cial and ecological costs" (p. 66). The first key research and policy objective of the nine that he proposes is: "The 'built environment' should have long-term integrity that can enhance the quality of life..." (p. 67). However, it must also include and balance everything else. Herman points out that these goals are desirable, but knowledge is weak about long-term ecological consequences. Ecologists can suggest some remedies to future problems, but scientific certainty about these future problems and their remedies is low compared with a high certainty on how to remedy obvious, immediate human distress. He implies, through a Gertrude Stein quotation, that the future is unknowable at the level of the immediate. For Herman, ignorance provides both a cause for caution in design and an essential research area.

Costanza provides a rich discussion of problems that are related to long-term sustainability. He uses network analysis to sort through energy and economic considerations. He agrees with Herman that the future is unknowable, although he does not cite Herman's writings. Costanza states that planning for sustainability is difficult because "one knows one has sustainability only after the fact" (p. 79). The essence of sustainabilty is future oriented; it can never be known. Just as uncertainty is a combination of ignorance, error, and stochastic events, ignorance has multiple parts: that which is not yet known and needs more study, and that which cannot be known, for example, the future. The future, at least, cannot be known well enough to plan precisely for future side effects. Herman thinks these future scenarios are mostly unknowable, whereas Costanza does not, although both recognize that the future will come.

The difference between Costanza's and Herman's views is among the most striking in the book. Herman wants to gain the knowledge to control future outcomes, but the ecologists, as emphasized earlier by Holling and later by Mitsch, propose to develop options to adapt to the future. Costanza captures the view that network analysis can help to lay out the stochastic options available in a simple but telling payoff matrix for technological optimism and pessimism. If a technological optimist policy is followed, and the optimists are right, the quality of the world will be high. If this policy is followed but the pessimists are right, the world will be a disaster. If the policies of the technological pessimists are followed but the optimists are right, the quality of the world will be moderate; if the pessimists are right, it will be tolerable.

Karr, in his essay, expresses pessimism about the integration of engineering and ecology. He suggests that the disciplines involved differ so much in outlooks and, more important, knowledge base, that integrated solutions can come only when "...scientists, engineers, policymakers, resource managers, and citizens...develop approaches for attaining those goals" (p. 105). Wurth disagrees with Karr; he analyzes the philosophical differences between engineers and ecologists and decides that the differences are "overstated," pointing out that both study mass balance and functional analysis. Mitsch follows this divergence of opinion between Karr and Wurth with a well-documented proposal to develop a new discipline, "Ecological Engineering." This new field, which combines parts of theoretical and applied ecology, has five principles: application of self-design, ecosystem building as the acid test of ecological theories, reliance on system approaches, conservation of nonrenewable energy, and conservation of nature.

The case studies enrich the book by demonstrating practiced integration of engineering and ecological thought. The case studies also stand alone as examples of a technological/ideological synthesis used to enhance the value of a complex project. They cover several classic examples of large-scale ecological engineering activities, including the development of a pipeline through an Ecuadorian tropical ecosystem, the water management of the Everglades and the California Delta, the restoration of the Kissimmee River, and flood control in the Upper Mississippi. Each case study has elements of second guessing, prediction, optimism, and advice.

Engineering Within Ecological Constraints is a step toward the necessary interdisciplinary thought that present-day environmental problems require. However, the exercise is still multidisciplinary, with the experts each repeating his or her own story. To some extent, the essay authors talk past each other. The collection craves the next step in synthesizing the different perspectives. NAE should invite each author to write a second paper after he or she has studied and thought about the ideas and proposals of the other authors. They should also interpret the case studies for each other. Perhaps, then, a real integration of thought and knowledge would occur.

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UNDERSTANDING RARITY

The Biology of Rarity: Causes and Consequences of Rare–Common Differences. William E. Kunin and Kevin J. Gaston, eds. Chapman & Hall, London, 1997. 280 pp., illus. $99.95 (ISBN 0-412-63380-9 cloth).

The notion of rarity has increasingly taken on importance and urgency inasmuch as the extinction crisis looms over the discourse of conservation biology. A species, after all, cannot become extinct without first becoming rare; thus, biologists have a vested interest in understanding this phenomenon. But, as this book makes clear, when academics put their minds to this issue, they can find ways of convincing one that they really do not know what rarity means—why some organisms are rare and others common, what factors cause or maintain rarity, and what might be the relationship between rarity and extinction. Now, this is somewhat of an overstatement to be sure, but after reading this book one cannot help feeling a bit frustrated, not because the papers are not interesting or informative, but because the problem of rarity is elusive to any simple analysis that might have some relevance to the problem of extinction, and therefore to conservation action.

The editors, William E. Kunin and Kevin J. Gaston, who are already well known for their work on rarity (indeed, Gaston wrote a book on the subject a few years ago), have organized this volume into three sections covering rare–common differences, what causes them, and future research directions. This book belongs, in many ways, to Kunin and Gaston because one or both of them wrote six of the 14 chapters. They envision the goal of the book as separating "pattern" and "process"; this goal remains unfulfilled for various reasons, not least the idiosyncratic nature of the contributions of the other authors. Then again, the notion of rarity almost defies conceptualization. In his introduction, Kunin sees rarity as an emergent property of populations, but that is surely not the case if by rarity one means a population with *relatively* few numbers of individuals. There is nothing "emergent" about that; it is simply a matter of counting (and judging what one means by "relatively"). But as the editors and others point out, there are multiple ways of *defining* rarity, and, from the perspective of the observer, multiple ways of *viewing* rarity.

One only has to read the chapters by Gaston (chapter 3) and by Tim Blackburn and Gaston (chapter 4) to get the idea that studying rarity is not for the faint of heart. Rarity, they point out, is usually seen in terms of restricted geographic distribution and/or low abundance (the two are correlated). But there is a host of different ways of seeing and measuring geographic distribution and of measuring abundance. Combine those difficulties with the fact that rarity (low values of those measures) is relative to higher values in "comparable taxonomic entities" (whatever that may mean), and one is driven to the conclusion that making comparisons among studies is problematic indeed.

Much of this book seems to be about "natural" rarity—those species or populations that are intrinsically rare, without the imprint of anthropogenic change—and what "causes" that condition. That humans can cause rarity is discussed, but what is not discussed in sufficient depth is the inherent dilemma of wanting to study natural rarity without first eliminating the possibility that the phenomenon being studied is a consequence of prior human activity. It is another causal factor that must be partitioned if one is interested in the reasons for why a particular species, or group of species, is rare. Thus, many of the comparisons in various chapters that correlate variation in the expression of certain traits (breeding system, dispersal, genetic, resource specialization, range size) with rarity across taxa do not make this distinction. This is critical because running throughout some discussions is the implication that certain traits *cause* (or maintain) rarity.

One of the more provocative chapters, focusing on causes of extinction, is that by Michael Rosenzweig and Mark Lomolino, who present a long discourse on the ecological causes of rarity—not surprisingly, within the MacArthurian broken-stick model. They also conjure a list of "consequences for conservation"; some are a bit common sense and not at all tied to their theoretical discussion, but others come across as a bit strange and, perhaps, self-defeating politically. The latter include protecting a species against invasives (in part, by increasing "the rate at which it develops resistance to the invading enemy"); killing competitors (e.g., via pest control tools) that pose a threat to rare, narrowly distributed or adapted ("intolerant") species, without, of course, hurting the latter; protecting "chaotically" rare species (they suggest that "chaos might actually help to prevent extinction" and "may engender adaptations that coincidentally protect chronically rare species from extinction"); and protecting "other kinds of rare species," a heading that produced such incomprehensible statements as "Maybe a centrifugally produced relictual species does not warrant our help—it is an evolutionary backwater anyway" (p. 85). I am not trying to belittle Rosenzweig and Lomolino's concern for extinction, but I walked away from this chapter, and statements such as these, thinking that theoretical ecology may be relatively limited in what it offers conservation, which I am sure the authors themselves do not believe (nor do I, actually).

Picking up on the causes of rarity and what that implies for conservation policy, Georgia Mace and Melanie Kershaw (chapter 8) point out that the meaning of rarity has been sometimes confused when categorizing threatened and endangered species. Rarity, they point out, does not necessarily signify that a species is in danger of extinction; that depends on the processes causing population decline. They raise an important issue—also noted by others in the volume but, unfortunately, not dealt with in sufficient detail, even in this chapter—that rare species may be well adapted to being rare and thus have a *lower* extinction risk than one might expect. Mace and Kershaw analyze two avian data sets, one for Natal, South Africa, and the other for 1111 species of birds on the IUCN threatened list. Both analyses show that small population size (i.e., rarity) is closely related to risk. But then they reach two conclusions (p. 146): "rarity per se is not useful in the assessment or diagnosis of threatened status unless the precise way in which a species is rare can be determined" and "the set of rare species that are at highest risk of extinction, and which are declining most rapidly, are those with limited population size." The fact that low abundance is the primary criterion (definition) of rarity compromises the logical clarity of these conclusions.

How all the theoretical exegesis of this book fits into conservation policy is uncertain. Most workers seem to agree that rarity—defined as populations with either low abundance or small ranges—entails a greater risk of extinction through stochastic fluctuations. This in itself should tell us that rare species are more threatened in general. Maybe that is all we need to assume when designing conservation action. In their summary (chapter 14), the editors point out that knowledge of rare–common differences among closely related species may help in the design of management plans when knowledge about the biology of the rarer species is relatively unknown. This assumption depends, of course, on being able to infer generalized rare–common differences to individual cases. The editors also point out that species that have had an evolutionary history of adapting to rarity—which might be inferred from phylogenetic analysis—may have suites of characters that make them less vulnerable to extinction. Newly rare species, by contrast, might not have these adaptations and, thus, might need more help to avert extinction. Well, perhaps—but it seems to me we would have to be in a severe mood for triage to formulate conservation decisions based on academic knowledge such as this, given all the ongoing factors that might be contributing to extinction risk, as well as the other conservation priorities that might need due consideration.

Readers interested in the biology of rarity will want to have this book. Because of its more theoretical emphasis, however, I am less certain what conservation biologists and resource managers will take away from it that will help them. The book demonstrates that the biology of rarity is difficult, but much of that difficulty comes from the ontological complexities of studying rarity and from the idiosyncratic variation exhibited by rare species. It is not immediately obvious that these difficulties can be circumvented; if so, we may have to face the possibility that a general synthesis relevant to conservation biology will not be forthcoming.

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