review of nutrient recycling clearly indicates that "new" production can account for no more than 10 to 20 percent of total production on a global basis. If these estimates are correct, then nitrogen atoms are recycled 10 to 20 times in the euphotic zone before being lost from surface waters. The importance of recycling is not restricted to marine systems, for phosphorus recycling in fresh waters is just as critical. The relationship between production and consumption in planktonic systems is ill understood, but the data point to a highly coupled set of coevolved mechanisms. Because recycled nitrogen is in the form of ammonia and "new" nitrogen is introduced as nitrate, Malone even goes so far as to suggest that there are size-class differences in the utilization of nitrogen in the oceans. He suggests that nanoplankton are the dominant users of ammonia; in short, the organisms most likely to be recylced are most likely to be the consumers of recycled products.

The problem with the interpretation of productivity measurements is methodological. Confinement of phytoplankton in bottles for a number of hours while carbon-14 uptake takes place has a severe effect on physiological processes, survivorship, and the small-scale grazing and recycling mechanisms. This problem is well reviewed in this book, cropping up in a number of contexts. For example, Eppley attempts to reconcile the productivity estimates from the North Pacific with data from a number of sources and concludes that there is still an order-of-magnitude uncertainty in the data. Many of the papers in this book suggest, sometimes in subtle ways, that we have indeed underestimated the productivity of the oceans, that the phytoplankton in oligotrophic ocean waters are not nutrient-limited and that phytoplankton growth rates in such areas are close to maximal. Such a message should not go unheeded by limnologists.

One other important message comes through clearly. If the algae are to be thought of as microbes and their growth rates and physiology are heavily dependent on small-scale, high-frequency processes, then we must learn much more about the time course of the algal responses at these scales. The physiological and hydrographic data presented in the book indicate that at scales of less than 24 to 48 hours there is considerable interplay between the environment and the cells. It appears that, by knowing what the algal response times are, it may be possible to infer aspects of the physical structure of the environment. Research in the Great Lakes has led to the same conclusion, and we are faced with the interpretation of some complex non-steady-state processes at such scales. The dominant message from this book is that the study of small-scale processes in the oceans, through physiological and hydrographic techniques, will lead to an improved understanding of an important group of organisms and an important global resource. As the last two papers point out, the impact of oceanic productivity on the global fluxes of carbon dioxide is considerable. A better understanding of oceanic productivity and its distribution in time and space is not simply an academic concern.

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Managing Wetlands

Wetland Functions and Values. The State of Our Understanding. Proceedings of a symposium, Lake Buena Vista, Fla., Nov. 1978. PHILLIP E. GREESON, JOHN R. CLARK, and JUDITH E. CLARK, Eds. American Water Resources Association, Minneapolis, 1979. x, 674 pp., illus. $49. Technical Publication Series.

Wetland ecosystems currently make up 3 to 4 percent of the landscape of the United States, but the total area is decreasing 0.5 to 1.5 percent annually. Though very productive, wetlands often have unappreciated local and regional influences on organisms, the cycling of elements, the storage and degradation of pollutants, and water budgets. Although wetland fur trapping played a significant role in the European colonial expansion in North America and coastal marsh haying was common, wetlands were once largely considered worthless. George Washington, Thomas Jefferson, and Patrick Henry formed a company to drain the Great Dismal Swamp, for example, and the family of William Bartram, one of America's first naturalists, profited from the grain yields of the wetlands they drained. But over decades the "wetlands are wastelands" philosophy gave way somewhat to a growing interest in wetland conservation, especially with regard to wildlife. This symposium proceedings is a landmark publication in the continuing evolution of an improved and broader understanding of wetland ecosystems and their importance in society. The National Wetlands Technical Council and the Conservation Foundation organized the symposium, which was sponsored by nine federal agencies led by the U.S. Water Resources Council. The emphasis is on management, conservation, and present value.

The book contains good sections on food webs, habitats, and water quality. But the more problematic aspects of wetland management involve the couplings between ecosystems. Organisms, water, and chemicals move through wetlands easily, and there is no clear consensus about where uplands or open waters end and wetlands begin. These couplings, then, are not easily discerned.

Gannon, Bartholic, and Bill ask if wetlands can influence downwind climatic conditions. The answer seems to be "yes" for southern Florida because of the thermal inertia of wet soils to cold fronts and the subsequent slow transfer of the stored heat from land to atmosphere. Wetlands there buffer the type of short-term temperature changes that damage the local citrus crop. The authors then raise the question whether local management agencies can effectively regulate land uses that can cause unintended atmospheric modifications.

Williams and Dodd describe how some large and numerically rare organisms, though consuming a minor portion of the total ecosystem energy flux, fundamentally affect wetlands. Alligator mud wallows, for example, provide a refuge for aquatic organisms during drought, and the elevated edges of the wallows provide a suitable substrate for tree and shrub seedling germination in the otherwise flat prairie. Alligator trails influence the local hydrology, and bay islands form from abandoned alligator nests.

Barber, Kirby-Smith, and Parsley connect the 1972 collapse of the Peruvian anchoveta harvest to an expanded market for alternative protein sources. This circumstance led to wetland clearing for soybean farms in North Carolina and finally to the "inevitable" deleterious effect of the clearing on the coastal estuary, which they document. They conclude by pointing out that needed long-term studies of wetlands are rare and that, since wetland research is often perceived as constraining agricultural development, the funding of long-term projects is often unpopular at land-grant universities and federal agencies.

There is general agreement that wetland functions are closely related to wetland hydrology, but this subject has largely been left to biologists by default. It is refreshing, therefore, to read the contributions of the few wetland hydrologists around. Carter, Bedinger, Novitzki, and Wilen review the flood storage capacity of different wetland types, considering water budgets and vegetation. To control flooding by the Charles River it was found to be more economical to purchase the existing wetlands than to establish a network of dams. Wisconsin peatlands also reduce flooding but deplete rather than sustain streamflow during summer drought.

Odum and Lugo and Brinson discuss the many difficulties in evaluating the "public" services of wetlands by means of an economic system that most effectively measures short-term, private, and selfish interests. Odum asks who is to use the wetlands and when. Lugo and Brinson flatly reject the premise that a value system based on accepted economic theory can address the physical and evolutionary reality of ecosystem dynamics. The discussion that followed their paper at the meeting is unfortunately not included here.

Perhaps there will be a second volume that will discuss more thoroughly other aspects of wetland ecosystems such as the microbiology of flooded soil, the many non-American publications on wetlands, and the usefulness of an experimental approach. Those involved in wetland management and ecology will find the present volume very useful.

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Plants under Stress

Adaptation of Plants to Water and High Temperature Stress. Proceedings of a Seminar, Stanford, Calif., Nov. 1978. NEIL C. TURNER and PAUL J. KRAMER, Eds. Wiley-Interscience, New York, 1980. xiv, 482 pp., illus. $40.

The global distribution and abundance of terrestrial plant species are determined to a large extent by the availability of water. Tropical rain forests are among the most diverse and productive of terrestrial ecosystems, whereas arid and semiarid regions show low diversity and low annual productivity. Environments with low annual precipitation are usually environments of high irradiance and frequently those that experience high temperatures during a significant portion of the year. Therefore, water stress and high-temperature stress are often encountered together in natural as well as in agronomic situations. The volume under review addresses the responses of both native and economically important plant species to these environmental factors. The volume contains 28 papers by an impressive international group of over 50 plant scientists representing such fields as plant physiology, agronomy, agricultural engineering, ecology, and forestry. The papers are not purely descriptive but attempt to characterize the long-term adaptation and short-term acclimation of plants to temperature and water stress.

The volume includes treatments of such topics as morphological and physiological responses to stress. It is evident that plant leaves show the greatest plasticity in response to water stress, though modifications in root structure and size are also seen. The responses of stomates to tissue water deficits and to evaporative demand are shown to be highly adaptive. Many species are capable of adjusting to regular water-deficit regimes by keeping stomates open at lower leaf water potentials, allowing for continued carbon dioxide exchange for photosynthesis. The influence of water stress on photosynthesis, however, extends beyond stomatal control. Fairly dramatic effects of tissue water deficits are expressed on chloroplast function at the biochemical and molecular levels. Though this topic is treated along with other metabolic consequences of water and temperature stress, it is clear at the outset that our knowledge of the molecular features of plant response to stress is meager.

Consideration is also given to long-term and seasonal integrated responses of native and agricultural communities to water and temperature stress. These types of studies, in conjunction with those summarized earlier in the volume, are providing the data bases for modeling efforts. In a paper by H. G. Jones, a stochastic model for plant response to water stress is developed. Though such activities are in an early stage of development, they demonstrate the potential for realistic predictive modeling of integrated plant responses to the environment as a means of evaluating productivity potential. The final section of the volume is devoted to the prospects of breeding plants better able to adapt to short- and long-term temperature and water stress.

The volume is well organized and illustrated, but it suffers from a problem common to this area of research: the lack of acceptable definitions and consistent usage of the terms "adaptation," "stress," and "acclimation." Kramer's introductory paper is devoted to this topic, and the problem is well illustrated in the book, since the contributors assume their own definitions and usage, making comparisons between some chapters difficult. Though the volume emphasizes plant responses to stress and their possible adaptive significance, it neglects treatments of mechanisms of stress perception and recovery from stress. Despite this shortcoming, many different and valuable perspectives on plant stress are successfully brought together, and the book provides important directives for future research. It should find its way to the bookshelves of a broad range of plant scientists.

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Paleobotany Surveyed

Paleobotany. An Introduction to Fossil Plant Biology. THOMAS N. TAYLOR. McGraw-Hill, New York, 1981. xvi, 590 pp., illus. $29.95.

This is the first textbook of paleobotany to be published in the English-speaking realm for more than a decade. The last one (Banks's *Evolution and Plants of the Past*, 1970) was a short overview of some major topics. The last textbooks comparable in size to Taylor's were Darrah's *Textbook of Paleobotany* and Andrews's *Studies in Paleobotany*, published in 1960 and 1961 respectively. This long gap is astonishing in view of the rapid progress that has been made in paleobotany over the last 20 years and the many major problems that have been elucidated during that time. It seems as if the rapid rate of paleobotanical discovery kept authors so much in suspense that they did not dare to attempt a comprehensive textbook. The lack of an extensive recent treatment of paleobotany has been felt not only in the classroom but also by those in other fields who wanted a summary of modern advances in paleobotany. Taylor's book fills both needs admirably.

The book is written in a readable style. The chapter arrangement is according to systematic group, with interspersed chapters dealing with major general topics—the early evolution of land plants