

ated assortative mating, and the effects of floral traits on pollen movement. The book ends with a chapter by N. M. Waser on pollinator behavior and plant speciation (Chapter 16). Waser eloquently shatters the “ethological isolation paradigm” providing a succinct synthesis surrounding not the specialization of pollination systems (as has been hinted at in many previous chapters) but, rather, the “generalization and opportunism” involved in pollination systems and how these traits may influence angiosperm speciation.

The strengths of this book are many. Foremost among them is the diversity of floral forms and pollinating agents addressed (e.g., bats, hummingbirds, honey bees, bumblebees, beetles, flies, and butterflies and moths). I could detect no taxon bias. Further, Chittka and Thomson took care to choose contributors from North America, Europe, and Asia. In addition, they were not biased towards “eminence”; contributors spanned from those early in their careers, such as R. Raguso, to eminent pollination ecologists, such as L. D. Harder and N. M. Waser. And on a technical note, the chapters were clearly written and edited, with especially informative figures and tables.

Despite these strengths, the work suffers from two major weaknesses. First, Chittka and Thomson left out a current major field of pollination biology—that of plant-pollinator-herbivore interactions. Plant traits are likely molded not only by pollinators but also by other visitors, such as herbivores. Numerous recent works have addressed how pollinators respond to plants before, during, and after herbivore damage and the effects these changes have on plant pollination and reproduction and plant traits. Dukas did an excellent job of expressing how pollinator enemies affect pollinator behavior

and potentially plant traits; it would have greatly strengthened the book to follow that chapter up with one examining how plant enemies indirectly affect pollinator behavior and subsequent plant traits. Second, the book desperately needed a summary chapter. The reader is confronted in the preface with this dichotomy in pollination ecology between botany and zoology; yet, have any of the viewpoints in the book provided innovative ways to ameliorate the view of zoologists vs. botanists? What are the most pressing questions for future investigators in pollination ecology? Where should the field go from here? These are questions the reader is left with—I wanted the authors to provide future directions and dilemmas.

Cognitive ecology of pollination is a book I would recommend to both graduate students and colleagues studying in botany, zoology, or pollination biology at any level of organization. It provides a fairly comprehensive view of the topics being examined in pollination ecology today, and some chapters do contain recommendations for future studies. Further, I think all ecologists benefit from a reminder that we can often gain new insight by looking outside of our own specialty. This work will hopefully provide the momentum for future collaborations between pollination ecologists working from zoological and botanical viewpoints.

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A REQUIEM FOR BIODIVERSITY IN THE AGE OF HUMANS

Pimm, Stuart L. 2001. **The world according to Pimm: a scientist audits the Earth**. McGraw-Hill, New York. xiii + 285 p. \$24.95, ISBN: 0-07-137490-6 (acid-free paper).

Ecologists have long since abandoned the illusion that they can study populations, communities, or ecosystems that have been unaffected by human activities. In the last two decades, several groups of researchers have attempted to estimate the proportion of the planetary productivity that is used by people, and by inference, that is unavailable for the other 10–100 million species with which we share the planet. In this book, aimed at a literate general audience, Stuart Pimm checks and rechecks these figures, summarizes the key findings of a number of technical papers, proceedings, and books, and illustrates clearly the large-scale impacts of humans on the biodiversity of terrestrial and aquatic ecosystems. In addition, Pimm conveys the exuberance that he brings to field ecology, and in spite of the data, remains optimistic about the future prospects for the Earth’s biological richness. The

book is written in a conversational tone, liberally sprinkled with exclamation points, anecdotes, and British humor. There is also a set of black-and-white maps illustrating the distributions of croplands, cities, forests and other biomes, rivers, oceanic productivity, bird species richness in the Americas, and global hot spots of endemism. Given that the publisher could afford glossy paper for these maps, it doesn’t seem too much to have asked for color.

In essence, this book is a review of three key papers. The first part, which accounts for nearly half of the text, is a review of the data that undergird the seminal paper by Vitousek et al. (Vitousek, P. M., P. R. Ehrlich, A. H. Ehrlich, and P. A. Matson. 1986. Human appropriation of the products of photosynthesis. *BioScience* 36:368–373). They estimated that humans use nearly 40% of the terrestrial primary productivity, a figure that at the time came as a real surprise to ecologists. Pimm recounts that in 1985, he had glibly guessed, in response to the question by Paul Ehrlich, that humans use 42%, based on the magic number that recurs throughout Douglas Adams’ science fiction farce, *The hitchhiker’s guide to the*

galaxy (1980. Harmony Books, New York). After describing this conversation, Pimm goes about checking Vitousek et al.'s estimate by comparing different data sets (including a 1983 compilation from Oak Ridge, and the mid-1990s data of the World Resources Institute). After 100 pages or so, he concludes that the value Vitousek et al. described in six pages is about right, $\pm 10\%$. Given that the human population has grown by a billion or so (20%) since Vitousek et al. published their paper, I was disappointed that Pimm didn't attempt to account for the expected concomitant change in our use of the Earth's capital, but I expect the data haven't kept pace with the population. This section concludes with a brief review of a similar set of conclusions for the world's available freshwater (Postel, S. L., G. C. Daily, and P. R. Ehrlich. 1996. Human appropriation of renewable freshwater. *Science* 271: 785–788); the take-home message is that we use about 60% of the available freshwater runoff.

The second part of the book, accounting for about one-third of the text, reviews a similar data compilation assessing the marine productivity required for fisheries (Pauly, D., and V. Christensen. 1995. Primary production required to sustain global fisheries. *Nature* 374:255–257). Pimm admits to knowing less about the marine realm than the terrestrial one, and most of this section is taken up with descriptions of his adventures on research ships off the coast of Antarctica and South America, interspersed with recapitulations of Pauly and Christensen's data (we use 35% of the productivity of the ocean's continental shelves). He also covers the travesties of by-catch ("trash" fish caught while fishing for particular species), disturbances due to bottom-trawling, and the dangers of the discount rate when trying to protect threatened species.

The final part of the book looks at patterns of species diversity and rates of extinction. These topics, about which Pimm is most familiar, get the least space and have the highest range of uncertainty. There is still no consensus, even within an order of magnitude, about how many species there are on earth, or the actual rate at which humans are driving them extinct. We do know that both numbers are large, however, and that the activities of the Age of Humans will lead to one of the greatest extinctions of the Phanerozoic.

Pimm chose to focus his analysis on where we are now with respect to resource use and biodiversity, as opposed to where we are going to be in the coming decades as the climate warms and the population grows. Nonetheless, he concludes the book with an epilogue containing advice for what do to next. To us, his professional colleagues, Pimm recommends

that we measure global variables with adequate precision to detect change in a 10-yr period; that we get involved in the practical issues facing the planet (e.g., tithing 10 % of our time and effort to "applied" as opposed to "academic" pursuits, as if they are still separable); and that we communicate our concerns to our elected decision-makers. To the lay public, he recommends that individuals better quantify the value of their environment, encourage its sustainable use, and discourage activities that deplete it. He also suggests that the amelioration of human impacts will require a concerted approach between "science" and "religion." While Pimm feels that this is a real possibility, there are fundamental incompatibilities between science, especially evolutionary ecology, and religion. Finally, he recaps the conclusions of a conference at Cal Tech, hosted by Harvard biologist E. O. Wilson and Intel co-founder Gordon Moore, addressing the challenges of protecting and saving the Earth's biodiversity: protect the remaining natural ecosystems, by buying them if necessary (at a price tag of several hundreds of billions of U.S. dollars); increase training of in-country environmental professionals; and eliminate governmental subsidies that encourage over-harvesting and subsequent extinction of species.

This book was written before the U.S. began its "war on terrorism," and in war, the environment is one of the first casualties. In light of current events as I write this review, Pimm's prescriptions and recommendations seem vaguely quaint. Since 11 Sept. 2001, the major environmental organizations have ceased their critiques of government policies around the world that threaten the environment. The hundreds of billions of dollars needed to protect the world's biodiversity are being spent to prop up failing businesses and to increase the perverse subsidies that directly cause extinction. Budgets for environmental research, both "applied" and "academic," are expected to decline precipitously. And dissenting views, which include concern for non-human species, are being stifled, either officially or through self-censorship. I fear that *The world according to Pimm* comes too late. Rather than being a call to action, it most likely will be a requiem for biodiversity in the Age of Humans.

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