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A Rising Tide of Species and Literature: A Review of Some Recent Books on Biological Invasions

DANIEL SIMBERLOFF

Biological invasions have recently caught the public's attention, as demonstrated by occasional television and radio reports, almost daily newspaper articles, and a presidential executive order in 1999 that established the National Invasive Species Council. The subject captures the imagination for several reasons. Introduced species cause, in whole or in part, the endangerment and extinction of more species than any other factor except habitat destruction. They cause enormous economic losses. Introduced pathogens are a scourge of human health (e.g., West Nile virus), wildlife (e.g., whirling disease), agriculture (e.g., hoof-and-mouth disease), and forests (e.g., sudden oak death). And the idiosyncratic, baroque, and apparently unpredictable nature of some invasions intrigues scientists and lay citizens alike. The recent exponential increase in books on invasions is thus unsurprising, though it is noteworthy that this surge is actually outpacing that of invasions themselves (figure 1). These works, which include both academic and popular syntheses of the issue, run the gamut from popular accounts of single invasions through technical treatises on management of particular classes of invaders.

Among several recent books that aim to bring the great scope and complexity of biological invasions to a broad readership, two stand out on grounds of scope, accuracy, and literary merit: Yvonne Baskin's *A Plague of Rats and Rubbervines* (2002) and Tim Low's *Feral Future* (2002). Someone wanting to read just one good introduction to the issue should choose one of these.

Low, an Australian wildlife biologist and popular author, focuses on impacts of invaders in Australia and Australian invaders elsewhere. His scholarship and lively prose appeal to lay readers and scientists alike. Treating animals, plants, and microbes of all habitats, he deals with the history, biology, sociology, and politics of invasions of Australia from the pre-historic through the present. A depressingly long series of activities have turned Australia into a hothouse of invaders, and Low assails various Australian government agencies and biologists, as well as private citizens, for having abetted this disaster. Ancestors of the aborigines and other early voyagers

probably brought many species, including some not even recognized yet as introduced, but early European explorers brought even more. Low's chapter on 19th-century acclimatization societies, which were dedicated to the establishment of exotic species, is one of the best treatments of this peculiar but significant source of introductions worldwide; many prominent biologists, the chapter shows, aided those organizations. A recurring theme is that most harmful introductions into Australia were deliberate, and many betrayed breathtaking shortsightedness. His strongest scorn is reserved for CSIRO (Commonwealth Scientific and Industrial Research Organisation) scientists who continue to introduce pasture grasses and legumes (460 species in 39 years in one area alone), many of which become weeds, some (such as fire enhancers) of devastating proportions. Unplanned introductions—from ballast water, for example—are also amply treated, and again government policy is lambasted, as is the reigning assumption that free trade is a net good. Finally, Low discusses in detail how Australian species have engaged in a form of worldwide payback by becoming devastating invaders elsewhere, erecting a striking counterpoint to the common dogma that Eurasian species are at an advantage everywhere because of their long coevolution with humans and their plants, pathogens, and livestock.

Baskin's book is an official project of SCOPE (Scientific Committee on Problems of the Environment), the IUCN (World Conservation Union), CAB International, and GISP (Global Invasive Species Programme). She uses the resultant access to many leaders in introduced species management, policy, and research to great effect. An excellent and experi-

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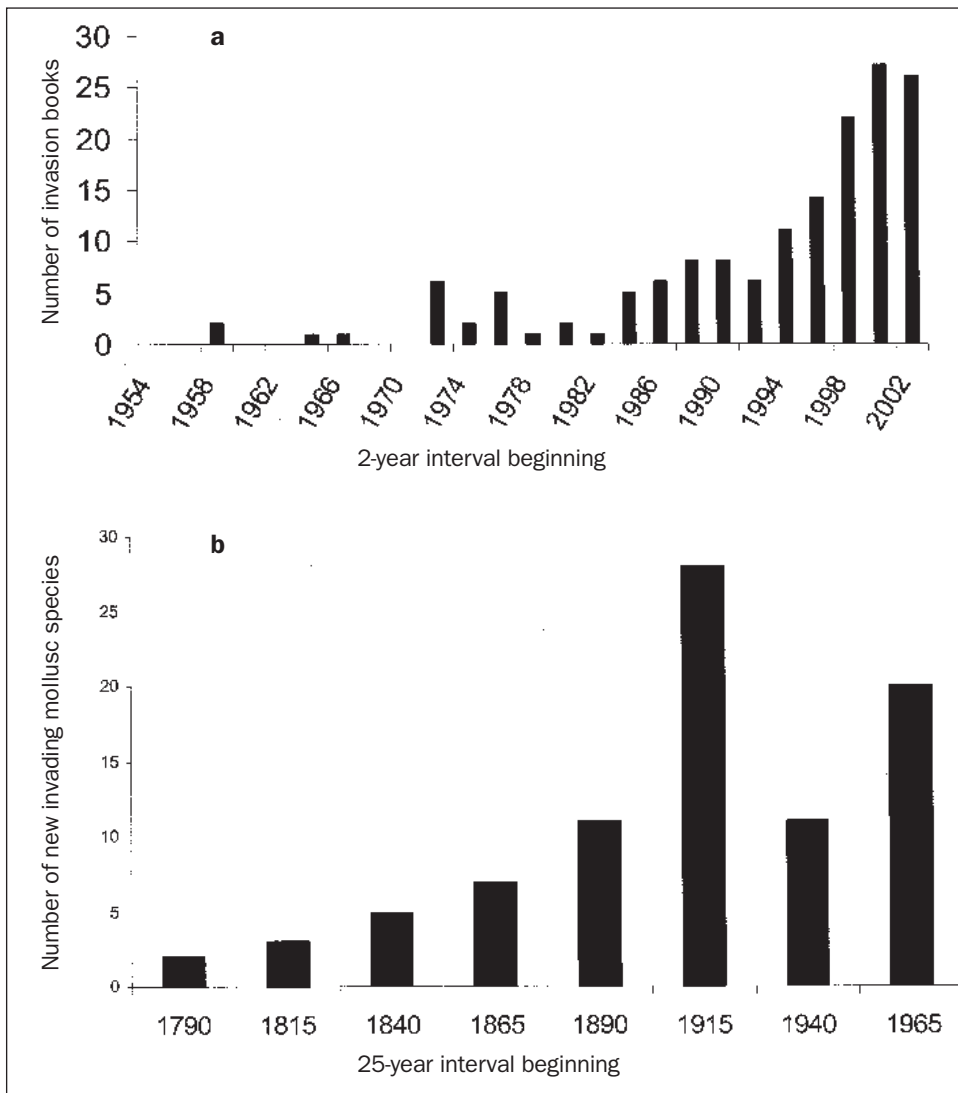


Figure 1. (a) Number of new books (of at least 100 pages) on biological invasions, 1950 through 2003, as determined from relevant subject categories in WorldCat, a worldwide union catalog with over 52 million records. The final bar will grow as the most recent 2003 books are added. (b) Number of newly invading species of terrestrial, freshwater, and estuarine molluscs in the United States between 1790 and 1990. Compiled with data from OTA (1993).

enced science writer, she is able to render technical matters in a clear, engaging style and with a good eye for irony. Also, Baskin shares Low's sharp eye for obscure invasion tales as well as the better-known horror stories.

She enlivens each aspect of the invasion phenomenon by interacting with someone coping with a specific problem—finding insects in internationally transported used cars, understanding why only some species are invasive, and so on. My favorite scene is from a New Zealand mailroom, watching X-rayed turtles and an aromatherapy pillow stuffed with seeds to illustrate the problem posed by the global explosion in trade. Baskin is more optimistic than Low about bringing invasions under control, featuring stories of at least partial suc-

cesses in dealing with particular invaders. It is striking that many of these successes stem from the vision and drive of one person initiating action without much of a plan or budget. (Tellingly, Low also points to lone heroes, but in his case, individuals who noted or predicted such problems could not solve them.) Baskin's description of the South African Working for Water Programme is the best popular account of an inspirational public works project launched by an underdeveloped country to deal with established introductions. She recounts how this effort is sensitizing, energizing, and even employing large numbers of citizens in the battle against invasive plants.

Baskin's optimism is perhaps the basis for her uncritical treatment of biological control. Some problems of nontarget impacts are legendary, such as the many extinctions caused by the small Indian mongoose, introduced for rat control in cane fields, and by the rosy wolf snail, introduced to control the giant African snail. Baskin sees these as largely a phenomenon of the past because of the increased sensitivity of biocontrol practitioners and rigorous host-testing for some species. She is also quite sanguine about the prospects that biological control will work in many cases. Low, by contrast, sees biological control as no magic bullet, but a tool that will provide some modest suc-

cesses but no great victories. Nor does he perceive the problem of nontarget impacts as solved. The statistics on biocontrol success rates and the continued exposure of effects on nontarget effects vindicate his attitude.

Jason and Roy Van Driesche's *Nature Out of Place* (2000) is quite similar to Baskin's book in many ways. Entertainingly written by a father (biological control specialist) and son (writer-naturalist), it juxtaposes visits to invasion sites with technical chapters about most aspects of the introduced species problem. It is thus something of a hybrid between the popular accounts of Baskin and Low and the technical, textbook treatment by biologist George Cox (1999), tending toward the former. The Van Driesches excel at personalizing

both those who fight invaders and those who bond with them, thus clarifying that invasion problems, and possible solutions, result from a complex melange of biology, sociology, and economics. An excellent depiction of the controversy surrounding feral pigs in Hawaii exemplifies the issue, as does another concerning removal of introduced buckthorn in Wisconsin. A chapter on the global history of anthropogenic biological invasions is especially interesting. However, even more than Baskin, the Van Driesches are remarkably optimistic about the prospects of biological control for dealing with established introductions while avoiding nontarget impacts, and they barely consider other approaches.

A final, idiosyncratic introduction to the problem for lay readers deserves mention: Kim Todd's *Tinkering with Eden* (2001), which explores what people were thinking when they deliberately introduced species that ultimately became horrors. Todd, restricting herself to North America and Hawaii, weaves a fairly comprehensive treatment of the entire introduced species issue around a series of such vignettes. Some of these stories are well known to invasion aficionados, such as Eugene Schieffelin's quixotic attempt to introduce all the birds in Shakespeare's poems to Central Park (he succeeded, at least with the starling) and Leopold Trouvelot's introduction of the European gypsy moth to Massachusetts in an attempt to breed a better silkworm. Others are equally intriguing. Many know that Edward McIlhenny, the Tabasco magnate, introduced nutria to Louisiana, but few are aware that Herbert Dozier, director of a federal field station, and Frank Ashbrook, a federal researcher, brought this scourge to Maryland. Or consider William Hamilton Merritt, the Canadian who spearheaded the drive to build the Welland Canal, thus opening the Great Lakes to the sea lamprey. Todd succeeds in exemplifying most aspects of the introduced species problem through these entertaining but chilling stories. In an era in which entrepreneurs are worshipped and regulations vilified, hers is an edifying tale.

Todd won the PEN/Jerard Award for her book while it was a work in progress, and it is interesting that all four of these popular, engaging books are authored (or coauthored) by professional writers. Not so a fifth, the 2000 reprint of Charles Elton's 1958 classic, *The Ecology of Invasions by Animals and Plants*. This bible of invasion biology, written by a leading ecologist of the last century, is an expansion of a series of popular BBC radio broadcasts. Elton vividly sketches the three basic components of invasion biology: the evolution of distinct biotas in isolation, the shattering of that isolation by human trade and travel, and the disastrous impacts of some of this mixing. Many of Elton's examples remain timely, and he foresaw some catastrophic subsequent invasions (for

instance, his concern with fouling organisms and ballast water was prescient). The generalizations in Elton's popular book—such as the high invasibility of disturbed areas—are almost point-by-point the same ones invasion biologists propound a half century later. The only major current topic he did not address is the evolution of invaders in their new homes. That he synthesized the major themes in a way that inspired much of modern invasion biology, while referring to H. G. Wells, Buffalo Bill, Walt Whitman, Charlie Chaplin, and Pieter Brueghel the Elder, indicates that this is no dry specialist's monograph.

None of the popular treatments discuss the interaction of the wave of invasions with the other major global changes—climate change, modified carbon and nitrogen cycles, and altered land use. Not only will these changes affect invasions, but invasions will affect them. Although it is a topic of much recent speculation, the only book that explores this issue in depth is a collection edited by Harold A. Mooney and Richard J. Hobbs (2000), *Invasive Species*

in a Changing World, another SCOPE project. Although this volume is quite technical, several excellent chapters are nevertheless accessible to most readers. Those by Scherer-Lorenzen and colleagues on nitrogen deposition and German plant invasions and by D'Antonio on the interactions among fire, plant invasions, and other global changes are particularly intriguing introductions to complex issues. A weakness is that the introduction and summary chapters by the editors are quite sketchy, which, combined with the somewhat idiosyncratic choice of particular authors and topics, largely leaves to the reader the task of constructing a framework for this enormously complex set of problems. The summary partially remedies this problem and begins to sketch out a research agenda to deal with the interaction of invasion with other global changes, but a more comprehensive, explicit discussion would have been useful from editors of this caliber.

All popular accounts refer to the enormous economic costs associated with biological invasions, under the assumption that knowledge of the economic burden, rather than information on ecological disruptions, would inspire the public and its representatives to try hard to solve this problem. Almost all discussions of this topic in the United States begin (and some end) with an estimate by David Pimentel and colleagues (2000) that the US economy incurs an annual cost of \$137 billion from invasions. This article is reprinted in a 2002 book edited by Pimentel, *Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species*. This volume consists primarily of chapters on the costs of various introduced taxa (especially plants) in Australia, New Zealand, South Africa, and Great Britain. These chapters

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follow no uniform approach and are of remarkably uneven quality and interest, but several, such as those on introduced plants in New Zealand and South Africa, provide compelling accounts of some types of costs associated with invasions. Costs fall roughly into two categories that seem straightforward to estimate in monetary terms—defense (costs incurred in keeping out new invaders and managing those present) and lost production—and a third category that all authors agree is much harder to estimate: ecological costs, such as a degraded natural environment (including loss of species and communities) and consequently diminished human gratification. Various economic techniques to assess this cost (such as estimates based on public willingness to pay) are all deficient. What is needed are standardized approaches toward estimating costs, as part of a comprehensive understanding of the economic aspects of invasions, including the economic forces that drive them, various subsidies and incentives that affect them, and allocation of resources to prevent and manage them.

The closest approach to such a comprehensive treatment is *The Economics of Biological Invasions*, edited by Charles Perrings and colleagues (2000), and it is not very satisfactory. Entire important subjects are untreated, such as multilateral trade treaties that spur invasions and economic incentives that might impede them. Whereas those authors in *Biological Invasions* (Pimentel 2002) who address benefits as well as costs of invasions usually do so as an aside (pointing, for example, to the fact that most major foodstuffs in Europe, North America, New Zealand, Australia, and South Africa are introduced species), in *Economics of Biological Invasions* (Perrings et al. 2000), authors of four case-study chapters on invasions known to many conservation biologists (calicivirus in Australian rabbits, plant invasions in tropical rain forests, nonindigenous plants in the South African fynbos, and Nile perch and other fish species in African lakes) try to estimate at least the short-term costs and benefits of an invasion. These case studies exemplify how complex such estimation is, how much relevant information is buried deep in the gray literature, and how many crucial data gaps exist.

Other chapters attempt more complicated analytic models of invasion cost, but the difficulty of measuring key parameters and the absence of statistical confidence limits for estimates or predictions are disturbing. Uncertainties and complexities involved in estimating and predicting economic costs and benefits greatly complicate the oft-declared difficulty of predicting the ecological trajectory and impact of biological invasions, caused by biological peculiarities, complicated interaction dynamics, and various stochastic factors. A chapter Naylor wrote in *Invasive Species in a Changing World* (Mooney and Hobbs 2000) outlining a framework for economic assessment of invasions is somewhat misplaced in that volume, as the book's focus is on the interaction of

invasions with other global changes, but it is a clear, concise overview statement that would have served well as an introductory chapter in the book by Perrings and colleagues (2000). Similarly, an excellent case study by Zavaleta in the Mooney and Hobbs book, on the cost of ecosystem services damaged by the invasion of *Tamarix* (salt cedar) in the US Southwest, would have fit much better among the case studies in *Economics of Biological Invasions* (Perrings et al. 2000).

A faulty treatment in Perrings and colleagues (2000) by Hill and Greathead on costs and benefits of biological control is mirrored in an otherwise fine chapter by van Wilgen and colleagues in the Pimentel book (2002). The problem is that the

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authors estimate benefit–cost ratios for successful biological control projects only. Most are high, as would be expected for successful projects. However, the much more numerous failed biological control projects are not similarly assessed; nor is the enterprise as a whole.

As Perrings and colleagues note,

this tack is analogous to predicting likely winnings from lotteries by looking only at winning tickets. Worse, there is not a good record of predicting which biological control projects will be successful; almost all of the projects are initially promoted as likely successes, though most end up contributing nothing to control. Furthermore, in neither chapter are likelihood and cost of nontarget impacts predicted, and neither attempts comprehensive benefit–cost analyses for alternative management strategies.

In addition to the general treatments noted above, another set of recent books examines ways to deal with the problem. Invasions can be fought at three points: We can try to keep invaders out; if they nevertheless invade, we can try to find them quickly and eradicate them; and if we fail to eradicate them, we can attempt to manage them at tolerably low densities. Judith Myers and Dawn Bazely (2003) discuss the last two approaches in an interesting, broad treatment of plant invasions. They examine the various quantitative approaches espoused as unifying theories for biological invasions—demographic and life history theory, population and community ecology, epidemiology—and find that, though each approach contributes important information, none is really adequate. Rather, understanding the impacts of specific plant invasions and achieving effective control will require field-oriented case studies. Also notable, given that Myers is a senior biological control specialist, is a modest message about biological control. Myers and Bazely see biological control as the most promising approach for many widespread invasions, but they concede there will be many failures and they discuss some sorts of biological control agents (e.g., seed predators) that they view as unpromising. They also admit that nontarget impacts are still possible, and they detail one that is currently of great concern: The South

American cactus moth *Cactoblastis cactorum*, having arrived in Florida and Georgia after a poorly conceived introduction to deal with the pest *Opuntia* in the Lesser Antilles, has attacked a rare endemic cactus in Florida. Myers and Bazely predict a potential disaster if this insect reaches the southwestern United States and Mexico. Another interesting feature of their book is the use of their own research on diffuse knapweed (*Centaurea diffusa*) to cast doubt on published success rates for biological weed control projects.

Myers and Bazely are downright skeptical that eradication—the complete elimination—of an introduced population can be achieved, except for highly restricted invasions, such as very recent ones or those on very small islands. Two books are considerably more sanguine about the prospects of eradicating introduced plants and animals. The Global Invasive Species Programme, a joint response by SCOPE, IUCN, and CAB International to a plea in the 1992 Rio Convention on Biodiversity to combat invasions, has published *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices* (Wittenberg and Cock 2001). This primer is aimed particularly at policymakers, resource managers, and the public in island nations, but it would be of interest to anyone struggling to find practical means of dealing with invasions. The book has a succinct summary of various strategies for dealing with invasions, illustrated by a wealth of case studies (primarily of successes), among which are eradications of insects, a mammal, a marine invertebrate, and a plant. The ranges of some of these species spanned hundreds of kilometers; others were narrowly restricted. An even greater (and partially overlapping) array of eradication successes is presented in *Turning the Tide: The Eradication of Invasive Species* (Veitch and Clout 2002). This volume focuses on island invaders, though some of the islands on which eradications of such challenging species as rats were successful are thousands of hectares in area.

Four points about the eradications described in these two books stand out. First, scientists and managers are getting better at this, succeeding against ever more widespread invasions and an increasing number of species. New Zealand has even turned eradication of island invasives into an export industry. Second, the panoply of weapons deployed in these eradication campaigns is broad and must be tailored to the target species; chemicals (poisons and baits) and physical methods (hunting, trapping, hand-weeding, etc.) have been heavily and effectively used, but more complicated techniques such as releases of sterile males and pheromonal attractants have played key roles. Third, some failures can be attributed to sociological rather than technological causes. For example, animal rights activists stymied a plan to eradicate the North American gray squirrel in Italy. Finally, even more so than economic support, the fervor of one or a few key individuals is crucial

to eradication. Many projects succeeded in spite of the considerable pessimism of scientists and government authorities.

If eradication fails or is not attempted, maintenance management may at least limit invader populations. There are four general technologies: biological control, chemical control, mechanical (or physical) control, and habitat management. Although Myers and Bazely grant a role for chemical control in the management of introduced plants, they provide few details that could guide a manager. The *GISP Toolkit* (Wittenberg and Cock 2001) gives many such examples, pointing to recurring problems with chemical control (especially expense and the evolution of resistance) but also to advantages and successes.

Even more specific advice is provided by James H. Miller (2003) in *Nonnative Invasive Plants of Southern Forests: A Field Guide for Identification and Control*, a federal document that has the advantage of being free. This book not only includes excellent guides to identifying the main plant invaders

of the southeastern and south-central United States but provides specific information that home gardeners, farmers, and resource managers can use immediately to attack these species. Interestingly, these prescriptions are almost entirely chemical, including specific herbicides, concentrations, and schedules.

Biological control is nowhere mentioned, although some attention is paid to mechanical techniques and habitat management (such as prescribed fire) in conjunction with herbicides.

Miller also lists several useful Web sites offering still more management information, including those of exotic pest plant councils, plus the remarkable Web-based Nature Conservancy handbook (Tu et al. 2001). This handbook assembles, collates, and evaluates a wealth of information (often gray literature or unpublished works) on managing almost all major plant pests. It is probably the first source someone aiming to manage a weed should turn to. Another fine source of information on managing invasive plants is *Invasive Plants of California's Wildlands* (Bossard et al. 2000), also available for free online. A superb chapter by Hoshovsky and Randall introduces the stages at which invasions may be fought and the technologies for doing so. Equally important, this chapter suggests a thoughtful, explicit consideration of any management project's short- and long-term goals and of the prospects for success. The bulk of the book then consists of accounts of 78 nonnative species, with information on identification, history of introduction, habitats, impacts, life history, and how to get rid of those species. The latter sections thoroughly detail experiences with all the technologies, but mostly feature physical, mechanical, or chemical control.

A final excellent book with much information on management is the *Invasive and Exotic Species Compendium* of the Natural Areas Association (Ver Steeg 2002), a CD-ROM

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containing 93 key articles on introduced species published in *Natural Areas Journal* through the end of 2001. Although the journal presents interesting information on various aspects of the invasion problem (especially ecological impacts), it has consistently published important information on management of natural areas, and it was in the vanguard of journals treating invasive introduced species. Articles are indexed not only by species name and region but also by management method, so one can examine series of papers on each of the four maintenance management technologies. These articles are not by chemophobic ideologues: There are 10 papers on biological control, 45 on chemical control, and 53 on mechanical control plus habitat management. Another useful feature of this book is its bibliography of some 1800 papers on introduced species, a collation of the bibliographies of the individual articles. The compendium also has a list of Web sites, which largely overlaps the one in Miller's book.

The first step in managing invaders—keeping them out—is stymied by two distinct problems: deliberate invasions and accidental invasions. Many of the popular treatments (e.g., Todd 2001, Baskin 2002, Low 2002) lambaste the lax attention most governments (New Zealand is a striking exception) afford the former. It is clear that political and economic pressures impede attempts to strengthen regulation of planned introductions, which account for approximately half of all damaging invaders among some taxa. Importers of such commodities as pets, seeds, and horticultural varieties, as well as general free-trade enthusiasts, typically fight enhanced regulation at every turn. Accidental invasions—species hitchhiking on baggage and cargo—present a somewhat different problem, but again the current worship of free trade hinders solutions. As described in *Invasive Species: Vectors and Management Strategies* (Ruiz and Carlton 2003), the majority of such hitchhikers use a finite group of pathways. About half of the chapters in this edited collection detail the pathways for most major invasive taxa, and the rest of them propose ways of constricting these pathways. Some important pathways are not widely known even among invasion biologists. The chapter by Cowie and Robinson, for example, shows that snails move in military equipment, and recent US military involvement overseas has caused a spike in alien snail interceptions on returning military equipment. Similarly, Ribera Siguan describes the huge role that oyster culture plays in spreading nonindigenous marine plants worldwide.

Many authors in both sets of chapters outline ways of reducing pathways, but, as the editors note in a summary chapter, the great majority of these pathways are associated with the expansion of global trade, and the momentum of this expansion will act against the reduction of pathways for accidental invasions, as it will against tighter regulation of planned introductions. Andow's chapter on risk assessment procedures for introduced species clarifies the issues and draws an important distinction between assessments for planned invasions by particular species and assessments of risk posed by particular pathways for masses of species. Along with many other authors, he is skeptical about the former, but he gives

reason for some optimism that the latter sort of assessment can at least indicate the relative magnitudes of threats posed by various pathways. An interesting chapter by Fofonoff and colleagues on the relative importance of transfer of coastal species by fouling organisms and by ballast water is a good example of what might be achieved. Regulating on the basis of such exercises, however, is another matter entirely.

Several governments have published books on the status of the introduced species problem and what to do about it. The classic early effort along these lines, still timely, is by the now-defunct Office of Technology Assessment of the US Congress (OTA 1993). Some national efforts consist largely of lists of introduced species present and speculation about potential impacts, but two go much further.

New Zealand has been a leader (with South Africa, Australia, and the United States) in confronting and publicizing introduced species. In 1993, it passed a comprehensive biosecurity act, and in 2000, the Parliamentary Commissioner for the Environment published *New Zealand under Siege* (PCE 2000a), a review of the problem and of the act's performance in combating it. This appraisal is extremely informative, not least because, instead of just touting the considerable successes of the act, it candidly appraises the various weaknesses and recommends at least partial remedies. Several interesting case studies are included.

Canada has lagged behind these other anglophone nations in responding to invasions (except for agricultural ones), but Natural Resources Canada has begun to catch up with *Alien Invaders in Canada's Waters, Wetlands, and Forests* (Claudi et al. 2002). Featuring an introduction to the international scope of the problem, assessments of the invasion status of many taxa in many Canadian regions, a series of case studies of key invaders (such as the gypsy moth and the green crab), and nine chapters on how to respond to invaders, this book serves as a good introduction to invasion biology and management techniques, as well as a summary of the great scope of the problem in Canada. This book is particularly welcome because it counters the myth, occasionally articulated by scientists and policymakers (e.g., Hämet-Ahti 1983, Nilsson and Ericson 1997), that boreal regions are somehow relatively immune to invasions.

Finally, a recent book by the US National Research Council (2002) explores the frequently noted fact that many aspects of biological invasions have been quite unpredictable. Focusing on plants and plant pests, the authors conclude that predicting whether or not a species will survive and establish is far more tractable than predicting its impact. Climatic simulation models aid in predicting establishment, although species in the introduced range may also affect whether an invader will survive and spread. However, the usual dearth of information on the tremendously complicated web of interactions that determines the impact of a species on its recipient ecosystem renders prediction of impact difficult; the best current predictor is the performance of the same species when introduced elsewhere. The authors are highly circumspect about the current risk assessment procedures used

by the US Animal and Plant Health Inspection Service to regulate some planned introductions. While not ruling out the possibility that quantitative risk assessment for introduced species can become a useful tool, they indict the current framework for its subjectivity, lack of transparency, and absence of replicability. Even were these features remedied, the sheer absence of experimental or observational data on many planned introductions would cast doubt on the accuracy of a quantitative risk assessment.

Several books detail particularly notorious invasions, often for a lay audience. Christopher Lever's *Cane Toad* (2001) is disappointing. Owing to Mark Lewis's 1958 cult film classic, *Cane Toads*, this species is a legendary invader. Lever has assembled an enormous bibliography on it, but his presentation is a largely an undigested string of facts and citations about its many introductions, with little synthesis. More promising is his *Naturalized Reptiles and Amphibians of the World* (2003). In the style of previous books by Lever on introduced birds, mammals, and fishes, this volume is a massive compendium of facts about introduced herptiles worldwide; the bibliography of 1500 entries is a gold mine. Again, there is little synthesis, and the brief introduction on invasion biology does not relate the field to the information subsequently presented in the book. There are some omissions of important information (e.g., almost no mention of failed introductions, of which there are many), but the book is valuable for its comprehensive but brief accounts of the many successes (one is not brief—a 28-page entry on the cane toad that covers all the important material from the earlier book) and for its appendix of successful introductions to each nation.

Eric J. Dolin (2003) was out of the gate remarkably quickly with *Snakehead*, an account of the invasion of a toothy Asian predatory fish species (widely reported—erroneously—to be able to traverse land) whose discovery in 2002 in suburban Washington, DC, triggered a flurry of both local and national news reports. Dolin describes the discovery, the subsequent media circus, and the eradication of this population of an animal that came to be known as “Frankenfish.” In addition to reporting the facts about this species and this invasion, Dolin delves into the sociology of the snakehead fever that gripped the nation for much of 2002, depicting its infiltration into popular culture and tortuous treatment by federal and local politicians. *Snakehead* is entertaining and well-written, but it is disappointing that Dolin did not firmly relate this case to the larger issue of invasions (an issue mostly absent, except for a short introductory chapter) or draw more general insights from the remarkable response.

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A comparable book that goes much further in this direction is Alexandre Meinesz's *Killer Algae*, on the heralded invasion of the northwest Mediterranean by the tropical alga *Caulerpa taxifolia* (the 2001 edition contains an extended postscript on the spread of this species to California and Australia). From the bizarre introduction (aquarium contents from a tank of the Oceanographic Museum of Monaco discarded from a window into the Mediterranean below), through the political and scientific squabbling that kept the governments of France and Monaco from capitalizing on a real opportunity to nip this invasion in the bud, to the current situation (*Caulerpa* has spread along the coasts of Spain, France, Monaco, Italy, and Croatia, causing overgrowth of thousands of hectares of sea grass meadows), Meinesz explores all facets of this tragedy. Having sounded the first alarm and been ignored, he does not mince words on the remarkably ineffective actions of important politicians and scientists. Further, he locates the *Caulerpa* invasion in the larger picture of the ongoing global biotic homogenization, and he details how the politics and sociology of the French scientific establishment caused it to malfunction in this instance and how such a fiasco might be avoided in the future.

My favorite book about a single invader, however, is a rather different enterprise: Tijs Goldschmidt's *Darwin's Dreampond* (1996). Goldschmidt, a student of the role of sexual selection in the famed evolutionary radiation of the hundreds of cichlid fish species in Lake Victoria, conducted his research right at the time the predatory Nile perch was introduced to establish a new fishery. Seeing the very species he was studying going extinct by the dozen, he weaves three stories together in an astonishing, poetic synthesis—a history of the trajectory and impact of this invasion; an exposition of modern conservation biology (including its strengths and weaknesses in confronting a threat such as the Nile perch); and a sometimes painfully intimate and frank account of the everyday life, personal relationships, triumphs, and failures of a scientist conducting intensive fieldwork in tropical Africa.

A more technical account of a particular invasion than the previous ones is *The Brushtail Possum* (Montague 2000), a collection of 25 papers on all aspects of the worst invader of one of the most invaded nations. The Australian possum was introduced to New Zealand in 1858 and for several years thereafter by private individuals and acclimatization societies seeking to redress the perceived paucity of the native fauna with a new furbearer. After controversy beginning in the 1920s over damage to forests, the 1940s saw a radical government attitude adjustment, and various means were attempted to stem this plague (densities reach 25 per hectare).

The possum not only damages forest plants by folivory, ground browsing, and trampling but also preys on adults, chicks, and eggs of native birds; it is the major reservoir for bovine tuberculosis. As might be expected in a nation that leads in managing introduced species, New Zealand scientists have learned an enormous amount about the biology of this species and have evolved a variety of techniques to control it. Unfortunately, none of these techniques have solved the problem. The most effective, the poison 1080 (sodium monofluoroacetate), which causes death by respiratory depression and cardiac failure, is increasingly unacceptable to many citizens primarily because it is perceived as inhumane, and because it has impacts on some nontarget species. A number of proposed alternatives, including classical biocontrol and fertility manipulation, have become conflated in the public mind with genetic engineering and are opposed on these grounds. The complicated sociology of this issue, including the activities of environmental organizations, animal rights groups, and opponents of genetic engineering, is insightfully depicted in *Caught in the Headlights: New Zealanders' Reflections on Possums, Control Options and Genetic Engineering* (PCE 2000b). Management of many introduced species is complicated by public perceptions of possible methods, and this book is a valuable primer for any manager dealing with this issue.

The curve of figure 1a raises the question of when, or whether, the flood of invasion books will cease. Many biological curves that initially show exponential growth eventually become sigmoidal and approach an asymptote. For instance, for introduced species, both population size and the square root of occupied area follow this form. However, there are roughly 7,000,000 species (not counting microorganisms) worldwide, of which, for example, the continental United States so far has only about 7000 nonnative species (compared with about approximately 200,000 natives). Further, there is a well-known time-lag phenomenon in invasions—"sleepers" appear innocuous for decades before their populations explode, spread, and wreak havoc. It seems likely that the invasion book industry will flourish for a long time to come.

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