Book Reviews

Earth as a Productive System

Primary Productivity of the Biosphere. HELMUT LIETH and ROBERT H. WHITTAKER, Eds. Springer-Verlag, New York, 1975. viii, 340 pp., illus. $29.80. Ecological Studies, vol. 14.

The attempt to estimate the rate of organic production, or primary productivity, of the world's solar-powered natural systems has an interesting history. In 1862 Justus Liebig, the pioneer agricultural chemist and plant nutritionist, well known today for the concept of the law of the minimum, based an estimate of the dry matter production of the global land area on a single sample, a green meadow. Interestingly enough, his estimate of approximately 10^{11} metric tons a year is very close to the estimate of 118×10^9 tons a year for continental areas derived by the editors of this volume (see table 15-1, p. 306) on the basis of measurements in many vegetation types and with the use of models, computer mapping, and other modern techniques. On the other hand, Gordon Riley, in 1944, overestimated ocean productivity by basing his estimate on measurements in fertile inshore waters. It was not until the 1960's, after the introduction of the carbon-14 measurement technique, that the very low productivity of most of the open ocean was recognized. Since the oceans cover more than three times the area of the land, it was natural to assume, as did Riley, that marine ecosystems fixed more total solar energy than terrestrial systems. Actually, land seems to outproduce the sea, perhaps by as much as 2 to 1 according to estimates in this volume (of a total 173×10^9 tons of dry matter a year, 55×10^9 are estimated to be marine and 118×10^9 to be terrestrial).

This book is one of several recent collections of papers on productivity that are outgrowths of the International Biological Program (see also R. H. Whittaker and G. E. Likens, Eds., "The Primary Production of the Biosphere," *Hum. Ecol.* **1**, 301–369 [1973] and D. E. Reichle, J. F. Franklin, and D. W. Goodall, Eds., *Productivity of World Ecosystems*, National Academy of Sciences, Washington, D.C., 1975). It has 15 chapters arranged in four groups: Introduction and History, Methods, Global Patterns, and Utilizing Knowledge of Primary Productivity (the last being mostly about methodology and modeling). The heavy emphasis on methodology is understandable, for no two methods measure exactly the same quantity in the complex, stepwise flow of energy through plant populations. Chapter 3, by A. S. Hall and R. Moll, contains an excellent account and diagram of the total production process; this and the other chapters on methods are especially recommended to students who contemplate attempting field measurements. The disparity between land and water poses special difficulties. The techniques most widely used in the aquatic environment measure gross, or total, production, or some fraction thereof. In contrast, the harvest and similar methods widely used in terrestrial environments measure net community production, which is net primary production minus loss to consumers and decomposers during the period of measurement. Unfortunately, the editors of this volume chose to use net primary productivity as the unit for comparison. A large-biomass forest, where less than a third of the organic production may be "net," and a small-biomass, high-turnover plankton community just cannot be compared on this basis. There is much to be said for assessing productivity on the basis of gross production (that is, total energy flow through the organic system), since harvest and yield to man represent only part of the value of the plant cover. The myriad life-support functions (CO_2 removal, waste assimilation, nutrient retention, and the like) performed by the world's green belts constitute a large part of the "work of nature," and these functions are more directly related to gross than to net productivity.

In summary, this volume is a collection of well-prepared individual papers with little synthesis, except that several articles validate in detail what is already in textbooks, namely that for many ecosystem types primary productivity can be accurately estimated from data on key physical limiting factors, such as precipitation on land and nitrogen-phosphorus fluxes in water. Whittaker and Gene Likens do make a brave attempt at synthesis in the final chapter, entitled "The biosphere and man." These authors conclude that the carrying capacity of the globe for man has already been exceeded, even though man utilizes only a small fraction of the total organic output of the biosphere. Industrial pollution, exhaustion of mineral resources, the shortage of high-quality arable land, and the inherent instability of high-energy agricultural and industrial systems, rather than primary production, are viewed as the major factors limiting further growth of human populations and industrial development. Whittaker and Likens obviously subscribe to the general notion that the optimum or desirable population level for man is substantially less than the maximum human biomass that could be supported by maximum utilization of resources.

I believe we can say that the IBP has been successful in the inventory phases, but it now must be followed by a more direct analysis of the carrying capacity question. For such an analysis interactions between systems become more important than what goes on within systems. Accordingly, one approach would be to focus on the manner of coupling between the three major energy systems of the world, namely, the solar-powered natural systems, the solar-powered but subsidized agricultural food-fiber systems, and the fuel-powered, urban-industrial systems. Models could then be set up to simulate different spatial arrangements and outputs in order to determine optimum mixes of these elements, all of which are required for the survival of man and nature as a symbiotic whole.

EUGENE P. ODUM
Institute of Ecology,
University of Georgia, Athens

Assessing Danger

Of Acceptable Risk. Science and the Determination of Safety. WILLIAM W. LOWRANCE. Kaufmann, Los Altos, Calif., 1976. x, 182 pp. Cloth, $8.95; paper, $4.95.

"One can scarce be in the most humanized society," Sir Richard Steele observed in 1709, "without risking one's life." It is still true. Indeed, the march of civilization has recently brought us chemical pollutants unknown in nature,