EXPLORING MANGROVES

Tropical Mangrove Ecosystems. A. I. Robertson and D. M. Alongi, eds. American Geophysical Union, Washington, DC, 1992. 329 pp., illus. $37.00 (AGU and AIBS members $29.60) (ISBN 0-87590-255-3 cloth).

Mangrove forests are the dominant ecosystem on tropical protected coastlines worldwide. Although mangroves are being cleared at alarming rates (more than 1% per year), the loss of mangroves has not inspired the level of research and conservation activity devoted to rainforests. The difference is most likely due to mangroves' reputation as "foul smelling places, full of stalking, quiet murder" (Steinbeck 1951). One center of mangrove research can be found at the Australian Institute of Marine Science (AIMS), where all the contributors to this excellent book have worked at some time since the institute's founding in the mid-1970s. The editors modestly categorize *Tropical Mangrove Ecosystems* as a review of mangrove research conducted at AIMS from 1981 to 1991 (the preceding decade was summarized in Clough 1982), but this book is a true synthesis of the state-of-the-art of mangrove systematics, population and community ecology, and ecosystem dynamics.

Mangrove research at AIMS began north of Townsville, in Missionary Bay on the approximately 50-square-kilometer Hinchinbrook Island. J. S. Bunt describes the expansion of the AIMS mangrove project from an initial focus on primary production within Missionary Bay to incorporation of mangrove ecology, conservation, and management throughout the Indo-Pacific. The strength of the AIMS research program has been experimental testing of hypotheses derived from observational and correlative studies conducted primarily in the Neotropics.

As with any biological investigation, understanding begins with accurate taxonomy. The term *mangrove* is an ecological, not a taxonomical grouping; it refers most simply to tropical trees and shrubs growing in the marine intertidal zone and displaying a broad suite of evolutionarily convergent characters enabling them to tolerate saline, anoxic soils. However, as N. C. Duke illustrates, this simple characterization belies both a lack of agreement on the limits to the mangrove category and an incomplete systematic understanding of the species, genera, and families within which mangrove organisms are categorized. Continued research in alpha taxonomy (naming previously undescribed species) and revisionary systematics is required, especially in the Indo-Pacific, where mangrove species diversity is highest, before general conclusions can be drawn about the evolutionary history and population biology of mangroves.

Studies of population biology and community ecology of mangroves rarely have been placed in general theoretical constructs of contemporary plant ecology. T. J. Smith III attempts to remedy this situation but is hampered by the paucity of controlled experimental studies on mangrove population dynamics and species interactions. For example, the gap dynamic/patch phase mosaic models of forest dynamics have not been applied rigorously to mangrove forests. Studies of mangrove ecophysiology, unfortunately not reviewed in this book, also need to be incorporated into models of mangrove forest dynamics. Gathering the data needed to develop a coherent theory of mangrove forest structure and dynamics is a crucial task for the next several years.

Like terrestrial forests, mangroves are dynamic systems. Colin Woodroffe and E. Wolanski, Y. Mazda, and P. Ridd review the geomorphological and hydrological processes that over long periods control mangrove swamp formation and a mangrove's relationship to adjacent marine ecosystems (e.g., estuaries, seagrass beds, and coral reefs). One of the most characteristic and intensively studied attributes of mangrove forests is the distinctive species zonation with respect to tidal elevation (reviewed here by Smith), but ignorance of or inattention to coastal geomorphology has yielded a limited understanding of spatiotemporal dynamics within mangrove swamps.

The conception of mangroves as active land-builders has also constrained studies of species patterning and succession in mangroves. Woodroffe's summary of mangrove geomorphology shows that rather than actively creating new coastline, mangroves are responding to constraints imposed by local geomorphology. His review provides firm grounding for any future study of mangrove zonation, succession, and predictions of the likely responses of mangroves to anticipated sea-level rise.

Similar inattention to hydrodynamic processes controlling, among other things, energy and nutrient export from mangrove swamps, has resulted in spectacular failures of salinas and shrimp farms carved out of mangroves and the overexploitation of nearshore tropical fisheries. Wolanski et al.'s review of mangrove hydrodynamics illustrates the complexities of fluid (and therefore carbon and nutrient) transport within mangrove swamps and should be required reading for anyone involved in tropical (or temperate) coastal ecosystem dynamics and management.

Research on mangrove ecosystem dynamics has been driven by the paradigm, developed by W. E. Odum and E. J. Heald in the 1960s (Odum and Heald 1972), that mangroves are highly productive ecosystems supporting nearshore secondary production through substantial carbon export. Much of the argument for preservation of mangrove forests depends on the validity of this paradigm.

Although not minimizing the importance of mangroves as the basis for nearshore secondary production, the reviews of primary production by B. F. Clough and of food chains and carbon fluxes by A. I. Robertson, D. M. Alongi, and K. G. Boto illustrate that mangrove production and energy flow are much more variable than previously thought. The wide geographic range of mangroves (roughly 35°N to 38°S latitude) affects substantially net primary production (NPP). At latitudinal extremes, and in extremely saline habitats, mangrove NPP is close to zero, whereas in lower-salinity regions of the Indo-Pacific annual aboveground NPP can reach 45 tons per hectare. These estimates are conservative, however, because there are no reliable data on belowground NPP in mangrove forests. Isotope studies reviewed by Robertson et al. illustrate that dependence of nearshore fisheries on mangrove-derived carbon varies greatly with location and hydrodynamic regime.

The importance of herbivory in mangrove carbon cycling, also reviewed briefly by Robertson et al., has received experimental attention only in the last five years. With the exception of fisheries dynamics (reviewed by A. I. Robertson and S. J. M. Blaber), population and community ecology of animal communities associated with mangroves has received scant attention. Recent studies of the mangrove benthos (reviewed by D. M. Alongi and A. Sasekumar) should address this historical lacuna and greatly improve the precision of mangrove ecosystem models.

Nutrient cycling in coastal wetlands is understood much better in temperate-zone salt marshes than in mangrove ecosystems, and nutrient cycling dynamics in the latter have been extrapolated from studies of the former. Alongi, Boto, and Robertson comprehensively summarize all available information on nitrogen and phosphorus cycling in mangroves. Their chapter presents a detailed nitrogen budget for Hinchinbrook Island, the only mangrove swamp for which a complete nitrogen budget has been constructed. Alongi et al. illustrate clear differences between salt marshes and mangroves in the process controlling nitrogen cycling, but generalizations depend on similarly detailed studies in other mangrove forests.

Mangrove forests occur in regions where annual population growth ranges from 1.3% to 3.8%, and development pressure on these forests is intense. For example, mangroves are used for charcoal, timber, honey, and ethanol, and they support lucrative fisheries. Yet, in his concluding remarks, Robertson states that scientific knowledge has not advanced the cause of sustainable management of most mangrove forests. The reasons are hauntingly familiar: lack of basic scientific information, overemphasis on curiosity-driven research, and a lack of willingness of scientists to place their results into a management framework. The AIMS researchers are attempting to bridge the gap between basic research and ecosystem management, and this book serves as an example for those interested in building such bridges.

AARON M. ELLISON
Department of Biological Sciences
Mount Holyoke College
South Hadley, MA 01075

References cited

Clough, B. F. 1982. *Mangrove Ecosystems in Australia: Structure, Function and Management.* Australian Institute of Marine Science and Australian National University Press, Canberra, Australia.

Odum, W. E., and E. J. Heald. 1972. Trophic analysis of an estuarine mangrove community. *Bull. Mar. Sci.* 22: 671–738.

Steinbeck, J. S. 1951. *The Log from the Sea of Cortez.* Viking Press, New York.

CLIMBING INTO THE BIG PICTURE

Scaling Physiological Processes: Leaf to Globe. James R. Ehleringer and Christopher B. Field, eds. Academic Press, San Diego, CA, 1993. 338 pp., illus. $69.95 (ISBN 0-12-233440-X cloth).

Scientific advancements are often marked with a restless tendency to stray from the core issues of a discipline and probe the boundaries for expansion. In biology, such forays often originate in the needs of disciplines at higher scales, which seek the reductionist view for the purpose of organizing higher-scale phenomena around generalized patterns or processes. This pattern can be evoked to describe the recent birth of molecular systematics and the older birth of physiological ecology.

Scaling Physiological Processes, an edited volume by J. R. Ehleringer and C. B. Field, reflects one such pattern, in this case an expansion of plant physiological ecology to meet the needs of ecosystem ecology in seeking a mechanistic understanding of biogeochemical cycles and their role in global processes. Plant physiological ecology is that discipline concerned with the functional determinants of plant growth and persistence. Traditionally, studies in the field have focused on carbon-dioxide and water-vapor exchange across leaf surfaces. Reflecting the discipline as a whole, this book describes the means by which such gaseous exchanges can be aggregated from the single-leaf to the global scale. The articles were originally presented at a workshop on the topic of biological scaling in Snowbird, Utah, in December 1990.

This seminal work represents the first synthetic formulation of approaches to bring plant ecophysiology into the larger arena of earth systems sciences. It is groundbreaking in this respect. The book successfully accomplishes the task of defining the process of aggregating patterns at one scale to feed the inputs of higher scales. It provides a thorough review of the concepts and approaches that ultimately lead to successful scaling studies. However, when it comes to actually defining new scaling paradigms, the book takes more the tack of cobbling together existing ecological theories than creating a new, tight conceptual framework.

The book is divided into five parts that do not appear to fit the same logical scale (leaf to globe) espoused in the title. Rather, the grouping of chapters wanders, reflecting more the strengths of the contributors than an editorial strategy designed to define the leaf-to-globe hierarchical approach.

The strength of the book falls in a series of six chapters grouped within the section titled "Leaf to ecosystem level integration." These chapters lay down the leaf-to-canopy and leaf-to-ecosystem approaches that have been so successfully developed by the individuals (J. Norman, D. Baldocchi, P. Jarvis, J. Reynolds, and S. Running) who have been at the core of scaling for many years.

For those readers interested in an overview of the factors that matter most in leaf-to-ecosystem scaling, they need look no further than these chapters. They provide beautiful lessons in some of the modeling shortcuts required to match the input of one scale with the output of another. Examples include J. Norman's exploitation of the correlative rela-