lou's *Mathematical ecology* presents a comprehensive survey of the mathematics, but the language and pace of her exposition are geared towards an audience already familiar with mathematics. In a new textbook, Vandermeer attempts to provide students with an easy entry point into quantitative ecology. The book is designed to be a guide to mathematical literacy as opposed to a treatise on the theory itself.

Instead of authoritatively developing mathematical results, Vandermeer uses extensive problem sets that lead students to their own discoveries. These exercises, which are well integrated with the text and provided with detailed solutions, represent the best aspect of the book. By gradually building from calculations of exponential population growth to calculations of eigenvalues for linearized systems of differential equations, Vandermeer makes his material accessible to anyone with even a foggy memory of calculus. I am not convinced, however, that this book delivers an adequate introduction to the tools and language of mathematical ecology.

The first third of the book concerns the dynamics and demography of single populations. The discussion proceeds from the logistic equation to Leslie matrices and life history calculations. The concept of reproductive value is never mentioned and there are no references to the extensive literature on life history theory. Vandermeer's treatment of difference equations typifies the problems he has developing underlying mathematical principles. Using a strictly graphical approach, Vandermeer "demonstrates" the relationship between the eigenvalues of $N(t + 1) = F\{N(t)\}$ and the qualitative behavior of equilibrium points. Although the graphs are illuminating, they should have been complemented with a formal Taylor expansion and comparison to the linear system $N(t + 1) = \lambda N(t)$. Students following Vandermeer's guide to difference equations will learn the mechanics of single-species stability analysis, but they will not understand why the analysis works, in what sense it is only a local analysis, or how it generalizes to multispecies difference equation models.

Vandermeer devotes one chapter apiece to analyses of spatial patterns and of species diversity data. Although these statistical subjects are clearly explained, their inclusion does not add much to the book. Both of these topics are more effectively discussed in alternative introductory-level books (spatial patterns in Southwood's *Ecological methods* and diversity statistics in Pielou's *Ecological diversity*).

In Chapters 7 and 8, ordinary differential equations are used to model two-species competition and predator-prey systems. Vandermeer is at his best exposing assumptions and limitations of classical competition theory. In contrast, Vandermeer's treatment of predator-prey theory is both biologically and mathematically flawed. The application of eigenvalues to stability analysis is made to look easy by simply stating arbitrary criteria with respect to dynamic behavior. There is no explanation of where stability criteria come from or why eigenvalues provide any information about neighborhood stability. Vandermeer, himself, seems confused when he claims that "if any sort of density-dependent negative feedback is added" to a predator-prey interaction, "the system becomes stable." This is not a valid generalization; it is true for only a narrow class of predator-prey models.

In the final chapter, Vandermeer skims over the equilibrium theory of island biogeography, MacArthur's consumer-resource equations, and applications of the community matrix. Since all of this is done in less than 15 pages, the discussion of these topics is necessarily superficial.

For those trying to learn about mathematical ecology on their own, I recommend this book as a good beginning point. As a textbook, however, it is too incomplete to be used by itself in a full semester course. Noticeably lacking is any reference to methods for dealing with spatially distributed populations or stochastic processes, two areas of study that play a central role in theoretical ecology. In addition, Vandermeer is a little too "easy" when he glosses over the reasons behind fundamental methods such as linearization and calculation of eigenvalues. I have found students to be appreciative of Vandermeer's gentle problem-solving approach, but also sometimes frustrated by his tendency to produce results magically, without explanation. Although this book provides an unfrightening introduction to parts of mathematical ecology, it does not sufficiently develop the quantitative literacy needed to appreciate the important mathematical techniques of contemporary ecology.

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NUMERICAL ECOLOGY

Legendre, L. and P. Legendre. 1979. **Ecologie numérique.** Tome 1 & 2. Masson, Paris. xiv + 197 p.; viii + 247 p.

This two volume text by the Legendre brothers, Louis and Pierre, constitutes a timely and effective tool for the teaching and practice of data analysis in ecology. Not another text on statistics in ecology, it treats primarily the quantitative problems that arise in the empirical practice of ecology before and after standard statistical analyses of data might occur. Always thoroughly integrated with the practical needs of ecologists to treat quantitative data in an organized and rationally defensible manner, these two volumes present a wide variety of quantitative concepts and techniques.

Following a brief description of the quantitative and qualitative distinctions among kinds of ecological variables, together with a brief overview of three standard statistical packages for computation, the authors present a solid foundation in basic matrix algebra. Because matrix algebra has come to form the cornerstone of a principal edifice of mathematical technique for the analyses of multidimensional data in ecology, such an exposition is not only justified, but required for even the most practical of practicing ecologists who would reason with quantitative data.

The authors then present a vitally important discussion of the logical treatment of the units in which ecological measurements are made, and of the effects on these units as the measurements to which they are associated pass through various analytical processes. More than seventy distinct units (e.g., kg, mol, s, etc.) are mentioned as appropriate for ecological measurement. The fate of these units and the compounds built from them is of fundamental importance to the logical consistency of quantitative analyses and arguments. The excellent 30-page treatment of this fills a void left by most ecology texts.

A discussion of information and entropy in ecological systems is followed by an effective yet efficient exposition of basic statistical techniques for multidimensional data.

I am tempted to speculate that the advances of quantitative techniques and their application in the field of Numerical Taxonomy play an ancestral role for the next few chapters in the Legendres' text. These authors pass the benefits of their knowledge and experience with the development of the field of Numerical Taxonomy on to their readers with an effective, complete yet concise exposition of similarity and difference coefficients; of cluster analysis and hierarchical classification; and of ordination methods. These techniques are then enriched by additional statistical procedures to provide effective strategies for applied ecologists to use to search for structure in data.

A discussion of time series and first order stationary stochastic processes rounds out the variety of quantitative ideas presented in this work. The volumes are additionally enriched by an extensive bibliography of over 300 publications, and by a richly cross-referenced index.

For other than my personal use, the striking shortcoming of this text for my students and colleagues at present is that the full effect of its clarity and completeness can be appreciated only by those who read French. Fortunately, an English translation will soon be published by Elsevier Scientific Publishing Company, Amsterdam. This will constitute a significant contribution for English-speaking ecologists.

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FLUID MECHANICS AND LIFE

Vogel, Steven. 1981. **Life in moving fluids: the physical biology of flow.** Willard Grant Press, Boston, Massachusetts. xiv + 352 p. $24.95.

Modern ideas in ecology, as in biology in general, rely heavily on the concepts of mathematics, physics, and chemistry. Steven Vogel has set out to educate biologists in an area of physics that up to this time has had little attention from them, but which is full of exciting possibilities. This book grew out of a course on the biological applications of low speed fluid mechanics, and sets out to provide "an easy introduction to the subject for those who suspect that it might bear relevance to their projects, but whose time and vigor is unequal to the full rigor of engineering and applied mathematics." In my opinion, it succeeds in this aim extremely well, but I would go further and suggest that it may well help many biologists see for the first time that fluid mechanics is relevant to their interests.

The general pattern within each chapter is to give an exposition of some aspect of fluid mechanics and then give examples of biological applications. Material that is liable to be inherently difficult for biologists is expounded with admirable clarity and a humorous use of language. In fact, the most distinctive feature of the book is the way in which the author delivers a rigorous analysis of his subject in a language that conveys a sense of fun and of delight in the wonder of it all. After a comparison of some properties of muscular pumps and ciliary pumps, he says "Some inveterate invertebrate sort might find the situation worth investigating." After explaining that the shape of the rear end of an object makes a big difference to the drag, he says "discriminating design of the derriere is de rigueur." A discussion of adaptation is "revelling in adaptive tricks," and his way of fending off criticism of his occasional bursts of speculation is to say "If anyone feels strongly enough for or against some assertion to give the matter a decent investigation, then we'll all be a bit further ahead."

This reviewer is a biologist with only a token background in physics, but the book seems to me to cover the subject carefully and precisely, with logical progression and with proper attention to the limitations of knowledge. Thus, the first three chapters deal with the importance of dimensional analysis in fluid mechanics, the distinction between fundamental and derived units of measurement, the basic assumptions of fluid mechanics, and some elementary concepts such as the principle of continuity, streamlines, and the distinction between laminar and turbulent flow. The next two chapters introduce us to Bernoulli's principle and to the power of the Reynolds number. Steven Vogel gives the equations necessary to understand the properties under discussion, but does not attempt full mathematical derivation. Yet, from his own deep understanding of the subject he warns biologists of pitfalls: "Bernoulli's equation doesn't work well in boundary layers, Poiseuille's law presumes one is far from the entrance to a pipe, and Stoke's law works (in general) for small spheres, not large ones."

Applications are many: one gains a better understanding of the adaptations of organisms to flight and to swimming; new light is thrown on the adaptations of stream-living insects; circulation of body fluids is understood in a different way; and drag is seen as a critical factor in survival on a rocky shore. There is material here for the plant ecologist: one gains insight into the structure and function of trees by considering their need to resist wind drag, and the relation of phytoplankton to their environment is illuminated by a discussion of life in a viscous medium. The various mechanisms for release and dispersion of seeds are better understood in the context of fluid mechanics. In the subject area with which I am familiar, the author covered the important points, showing how the shapes of seaweeds are determined in part by the need to resist breakage by wave action, while