amount of farmland and energy available for agriculture are restricted to current levels and if crop yields decline by 0.6% per year due to erosion. Even in less pessimistic scenarios, rising energy costs will prevent the use of energy-intensive inputs from compensating for land degradation.

*Beyond Oil* remains one of the most valuable books on energy analysis and the economy. Nevertheless, reading it in the context of other work on energy efficiency is frustrating. In an afterword to this edition, some of that recent research is mentioned, but the authors do not explain how their earlier conclusions are affected by subsequent findings. Can efficiency improvements in cars, appliances, and other end uses reverse the economic effects of a decline in energy profit ratios? Can new technology enable us to avoid the growing conflict between high productivity (high-wage jobs) and full employment as long-term energy costs rise? Can the increases in the GNP/energy ratio continue indefinitely? In short, there seems to be a gap between the pessimism of *Beyond Oil* and the hopefulness of Amory Lovins on the question of whether conservation and technological change can preserve current living standards. Who is right? We would all benefit from a direct exchange of their views.

CLIFFORD COBB
*811 28th Street*
*Sacramento, CA 95816*
*USA*

## DYNAMICS OF COMPLEX INTERCONNECTED BIOLOGICAL SYSTEMS

*Dynamics of Complex Interconnected Biological Systems*. Thomas L. Vincent, Alistair I. Mees, and Leslie S. Jennings (Editors). Birkhäuser, Boston, 1990, ISBN 0-8176-3504-1.

This volume contains the proceedings of the U.S.–Australia workshop on Complex Interconnected Biological Systems held in Albany, Western Australia, January 1–5, 1989. The book provides an interesting and informative review of some recent work in complex systems modeling applied to biological systems. The book should be of interest to both economists and ecologists interested in the problems of modeling complex systems, but be forewarned that little extra effort is expended to explain the mathematics to the uninitiated. There are two relatively introductory chapters (the first chapter of the book by M.A.B. Deakin and a later chapter introducing the "tools" section by A.I. Mees) but, while they are clear and informative, they both assume a relatively high level of previous exposure to the material. It is also mainly a book about modeling relatively *simple* biological systems that exhibit rather complex behavior, rather than a guide to modeling real ecological or economic systems which are complex to start with and whose behavior is that much more complex. While the former is no doubt useful for the latter, the book spends precious little time drawing out how this linkage is ultimately to be made.

The workshop participants included applied mathematicians, control theorists, mathematical biologists, and biologists. Each paper is supplemented by reviews by two other conference participants. The papers are grouped into three sections: (1) modeling; (2) tools; and (3) games. The modeling section includes the introductory paper by M.A.B. Deakin dealing with the general problems of modeling complex biological systems set in the context of the history and philosophy of science. Deakin emphasizes the growing concensus that

complex systems are predictable only to a limited degree, and that this recognition leads to new approaches to understanding and controling them. The Laplaceian paradigm of the perfectibility of mathematical understanding is not an adequate approximation for many — if not most — non-linear, discontinuous biological systems, and certainly for complex ecological and economic systems. As work in chaos theory has shown, even *simple* non-linear models of "biological" systems can exhibit complex and unpredictable behavior. Real, *complex* biological systems almost invariably exhibit a high degree of unpredictable behavior. The modeling section continues with several papers on specific systems, including: (1) the rock lobster fishery of Western Australia by N.G. Hall, R.S. Brown and N. Caputi; (2) competition between two strands of sub-clover by A. Pakes; (3) pattern formation in chemotactic systems by M.R. Meyerscough et al.; and (4) control of blood glucose levels in diabetics by insulin infusion by M.E. Fisher.

The tools section contains papers describing methods useful in analysis of a wide range of biological systems, such as chaos theory and scaling techniques. The four papers on chaos theory include: (1) a general (but somewhat cryptic) introduction to the subject by A.I. Mees; (2) two papers on identifying structure in chaotic systems by J. Glover and K. Judd; and (3) a paper investigating the question of whether or not the solutions obtained by difference approximations accurately represent the solutions of the original differential equations in the case of chaotic systems by W.J. Grantham and A.M. Athalye. Other papers in this section discuss: (1) a highly mathematical theory using "impulsive evolution equations" by P. Diamond; (2) the usefulness of scaled dimensionless variables in analyzing biological models by D.L.S. McElwain; and (3) a numerical technique of optimal control applied to harvesting problems by L.S. Jennings and K.L. Teo.

The third section on evolutionary games contains two papers investigating the development and distribution of evolutionary stable strategies in the context of a Lotka–Volterra competition model by T.L. Vincent and J.S. Brown. The other two papers in this section focus on game-theoretic aspects of human intervention in biological systems, one involving a general model of exploiters and conservationists (by Y. Cohen) and the other examining harvesting of commercial marine fish stocks (by R. McKelvey).

Thus the book is a good theoretical reference for those already somewhat familiar with complex systems modeling, chaos theory, and the like, and does not attempt to serve as an introduction to ecologists and economists to this exciting field, nor as a practical guide to modeling real systems.

The bottom line: get this book if you already know a little about complex systems modeling and would like to know more, especially about some of the theoretical aspects.

ROBERT COSTANZA
THOMAS MAXWELL
*Maryland International Institute for*
*Ecological Economics*
*Center for Environmental and Estuarine Studies*
*University of Maryland, Box 38*
*Solomons, MD 20688, USA*

## COMMUNITY AND THE ECONOMY

*Community and the Economy: The Theory of Public Co-operation.* Jonathan S. Boswell. Routledge, London, 1990, 240 pp., £30.00, ISBN 0 415 05556 3.