromolaena odorata*, *Eichhornia crassipes*, *Eupatorium adenophorum*, *Ipomoea carnea*, *Lantana camara*, *Mikania micrantha*, *Mimosa invisa*, *Parthenium hysterophorus* and *Prosopis juliflora*. The alien invasive species form a major threat to terrestrial (forest and agricultural) and aquatic ecosystems across the Indian subcontinent, and functioning of these ecosystems is disrupted to such an extent that local vegetation types have vanished. For example, water hyacinth wiped out aquatic vegetation in native waterbodies. The invasion of grassland communities by *Parthenium hysterophorus* has virtually eliminated native grass species of fodder value. Invasion of *Prosopis juliflora* has eliminated native *P. cinererea* from Aravallis. The economic losses include not only in the productivity of these disturbed ecosystems but also in the eradication of these alien invasives and restoration of the ecosystems. In India, for example, annual expenditure in physical removal of water hyacinth alone amounts to several million US dollars.

The Centre for Environmental Management of Degraded Ecosystems (CEMDE) – an interdisciplinary research centre of the University of Delhi that was established in 1991 – is a constituent of the School of Environmental Studies, Faculty of Science, University of Delhi. The CEMDE has been working in areas interfocusing with the environment and ecology with respect to ecosystem functioning and restoration of degraded ecosystems. The centre has also been carrying out research and development programs relating to biological invasions and restoration of biotic communities. An International Symposium on *Ecology of Biological Invasions*, was held at the CEMDE, University of Delhi, in December 2003. The aim of the symposium was to discuss the ecological issues pertaining to biological invasions. Oversea participants included: Fakri A. Bazzaz, Prasanta C. Bhowmik, Neil Harker, Hans Lambers, R. Muniappan, John Romeo and Leslie Weston. Questions raised in the symposium included: 1) Is it possible to predict invasiveness? 2) What are the factors that make the community prone to invasion? 3) What are the functional traits of an invasive species? 4) What factors govern the dominance of invaders in their naturalized range? 5) What long-term changes are expected in the ecosystem as a result of biological invasion? This book includes some papers presented at the symposium and provides an insight on the science of biological invasions. In addition, scientists who could not attend the symposium were invited to contribute their work also to the book, resulting in a complete review of current status of ecological research on biological invasions. The Symposium could not have been possible without the generous financial support from the University of Delhi, Department of Science and Technology, and Council of Scientific and Industrial Research.

December 2004