

# Book Reviews

## Project at El Verde

**A Tropical Rain Forest.** A Study of Irradiation and Ecology at El Verde, Puerto Rico. HOWARD T. ODUM, editor and project director; ROBERT F. PIGEON, associate editor. U.S. Atomic Energy Commission, Washington, D.C., 1970 (available as TID-24270 [PRNC-138] from the National Technical Information Service, Springfield, Va.). Variousy paged, illus. \$10.

What effects do man's activities have on natural systems? Are some ecosystems more delicately balanced than others? And if so, why? How big a nudge does it take to make Mother Nature fall flat on her face? And can she get up by herself?

These are questions we'd all like answered. Ecology, the Great Green Hope, is obviously the place to get the answers. Some ecologists have ready answers, some don't. Most professional ecologists fall into the second category, pleading ignorance and asking for time and money for further research. The present book shows why "real" ecologists have reservations about answering such questions, and also shows how hard it is to find the answers.

The U.S. Atomic Energy Commission has supported studies of the effects of irradiation on ecosystems at several places. The present tome is a compendium of reports on their tropical study, done in a rain forest in Puerto Rico. The chapters fall into three main divisions: accounts of the biology of various groups of tropical forest organisms, reports of the effects of irradiation on these species, and discussions of the forest as a system.

Once I made my first survey of this vast book, I realized that I was far from the ideal person to review it. The main work was on the flow of matter and energy in the forest as a whole, whereas my own interests are in what the editor and project director, H. T. Odum, classifies as the systems which control these movements. This book

covers exhaustively the general metabolism of the forest, but scarcely touches on the control systems.

Faced with 111 chapters by 94 authors, mainly dealing with subjects which are peripheral to my own research interests, I decided that the only course was to review in detail those aspects I did know something about and give my impressions of the remainder. Since I have been studying the population ecology of rain forest trees, I will deal mainly with those parts concerning plants in the first two divisions described above. At the end I will comment on the sections dealing with the forest as a system.

As in the AEC projects in other areas, the design of the irradiation experiment was fairly straightforward: an area was irradiated with a strong source, the damage measured, and the process of recovery followed. An adjacent "similar" area served as a control. Two other sorts of damage were also inflicted on nearby sites: cutting all green matter by hand, and applying herbicides to the soil or foliage.

The design was simple, the execution terribly complicated. The four study areas, although near each other, differed in the kinds and sizes of trees, in details of topography, and in any number of other unknown ways. The areas were badly trampled when they were being mapped, but the irradiated area was probably much the most heavily disturbed beforehand. Because of the radiation danger a fence had to be built, and this plus other costs meant that there was no replication at all, except on the more distant herbicide treatments. Because of natural variability in time and space, the first rule in doing field experiments is replication. The second, if comparisons are to be made between different areas, is that treatments should be similar. Unfortunately, this wasn't so at the different AEC sites. At El Verde, the forest was irradiated almost continu-

ously for three months, whereas in the earlier, temperate-forest experiment at Brookhaven, New York, the forest was irradiated for 20 hours a day over a much longer period. Comparisons were also made with other experimental irradiations in Georgia, but I could not discover from this book whether the treatments there were the same as or different from those at El Verde.

What were some of the results emerging from these experiments? First, radiation was attenuated faster in the tropical forest than in temperate forests (p. C-42) (although it isn't clear whether the measurements were made after or before the damage had occurred). Second, reestablishment of woody vegetation may be slower after a tropical forest is damaged by radiation or herbicides than after the vegetation is simply cut. This conclusion is based on the fact that after the first two treatments herbaceous vegetation got established because most of the existing woody plants, including seeds, were killed. In contrast, many of the trees in the cut area were not killed, and these sprouted new branches; also, there was an explosion of new seedlings which quickly shaded the ground and evidently prevented herbs from sprouting.

Unfortunately it is often difficult to verify some of the conclusions because of apparent inconsistencies in the book. Figures and text sometimes don't agree, and often it is difficult to determine which area or subset of the data an author is referring to. Of the chapters I read closely, some are quite complete and others are more in the nature of progress reports than of finished scientific papers. At least two authors dealing with similar subjects were apparently not aware of each other's chapters. Thus on page D-205, an author maintains (without supporting data) that only one species became more abundant after irradiation in the zone receiving at least 35 kilorads, that is, within 10 meters of the source; yet in another chapter, page D-139, counts of seedlings in the same zone show that 3 species increased greatly, 9 species disappeared, and 13 new species arrived after irradiation. These authors also disagree in comparing the effect of radiation on temperate and on tropical forests: On page D-133 "the above evidence does not show that tropical rain forest vegetation is any more sensitive or resistant to irradiation than temperate oak-dominated forests"; on

page D-211 "the tropical forest appears to be more tolerant to radiation than temperate forests." My own feeling is that no such sweeping judgments can be proffered on the basis of these pilot experiments, with their obvious differences in treatments and with no replication to estimate the amount of natural variability. The question of how delicate is the balance of nature is obviously not answered in these experiments. The fault lies partly with the design of the experiments, but also is an inevitable consequence of the difficulty in doing field experiments. Experimental sites will be trampled, all difficulties cannot be foreseen, recovery after disturbance takes time. This is why working ecologists are cautious about making pronouncements of the effects of a disturbance of a natural ecosystem.

In the sections dealing with the forest as a system, Odum has tied together many of the findings in the other sections. In addition, he has constructed theoretical models of the whole system using "network diagrams" of power flows and control circuits. Most of the experimental data concern the power flows rather than the control systems. Odum has always used highly original approaches in his work, but his experiment at El Verde, in which he enclosed a whole section of forest in a plastic cylinder 60 feet in diameter and 67 feet high, is undoubtedly his most heroic one to date. The experiment was only partly successful, since some of the upper air was lost in eddies out the open top of the cylinder, but the device still served as a giant respirometer of the lower vegetation and the forest floor. With it, and numerous other ingenious experiments, he and his colleagues have made measurements of the metabolism of a sample of one of the most complex systems in the world.

I found Odum's circuit diagrams difficult to understand. The terms in the glossary of "modules of energy—circuit language" and the illustrative examples on pages A-6 to A-8 are not explained clearly enough to enable me to decipher the diagrams later in the book. A clearer explanation of the symbolism is given in Odum's recent book *Environment, Power, and Society* (Wiley, 1971; reviewed in *Science* 14 May).

Much of the summary chapter is devoted to compiling data on the biomasses of the different components

and summarizing the energy and cycling of matter. Animals and microorganisms do not loom large in these power flows; animals weighed less than 0.1 percent of the total biomass. I hope, however, that readers will not be led to the conclusion that the importance of animals in the control circuits is proportional to their weight. Such an impression would be as misleading as evaluating the importance to a heating system of the thermostat by comparing its weight to that of the furnace. As Odum points out (p. I-273), the next urgent need is to study the control system.

Relatively little reference is made to work in rain forests elsewhere; this is understandable, for few other studies have gone beyond measuring biomass. The metabolism of the El Verde forest is compared to that in rain forests in Thailand and Panama and in plantations in Europe and Puerto Rico. It is difficult to decide whether the differences are real or due to differences in techniques or to errors. Whether the findings from El Verde will prove of general applicability only time will tell. The site has a degree of uniqueness, being on an island whose flora and fauna are less diverse than those of the mainland, and in a forest recovering from selective cutting about 25 years prior to the study. But all ecological field studies are site-bound to a degree, as ecologists know to their sorrow.

Within the constraints of my interests, competence, and time, I have not been able to review in any detail some of the chapters on plants, or most of those on animals, microorganisms and fungi, cytological studies, mineral cycling, and forest metabolism. Specialists in these fields will need to judge for themselves; they will undoubtedly find much of interest.

Its weight (10 pounds), thickness (3 inches), and length (1644 pages) make this an extremely unwieldy book to carry or to read, even without attempting to refer from one chapter to another. However, the price would make it a best buy in any consumer index. Although nobody would use it as a handbook in the forest, it will be very useful as a basis for future work in the American tropics, as well as a stimulant to students of tropical forests elsewhere.

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## The Future of Deserts

**Arid Lands in Transition.** Proceedings of a symposium, Tucson, Ariz., June 1969. HAROLD E. DREGNE, Ed. American Association for the Advancement of Science, Washington, D.C., 1970. xiv, 524 pp., illus. \$15.75; to members, \$13.50. AAAS Publication No. 90.

The purpose of this conference was to contribute to a better understanding of the wise use of arid lands in different parts of the world, under different economic conditions and in countries in different stages of economic development. The papers include contributions from the physical, biological, and social sciences.

Perhaps the most significant feature of the proceedings is the movement toward a consensus by the ecologists and the developers concerning the potential for development and utilization of the world's arid regions. The traditional disagreement, posing man's responsibility for preserving the fragile ecological environment of the arid regions against the urge to make the desert bloom, is not completely absent, but it is considerably muted.

There is considerably greater disagreement regarding the economic welfare of the people who are forced to seek their livelihood in the arid regions. Kelso points out that among the world's arid regions "only the western United States . . . may be said to have escaped fully the restraints of aridity and entered into internally generated economic development," and this escape was possible primarily because the arid areas of the United States are part of the hinterland of a dynamic, urban-industrial economy in which the primary sources of growth lie outside the arid region. Unfortunately there is no easy escape from the lament, expressed by Dregne, "If a nation must be wealthy before it can provide modern services to all members of the rural community, the future is bleak for this and immediately succeeding generations in most of the arid regions." The arid areas of the American west can best be characterized as "low-density urban regions." It is unlikely that dependence on agriculture can be substantially reduced in most arid regions over the next several decades. And it is almost certain that most of the people who earn their livelihood in the arid regions will remain poor.

The most successful papers in the