scatterplots. He discusses examples of statistical thinking in Schrödinger's view of the thermodynamics of life, in Fisher's formulation of the fundamental theorem of natural selection, in Lotka's models of population dynamics, and in chaos theory. He notes that, in many cases, biological systems behave as stochastic systems subject to particular constraints. As in chaotic systems, while it may be impossible to predict exact future states of a particular system, it may nonetheless be possible to characterize the probabilities of future states. The processes that constrain those probabilities are what fundamentally interest Maurer.

The link from statistics to theory in this book is less clear. Much of the book involves thoughtful examination of models of population or community behavior, whether or not they derived from large-scale statistical analyses. For example, a chapter is devoted to linear models of population processes (e.g., Lotka-Volterra models) in an admittedly non-linear world. Maurer examines time-series of species abundances in a desert rodent assemblage and notes that, despite their over-simplifications, linear models reproduce the dynamics reasonably well over short time scales. Such models are, in Maurer's words, ''a temporary way of getting at the complexity [of much of the behavior] of biological communities.'' A chapter on non-linear models of community dynamics then follows. Maurer re-analyzes the same rodent data using a model that separates deterministic chaotic components of the dynamics from random components. Although the comparison is interesting, Maurer concludes that, ''ecologists simply cannot collect, much less conceptualize, the amount of information that would be necessary to identify precisely why species densities change the way they do.'' Complexity, says Maurer, is partly a consequence of seeing only part of a system.

The book continues with a surprisingly brief chapter on macroecology. In it, Maurer extends his earlier work on North American breeding bird distributions to a model of the evolution of body size in birds. A further chapter examines the spatial structure of bird distributions (higher population density near the center of the distribution than at the edges) and asks whether this may contribute to patterns such as species-area relationships, or nestedness of species, distributions. A final chapter leaps somewhat incongruously to a model relating species richness within clades to rates of speciation and extinction.

I found this work to be, by turns, fascinating and frustrating. As the heart of macroecology seems to be the search for broad patterns in nature, I had expected the book to contain more exploration of large data sets to that end. However, the data in the book are familiar from earlier papers by Maurer, Brown and their collaborators. The book does not deal, at any length, with the work of other authors who have used similar approaches (e.g., Peters, Rosenzweig, McNaughton). At the empirical level, the book stays on familiar ground.

Nor is this book about ecological complexity writ large, as the title suggests. Its focus is the composition and relative abundances in species assemblages. The book does not stray into questions such as patterns of productivity, species richness, or food webs. But these are quibbles about the book that Maurer didn't write.

My main objection to the book that Maurer did write is that it proposes no metric to judge whether his approach is better than any other. Maurer says that his goal is to explain how patterns in nature arise, to establish causal relationships, to understand. Yet how shall one know that one has explained, established causal relationships and understood? Maurer reaches a conclusion: ''. . . the only way to differentiate between general explanatory theories is by their predictions.'' But he immediately balks, rejecting predictive power as the criterion by which the progress of science is to be measured. Predictive theory too often lacks ''conceptual rigor.'' For the rest of the book, I was left to wonder whether the conceptually interesting approach that Maurer presents is in fact more rigorous, or makes better predictions about nature, than the small-scale approaches he criticizes. Yet this book is conceptually rich. And it does go beyond the ''conceptually agnostic'' presentation of patterns that characterizes much large-scale work. It is a very interesting work that may well have a profound impact on its field, at least in part because it contains so much that other readers will want to challenge and debate.

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More Than the Sum of Its Parts

Pace, Michael L., and Peter Groffman, editors. 1998. **Successes, limitations, and frontiers in ecosystem science.** Springer-Verlag, New York. xviii + 499 p. $99.95 (cloth), ISBN 0-387-98476-3 (acid-free paper); $49.95 (paper), ISBN 0-387-98475-5 (acid-free paper).

A plant ecology seminar speaker I once heard while I was a graduate student at Duke University shared a story that I have never forgotten. He said that, as an ecologist, he had been criticized by a colleague for being in a scientific field with no unifying concepts, in the way, for example, that physics and chemistry have the laws of thermodynamics. His retort to the colleague was that the field of ecology, to the contrary, did have a unifying concept—that of the ecosystem. Indeed, the concept that living organisms interact with their physical environment in a special, unique fashion is one that has been as essential to those of us within the discipline of ecology as it is misunderstood by so many outside the discipline.

This idea of placing components of the physical environment on par with living organisms can be traced back to the 19th and even 18th centuries. Consider the work of Humboldt and later Möbius and Thienemann of Germany, and Vernadsky of Russia. Thus, when Tansley first coined the term ''ecosystem'' in his classic paper of 1935, rather than develop a new concept, he articulated in a newer, clearer way an approach to studying nature that was more palpable to ecologists of the 20th century. His insights eventually galvanized a new sub-discipline of the field of ecology—ecosystem science.

And now, 65 years after what was essentially Tansley's invective on Clements's superorganism, critical questions might be asked of this new sub-discipline: from its uncertain beginnings, how has ecosystem science fared in the past, what is it doing now, and where is it/should it be going in the future? Pace and Groffman address these questions quite competently in their book, *Successes, limitations, and frontiers in ecosystem science,* adding measurably to the recently growing literature on the history of the ecosystem concept.

This book is derived from the 7th Cary Conference held in Millbrook, New York in May 1997. Pace and Groffman have edited 18 papers from the conference as chapters in their book, also providing introductory and synthesis chapters. They divide it into three sections corresponding to the three facets of their examination of ecosystem science: Successes, Limitations, and Frontiers.

Edited volumes are challenging to review, and this one is no exception, containing 18 single- to multiple-authored papers (a total of 40 authors/co-authors), each with a different writing style and specific focus. Accordingly, in my review I will provide a brief statement concerning the primary aim of each chapter, but will make critical comments generally regarding the book as a whole.

Chapters of the first section—*Successes*—emphasize ways in which ecosystem science has been successful in the past either in addressing and abating environmental problems or in providing insight and understanding regarding ecological processes and interactions. Smith (Chapter 2) explains how an understanding of nutrient limitations, particularly by nitrogen (N) and phosphorus, has led to solving problems of eutrophication in several aquatic ecosystems. Dale (Chapter 3) ties the studies of forest ecosystems to improved (i.e., ecosystem) management of forests, making analogies between responsible resource management and medicine with a poignant reiteration of a speech by her father, a physician. Zedler et al. (Chapter 4) provide a historical perspective on societal views and values concerning wetlands, making a strong link between advances in the study of wetland ecosystems and the preservation of wetlands. Lowrance (Chapter 5) describes the parallels between research in riparian forest ecosystems and increased awareness of the importance of maintaining riparian zones. Robertson and Paul (Chapter 6) describe the contributions of research in agroecosystems to understanding the importance of soil (especially N and organic matter) dynamics in all terrestrial ecosystems. Burke et al. (Chapter 7) emphasize the role of regional- and global-scale biogeochemical studies in our understanding of impacts of climate change and land use. Weathers and Lovett (Chapter 8) give a historical perspective on the benefits of research on acidic deposition to ecosystem science and the interaction of these areas with public awareness. MacMahon (Chapter 9) highlights the mutual benefits of ecological research and the restoration of degraded ecosystems.

Realizing that not all ecosystem research has been successful but wisely avoiding a painful recall of failures, Pace and Groffman use the second section—*Limitations*—to consider ways in which ecosystem science has been challenged. Likens (Chapter 10) considers intellectual challenges, including the increasing ''busy-ness'' of ecosystem scientists in their careers, and even proposes a relationship between scholarly output and frequent flier miles! Walters (Chapter 11) sees these challenges as the all-too-often conflicting agenda of, and associated insufficient communication between, ecosystem scientists and natural resource managers. Carpenter (Chapter 12) offers a segue from this section to the next (and in fact is placed in neither by Pace and Groffman in their introduction) by calling for more connections between basic and applied ecology, especially through the use of large-scale experiments.

The final section—*Frontiers*—uses past and on-going ecosystem research as a springboard to suggest directions the field should take for the future. Folke (Chapter 13) emphasizes the need to consider *Homo sapiens* as an integral component of virtually all ecosystems, especially in addressing management issues. Wessman and Asner (Chapter 14) consider remote sensing as an essential tool to study vital links between large-scale ecosystem structure and function. Zak and Pregitzer (Chapter 15) stress the need to integrate ecophysiology with biogeochemistry to better understand ecosystem dynamics. Lauenroth, et al. (Chapter 16) discuss past, current, and potential roles of simulation modeling in ecosystem science. Breitburg et al. (Chapter 17) present the challenges of studying effects of multiple stressors on ecosystems. Vitousek et al. (Chapter 18) use a simple simulation model to suggest mechanisms to minimize nutrient (e.g., N) accumulation and maintain nutrient limitation. Tilman (Chapter 19) suggests that species composition can be both a response and driving variable in the context of global change, calling for a new research initiative to understand more clearly the ecological significance of biodiversity.

No review would be adequate that did not point out inevitable problems with a book. I should state up front, however, that I found these to be minor in magnitude, relative to the contributions this book makes to ecosystem science. The keynote address at the Conference was given by Timothy Wirth, Undersecretary of State for Global Affairs. Although he is doubtless quite busy, it would have been a nice touch to have used at least part of his address as a preface to the book. Despite the organization of the book in three distinct sections, there is no clear separation of the chapters into these sections. One learns of this organization only through reading Chapter 1. A short synthesis/synopsis before each section also would have been useful. Finally, there was a surprisingly large number of errors throughout the book, including omitted words, lack of uniformity in expression of units, and misspellings.

Clearly, though, the assets of this book more than outweigh these liabilities. Pace and Groffman have assembled excellence among their authors, who do not disappoint, all drawing competently from their own work and that of others in their respective areas of ecosystem science. Among the many ways in which this book should contribute to its field, two stand out as particularly noteworthy. First, it addresses ecosystem science as a discipline that is to a large degree problem-driven. Drawing on appropriate analogies with the medical profession (as did Dale in Chapter 3), Pace and Groffman seem to suggest that we should be proud to contribute to solving some of the issues that threaten humanity on a global scale. Our science responds to an environmental problem and potentially derives benefits both basic and applied—gaining new understanding (basic) and solving the problem (applied). Second, this book reiterates the need to view humans as inseparable components of virtually all ecosystems, underscoring the ways we both influence and depend on them. Through their excellent selection, organization, and synthesis of diverse topics, Pace and Groffman have produced a whole that is more than the sum of its parts.

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DEDUCING THE GENERAL PRINCIPLES OF VASCULAR PLANT STRUCTURE AND FUNCTION

Schieving, Feike. 1998. **Plato's Plant: on the mathematical structure of simple plants and canopies.** Backhuys, Leiden, The Netherlands. xi + 360 p. $93.50, Dutch Guilders 168.00, ISBN: 90-5782-003-X.

In the early part of this century, the classical works of D'Arcy Thompson, Cecil Murray, and Julian Huxley inspired the viewpoint that the complexity of whole-organism form could be shown to follow general principles. These principles were hypothesized to stem from physical and biological constraints and were reflected in mathematical regularities such as phyllotaxy, allometry, morphology, branching patterns, and numerous other aspects of whole organism anatomy and physiological functioning. Certain aspects of this viewpoint were integrated into the development of modern zoology. In contrast, botany has not traditionally been guided by such mathematical formalisms. In last few decades, however, several integrative themes of botanical research have emerged including: allometry, hydraulic architecture, biomechanics, whole-plant physiological modeling, and applications of fractal geometry. Together these approaches have shown how physical and biological principles influence whole-plant form, function, and evolution. For example, recent work by K. J. Niklas has proposed that the evolution of vascular plant form represents a reconciliation of a few critical constraints such as: (a) light interception, (b) biomechanics, (c) hydraulic limitations of transporting resources, and (d) the need for maximizing reproductive output in differing environments.

Plato's Plant is a provocative attempt to treat plants as entities reflecting a deeper truth. As in the studies mentioned above, its central thesis is that plant form and function are integrated by a set of principles following physical and biological laws. This thesis is based on the premise that in any given environment plant form represents an optimal configuration of various functions. Natural selection is assumed to act upon each component (canopy, root, and reproductive components) to maximize net photosynthesis, reproductive output, and growth. The author's goal is "to determine [the] ideal principles by which a plant is driven."

The book is organized around the development of the idealized "Plato Plant" model. Chapter 1, "On canopies, light, and nitrogen," focuses on the interactions of nitrogen distribution and canopy leaf area. Here Schieving does not distinguish individuals and only models the canopy as an entity. Under simple assumptions of nitrogen limitation the author derives an optimal canopy leaf area and leaf-photosynthesis-light curve. Chapter 2, "A leaf area game," considers the consequences of optimal canopies consisting of individuals. The rates of net photosynthesis for various plant "types" are allowed to vary in canopy area and nitrogen distribution. The author demonstrates that an evolutionary stable strategy (ESS) exists where for a given leaf area nitrogen use efficiency is maximized at every height. By considering the ESS it is shown how the total canopy leaf area and nitrogen distribution of stands consisting of individuals must be higher than the "optimal canopies" derived in Chapter 1. In other words, within Schieving's framework, any individual that maximizes its leaf photosynthetic nitrogen efficiency will eventually outcompete plants having an optimal nitrogen distribution and leaf canopy area.

Individuals are allowed to grow in size in Chapter 3. Change in biomass is modeled by a series of differential equations and kinetic reaction equations of carbon and nitrogen uptake in shoots and roots. In non-fluctuating environments, maximization of growth is shown to represent a "functional balancing between roots and shoots" which depends on the limiting resource (nitrogen or light). This also gives the interesting prediction that increases in accessible nitrogen should lead to an increase in the concentration of plant tissue nitrogen and decreases in net carbon content. In contrast, increases in light intensity will lead to an increase in net carbon content.

The last three chapters, "An optimal control of Plato's Plant," "Equations of functional equilibrium," and "Equations of motion" include extensions of dynamic optimization models of allocation. Here the central problem is how to best allocate biomass to leaf, stem, and reproductive biomass at any given time so as to maximize the production of reproductive mass. Plant allocation is modeled through differing growth strategies including sudden and gradual transitions from vegetative to reproductive allocation. Most importantly, Schieving shows how variation in resources can influence seed production. The chapter "Equations of functional equi-