Order from Chaos? Making the Case for a General Theory of Ecology

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Source: BioScience, 62(4) : 435-436

Published By: American Institute of Biological Sciences

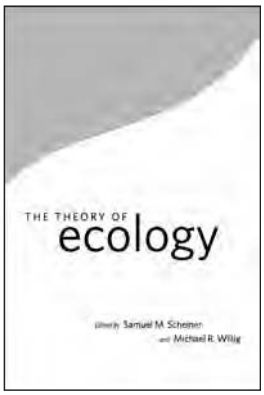
URL: https://doi.org/10.1525/bio.2012.62.4.14

Order from Chaos? Making the Case for a General Theory of Ecology

The Theory of Ecology. Samuel M. Scheiner and Michael R. Willig, eds. University of Chicago Press, 2011. 416 pp., illus. $40.00 (ISBN 9780226736860 paper).

The Theory of Ecology is an edited volume about the central domain and core theoretical concepts of ecology. Twenty-one contributors review the corpus of theory that guides ecologists in their studies while also presenting the defining concepts of and assumptions and beliefs about what they consider to be the most important branches of ecological theory. In the process, the authors recapitulate the history of ecological theory, discuss recent advances in the field, and present their vision of which direction the discipline may take in the future. The product is a useful summary of the development and current state of ecological understanding. As such, the book will be well received as a reference for graduate students and researchers. Editors Samuel M. Scheiner and Michael R. Willig clearly intended the book to be much more than a review of existing knowledge, however. In presenting the historical and ongoing evolution of ecological thought, they strive to demonstrate the maturity and utility of ecological theory, with the ultimate goal of establishing the foundation for a general, unifying theory.

This volume represents the culmination of a workshop, held at the University of Connecticut, during which the contributors took on the task of identifying and explicating the key foundational, current, and emerging concepts that could form the components of a general theory of ecology. This is not a trivial task. Ecology is perhaps the most interdisciplinary of the natural sciences, encompassing as it does a seemingly infinite array of evolutionary, biological, and physical processes that influence the abundance and distribution of organisms. Given the extraordinary scope of ecological studies, the establishment of a unifying theory of ecology would be an astounding achievement. Indeed, the modern science of ecology asserts as its purview the molecular basis of species diversity; the physiology of individuals; the temporal and spatial dynamics of populations, communities, and metacommunities; the causes of species-distribution patterns at every imaginable spatial scale; and even the causes of global climate change. Can an internally consistent framework of laws, propositions, and models be found that rigorously binds the vast enterprise of ecology under a single theoretical framework? The authors of this volume not only think it can, but they propose a detailed, hierarchical scaffolding on which to build such a theory. That is not to say that the contributors are in solidarity concerning which major subdiscipline should lead the way. The impression that one gets is that any one of the formative branches of ecology could serve as the foundation for a general theory, and the contributors often present them as such.



The book is divided into 15 chapters, organized into three major sections: an introduction (three chapters), "Constituent theories of ecology" (11 chapters), and a synthesis (one chapter). The introductory chapters discuss the conceptual and empirical basis for a general theory; compare and contrast past and present developments; and suggest which ecological concepts, beliefs, and constituent theories represent the foremost body of work that could form a general theory. The remaining chapters—save the last—establish the domain, constituent theories, and models that differentiate the major branches of ecology. The contributors present key propositions that define the theoretical components, or the primary hypotheses, of their chosen subdiscipline. They then elaborate on each proposition, elucidating its conceptual background and, if they are available, comparing specific models. The authors of each chapter frequently draw on the foundational work of the pioneers of their various fields and summarize recent work of their own and that of others.

By linking early conceptual development to recent advances, the contributors construct a view that encapsulates the current state of each major branch of ecological theory. In the final chapter, Scheiner and Willig selectively discuss specific points of the previous chapters. More important, they summarize several continuing challenges that impede the establishment of a predictive general theory, including the difficulty of understanding ecological patterns and processes that arise from multiple causes and the need to better integrate theoretical and applied topics.

For an edited volume, the writing style varies considerably among the chapters. I found the writing of some authors to be discursive and unduly philosophical, whereas the terse style of others appealed to me. Overall, the contributors succeed in presenting their ideas and opinions clearly and with sound arguments.

doi:10.1525/bio.2012.62.4.14

The subdisciplines selected for this volume fit into major themes that are widely recognized as fundamental to the field: foraging theory, population dynamics, predator–prey interactions, metacommunities, succession, the equilibrium theory of island biogeography, ecosystem ecology, global change, and gradient theory. More recent theoretical advances, such as the unified neutral theory of biodiversity and biogeography and the metabolic theory of ecology, are given only passing attention. The latter theories are noted in the book primarily to illustrate key points concerning the role of empirical patterns in the development of models or to add support to the major topics presented. The neutral theory and metabolic theory have generated much recent debate but have also sparked controversy, and it may be that the editors considered these developments to lack the level of maturity required for inclusion in a general theory at this time.

As is customary in the field of ecology, theoretical ideas and models are, for the most part, presented verbally and graphically (e.g. flow charts) with minimal use of mathematical formalism. (Chapter 7, "Natural enemy–victim interactions," is the sole exception.) Ecologists have traditionally turned first and foremost to descriptive narrative—often with the use of compelling conceptual arguments—to expound theoretical explanations for natural phenomena. This preference for conceptual description (and the use of null-hypothesis testing, see below) has earned ecology a reputation as a "soft" science in some circles. The editors and most of the contributors of this book clearly feel otherwise and have framed ecological theory as being mature, predictive, explanatory, and eminently useful. For example, in chapter 2, Jurek Kolasa argues that conceptual ideas and qualitative propositions are every bit as fundamental and useful as quantitative models for the development of theory. By contrast, Robert Holt, in chapter 7, writes, "It may not be possible to adequately describe, understand, or even identify the basic propositions of a theory without having a formal model at hand" (p. 126). I think many would agree with Holt, particularly scientists outside of ecology. Prediction and verification are particularly dependent on formal models, and despite the editors' enthusiasm for a conceptual framework, the integration of concrete formalism remains a major challenge for a general theory of ecology.

On the whole, Scheiner and Willig have succeeded in assembling the essential components of a general theory. However, although the content of the book is broad and philosophically rich in its exposition, the editors have overlooked two important problems: The first is the Sisyphean task of integrating into a whole the immense scope of topics that ecology investigates. The second is the many failings of the current approach to testing and validating theory. During the mid-twentieth century, ecologists adopted deductive falsification as their principal experimental method. In both natural and manipulative experiments, ecologists continue to rely heavily on null-hypothesis significance tests (NHST) to ascertain the validity of a theory. But it is now widely recognized that by constraining hypotheses to those that can be falsified, NHST leave out a universe of alternatives that could illuminate a much broader range of possible explanations. The use of NHST steers the development of theory along canalized conceptual constructs that limit advancement. This failing has led other fields that once relied on NHST, such as medicine and psychology, to abandon this method for less restrictive ones, such as model selection and Bayesian analysis. To their credit, ecologists are beginning to incorporate these methods as well. Yet until ecologists address the impact of NHST on their ability to test and validate constituent theories, the goal of developing a rigorous, predictive general theory will remain elusive. These failings aside, I believe *The Theory of Ecology* will enliven the debate over what should encompass a general theory of ecology—and whether that is even possible.

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EPTESICUS OBFUSCATION

Bats. Phil Richardson. Firefly Books, 2010. 128 pp., illus. $19.95 (ISBN 9781554078035 paper).

According to its back cover, the book *Bats* is intended to provide "a guided tour of the nocturnal world of bats," illustrating the major aspects of bat diversity, biology, ecology, and conservation, with examples of species from around the world. Developed and published in the United Kingdom by the British Natural History Museum, *Bats* is written for a general audience. Author Phil Richardson was a career science teacher and is a dedicated bat ecologist who has been working to promote bat conservation and research in the United Kingdom for more than 30 years. Had I received this book to review some 15 years ago, I would have considered it a fairly enjoyable introduction to bat families and bat natural history. I might have expressed some concern about the technical inaccuracies, inconsistencies, and generalizations that are scattered throughout the volume, but I would have acknowledged the book's nice illustrations and its wealth of color photographs, and complimented the author's comprehensive treatment of the material and his engaging style of writing. Today, however, I am immediately aware that much of the opening chapter, "Bat evolution and biology," is at least 10 years