The authors strike a balance between history and entomology. Historians will find this book most interesting for its entomological perspective and entomologists will find it most valuable for its historical perspective. Wiedenmann and Fisher do a fair job at threading this needle, although perhaps the best audience are those who are experts in neither history or entomology. In a world of specialists, there are plenty of historical and entomological tomes. It is not a bad idea to have at least one set of authors crossing between the two, devoting a six-legged perspective to our understanding of history.

Michael L. Smith, *Biological Sciences, Auburn University, Auburn, Alabama*

Quantitative Analysis of Ecological Networks. *By Mark R. T. Dale and Marie-Josée Fortin. Cambridge and New York: Cambridge University Press.* $115.00 (hardcover); $49.99 (paper). x + 221 p. + 16 pl.; ill.; index. ISBN: 9781108491846 (hc); 9781108740715 (pb); 9781108649018 (eb). 2021.

The foundations of the analysis of ecological graphs are provided in an almost encyclopedic format by two experts in graph theory. Their presentation emphasizes definitions, simple line graph illustrations, quantitative formulations, and references necessary for employing graph-theory concepts to analyze ecological communities. Such tools are sufficient for embarking on a topological study of how elements of a community relate to one another in nature. The authors' mindset follows that of physicists at the recent turn of the century, when they discovered that networks allowed them to address relationships, a concept almost missing from conventional physics with its preoccupation with objects and laws. Presumably, knowledge of how systems are put together is meant to yield clues as to mechanisms that regulate how things happen within ensembles.

The book begins with a comprehensive chapter on the basic elements and attributes of graphs—nodes, edges, degree of distribution of edges upon nodes, subgraphs and partitions, centrality, complexity, modularity, and assortativity, and proceeds with methods of analysis such as partitioning, spectral theory (predicated on the multiple eigenvalues of the associated matrix), signed networks (where edges can have negative values), and the application of an ad hoc information theory to network structures. Although sufficient material is provided to launch investigations on these topics, readers might desire more than simple line figures to give them a feel for how these methods address problems in real ecosystems.

The third chapter deals with tying together structure and function. Here Dale and Fortin treat the empirical side of building networks—important problems encountered during data sampling and inference as well as statistical considerations occasioned by necessarily large data sets. Their recommendations for connecting function with structure concern decomposition into graphlets or subgraphs. The succeeding chapter is perhaps of greatest contemporary interest—the complexification of two-dimensional graphs into multidimensional forms to deal with heterogeneities in medium, time, space, and type. Analysis of these multiforms are assumed to be generalizations of the methods described earlier on two-dimensional graphs—centrality, clustering, and spectral decomposition. The authors provide an excellent glossary of the many terms they introduce.

Despite this excellent review of the tools available via graph theory, Dale and Fortin seem innocent of the history of ecological networks, which began almost 80 years ago when Lindeman depicted ecosystems flows as a weighted digraphs. Although they mention weightings numerous times, they mostly leave those generalizations as exercises for readers. Weights in biological networks usually resemble power-law distributions, so that magnitudes differ greatly, and qualitative conclusions drawn from unweighted graphs can differ radically from those emerging from weighted digraphs.

Quantitative analysis of ecological weighted digraphs often appears under the rubric of "ecological network analysis." The literature here deals with important clues to underlying ecodynamics, such as total exchanges between particular nodes across all existing pathways, identification and quantification of all closed loops of exchanges, overall trophic structure, and characterization of organized constraint versus residual independence of the entire network.

This latter comparison derives from the established information theory of conditional probabilities and dates back to the late 1970s, when network "entropy" was partitioned into mutual information and conditional entropy (R. W. Rutledge et al. 1976. *Journal of Theoretical Biology* 57:355–371). The second component importantly measures the *lack* of constraint in the network, whereas conventional physics generally ignores characteristics that do not exist. What is missing in ecosystems can be very important to network dynamics and places limits on network efficiency in favor of reliability. Engineers are now reintroducing a degree of conditional entropy as ecosystem "biomimicry" to impart more reliability to the design of power grids, water distribution networks, traffic grids, cash-flow networks, and supply chains (A. C. Layton. 2014. Food webs: realizing biological inspiration for sustainable industrial resource networks. PhD diss., Georgia Institute of Technology). Perhaps most importantly, the partitioning of diversity into constraint and the lack thereof has given rise to a quantifiable dialectical metaphysics of ecosystems (R. E. Ulanowicz. 2009. *Ecological Modelling* 220:1886–1892), which Chinese network investigators have heralded as a bridge between Asian and European philosophies of nature (Z. Xu et al. 2018. *National Science Review* 5:417–426).

The comprehensive review of graph-theoretic analysis by the authors is an invaluable reference for those who wish to focus on how the topology of ecosystems provides clues concerning system structure and function; however, those seeking a more inclusive survey of ecological network analysis might want to wait for a second edition by these talented reviewers.

ROBERT E. ULANOWICZ, *Biology, University of Florida, Gainesville, Florida*

HANDBOOK OF TRAIT-BASED ECOLOGY: FROM THEORY TO R TOOLS.

By Francesco de Bello, Carlos P. Carmona, André T. C. Dias, Lars Götzenberger, Marco Moretti, and Matty P. Berg. Cambridge and New York: Cambridge University Press. $99.99 (hardcover); $44.99 (paper). xiv + 295 p.; ill.; index. ISBN: 9781108472913 (hc); 9781108460750 (pb); 9781108628426 (eb). 2021.

Functional trait-based approaches, at their best, offer ecologists potent tools for delving deeper in the drivers underlying ecological phenomena such as species turnover across abiotic gradients or the relationship between biodiversity and ecosystem function. Perhaps most importantly, trait-based approaches promise a common currency that can be used to extrapolate insights from one set of species to a novel community or to novel abiotic conditions. However, the fact that trait-based approaches have deep roots stretching back centuries and also have seen explosive growth and some contentious debates in the last few decades makes the task of getting up to speed on this topic intimidating, especially for aspiring functional ecologists.

In this new handbook, de Bello et al. fearlessly tackle this topic, and largely succeed at offering interested readers a concise foundation in a wide range of topics related to trait-based ecology, including highlights of the history of the field, trait-sampling strategies, and nuanced discussion of some of the more dynamic areas of the field in recent years, such as intraspecific trait variation or the complex relationship between trait differences and competitive outcomes. The authors also succeed in framing the topic and ongoing research in a broad context, including compelling examples from across the tree of life and from researchers from around the globe, although perhaps with a slight (and perhaps unavoidable) skew toward plant research from Europe. The book is at its strongest when it is weaving together disparate threads from the foundations of the field with current research, such as an early chapter on environmental filtering that connects the dots from Aristotle to Schimper to Whittaker to the modern day in a few short but very well-structured pages. The authors also lean into their considerable expertise in measuring the functional structure of communities, and readers interested in this topic in particular will find helpful insights into this issue throughout the volume. There were times when I was frustrated with the page space spent on concepts or tools that are less vital to where I think the field is going, such as null models or limiting similarity, but it is undeniable that covering these topics will help readers make better sense of the last few decades of work in trait-based ecology.

Finally, the title of the volume promises some R tools, and there is a substantial online-only document (250-plus pages) that walks readers through a wide range trait-based analyses in R. The structure of the R content mirrors the chapters of the book, but there is relatively little R code in the volume itself, so readers interested in worked examples will need to invest additional time in the extensive online content. All in all, this is an excellent starting place for readers interested in getting up to speed with trait-based ecology, and it could form the basis of an authoritative graduate seminar on the topic.

NATHAN J. B. KRAFT, *Ecology & Evolutionary Biology, University of California, Los Angeles, California*

ALGAE: MULTIFARIOUS APPLICATIONS FOR A SUSTAINABLE WORLD.

Edited by Sachin Kumar Mandotra, Atul Kumar Upadhyay, and Amrik Singh Ahluwalia. Singapore and New York: Springer. $179.99 (hardcover); $139.00 (eBook). xi + 373 p.; ill.; no index. ISBN: 978-981-15-7517-4 (hc); 978-981-15-7518-1 (eb). 2021.

COEXISTENCE IN ECOLOGY: A MECHANISTIC PERSPECTIVE. *Monographs in Population Biology.*

By Mark A. McPeek. Princeton (New Jersey): Princeton University Press. $105.00 (hardcover); $45.00 (paper). x + 454 p.; ill.; index. ISBN: 9780691204864 (hc); 9780691204871 (pb); 9780691229225 (eb). 2022.

Look anywhere toward nature and you will find species eating, being eaten, sharing space, and competing directly or indirectly for finite resources. How do species coexist? What does it mean to “coexist” and are these species “coexisting” at all? Answering these questions has been a major focus of empirical research in ecology in recent decades, in large part due to competition experiments that have allowed ecologists to skip the biological details and instead