

Six of the nine chapters that make up part 2 are devoted to aspects of geoarcheology. These range from landscape and stratigraphic context to site formation, modification, and destruction, and the treatment includes a consideration of human impacts on the landscape. The remaining chapters deal with archeometry, archeobotany, and zooarcheology. This apparent imbalance is partly a result of Butzer's predilection for and unrivaled experience in geoarcheology and partly an attempt to counterbalance the more highly developed subfields of archeometry and bioarcheology. This is justifiable in light of the present state of the discipline as a whole, but it results in the other subfields being dealt with in such a highly condensed fashion that some important topics—for example the potential contribution of ethnobotanical fieldwork to archeobotany—get little or no attention. Despite their brevity, however, these chapters are commendably up to date and supported by many recent references, as indeed is the entire book.

In the third and final part, entitled *Synthesis*, Butzer tackles the daunting task of integrating the approaches discussed in part 2. Three chapters are devoted to spatial integration. They deal with quantitative models of settlement patterns and resource use, principally gravity and central-place formulations derived from human geography, and resource-concentration models, including optimal foraging theory; with socioecological models of the dynamics of settlement systems, including the distinction between real and perceived environments; and with the empirical reconstruction of settlement patterns. These themes are examined with reference both to sedentary farmers and to mobile hunter-gatherers and pastoralists. The last two chapters are concerned with temporal change. In these Butzer analyzes the dynamics of human ecosystems in terms of cultural adaptation, which, he argues (p. 281), provides "an effective approach to the interactive human and nonhuman components" of such systems. He distinguishes fundamental evolutionary transformations of global significance, such as hominization, late Pleistocene cultural diversification, the origins of agriculture, and urbanization, from modifications of regional adaptive systems and from short-term adjustments to such phenomena as epidemics, famines, destructive wars, and dynastic changes. This approach permits diachronic analysis at varying spatial and temporal scales, and in the final chapter it is applied briefly to three examples:

the transformational changes of Pleistocene hominization and of Holocene food production and the adaptive modifications that made possible the persistence of hydraulic cultivation for some five millennia in ancient Egypt and Mesopotamia.

As the subtitle implies, Butzer's central aim is to provide a comprehensive theoretical framework for archeology conceived as past human ecology. In this he succeeds. The outstanding merits of the book are its breadth of coverage, its logical structure of conceptual categories, and its synthesis of an extraordinarily wide range of data. Such comprehensiveness entails some superficiality, but this is mitigated by the inclusion of case studies and by a 37-page list of up-to-date references. Not all will accept Butzer's claim that the book proposes a new paradigm for the study of archeology, complementary to that of social archeology, but those of us who regret the persistence of pedagogical barriers that continue to separate the natural and social sciences, and who share Butzer's vision of archeology as human ecology, will warmly welcome this pioneering prospectus.

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Bat Ecology

Ecology of Bats. THOMAS H. KUNZ, Ed. Plenum, New York, 1982. xviii, 426 pp., illus. \$49.50.

Bats are among the most ecologically diverse of all mammals. For example, the 850-odd species of Chiroptera exhibit a dietary diversity (insects, fruit, pollen, nectar, flowers, leaves, blood, fish and other vertebrates) that is unparalleled among mammalian orders. Researchers have recently begun to exploit this ecological diversity for comparative studies. The influence of environment (food, predators, shelter, and climate) has been detected in phenomena ranging from echolocation pulses to mating systems.

This volume's ten chapters, well organized and well indexed, constitute a broad sampling of current research interests that have not recently been reviewed from an ecological perspective. It is evident from them that bat ecology has come a long way from the days of species lists and anecdotes. More so-

phisticated study methods (including night viewing devices, radiotelemetry, and portable oscilloscopes with ultrasonic microphones) have made it possible to observe previously inaccessible aspects of bat life. Although many areas still suffer from a paucity of rigorous studies that frustrates meaningful synthesis, the field as a whole is becoming increasingly quantitative.

Among the more provocative contributions is Findley and Wilson's, in which they argue that multivariate analyses of bat morphology (for example of jaw, wing, and brain) generate predictions about behavior and community structure with an accuracy heretofore unappreciated. Another is Fenton's, contending that there is no convincing evidence for resource partitioning by insectivorous bats, despite opinions to the contrary held by many.

Notably thorough reviews of roosting and reproductive ecology are provided by Knuz and Racey, respectively. And Heithaus pulls together an especially broad literature to argue that the intricate mutualisms that characterize bat pollination and seed dispersal systems probably arose by preadaptation and "diffuse coevolution." ("Diffuse" coevolution is a term proposed by D. H. Janzen for situations in which the sequence of response and counter-response involves several species on both sides.)

Our understanding of most areas of bat ecology is based on a relatively few, intensive studies conducted within the past decade. In several cases, the key studies on the topic were done by the authors themselves. For example, major portions of McNab's chapter on physiological ecology and Erkert's on circadian rhythms are derived from their own excellent publications. Tuttle and Stevenson's data on gray bats are the most complete available on chiropteran growth and survival. A fascinating account of the curious ectoparasites of bats is drawn primarily from Marshall's own recent work.

Fleming cautions us that the generalizations that close out his chapter on the foraging behavior of fruit-eating bats are based on detailed case histories of only four species. Though the data are not in themselves sufficient to generate predictive patterns, it is interesting that so many of the findings are consistent with current theories of foraging and mating system evolution, theories for the most part inspired by studies of birds and non-volant mammals.

This last exemplifies one of the most

valuable contributions being made by bat ecologists at the present time. Namely, they are beginning to use the extraordinary ecological diversity of bats to test current hypotheses about the evolution of morphology, physiology, and behavior. Even if bat ecology remains primarily descriptive, this vast interspecific and intraspecific variation provides raw material for powerful comparative studies. This volume will have achieved its primary objective if it helps communicate that fact to researchers both inside and outside the field.

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Development of a Coral Reef

The Geomorphology of the Great Barrier Reef. Quaternary Development of Coral Reefs. DAVID HOPLEY. Wiley-Interscience, New York, 1982. xvi, 454 pp., illus. \$59.95.

Captain Cook's ship, the H.M.S. *Endeavour*, ran aground on the Australian Great Barrier Reef late one night in 1770. So entered this, the greatest of all coral reefs, into the annals of science. This and other bits of information make David Hopley's book interesting as historical reading, as well as valuable as a statement about coral reefs in general and this very large coral reef province in particular.

Most students of coral reefs realize that "Great Barrier Reef" is a misnomer referring not to a single reef but rather to an entire province containing at least 2500 coral reefs and covering more than 200,000 square kilometers (somewhat more than a third of the estimated reef area of the entire globe). The climatic, oceanographic, geological, and biological diversity of these reefs is considerable, so a description of the Great Barrier Reef is a fair start at a description of the characteristics of the coral reefs of the world.

Four of the 13 chapters plus miscellaneous other information scattered throughout the book might be described as geomorphological, classifying coral reefs or parts thereof. Another chapter might be described as physical geography, dealing with environmental factors that influence reef development in the Great Barrier Reef province. The remainder of the book is very much directed toward the processes that contribute to the formation of coral reefs. Three

chapters review our present knowledge about biological, physical, and chemical processes acting on coral reefs. I was mildly disappointed that the chapter on chemical processes is restricted to diagenesis, although in all fairness other aspects of chemical processes on reefs receive attention elsewhere in the book. Despite a few weaknesses of this sort, these chapters provide an excellent summary of our knowledge (up to about 1978, although there are a few more recent citations).

Three chapters contain the core of Hopley's original scientific contribution in this book, drawing heavily on his own research in the Great Barrier Reef over the past 15 years. These chapters deal with the Holocene flooding of preexisting limestone platforms and the accumulation of Holocene reef material on these platforms. Hopley specifically considers the so-called antecedent karst hypothesis: "The essence of the problem of reef morphology is the extent to which it is karst-induced as opposed to growth-determined." Hopley considers direct evidence from the Great Barrier Reef, analogy with karst topography elsewhere, small-scale experimental data, and the diverse opinions on this topic. He concludes that, though small-scale features related to underlying karst topography are clearly in evidence, "more influential in providing the relief of both the pre-Holocene foundation and the Holocene morphology is the pattern of growth during submergence that will favor the colonization of prominences at the expense of depressions."

This general conclusion is then synthesized with data on sea level over the past 125,000 years and with estimates of CaCO_3 sediment production in various reef zones to construct a generalized model of Holocene reef growth and erosion toward the observed morphology. Hopley has clearly not had the last say in the debate on reef growth and morphology in the Great Barrier Reef, but he has provided a lucid and carefully considered view for further discussion.

The last comprehensive geomorphological look at the Great Barrier Reef province was W. G. H. Maxwell's *Atlas of the Great Barrier Reef* (1968). Increasing access to the reef and a variety of environmental and political considerations have contributed enormously to our knowledge of it since that time, so a successor to Maxwell's book was in order. Hopley's contribution is a worthy successor.

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Books Received

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