

Plant Functional Diversity. Organism traits, community structure, and ecosystem properties.

E. Garnier, M.-L. Navas and K. Grigulis. Oxford University Press, Oxford, 2016, xxii + 231 pages Price £37.50. ISBN 978-0-19-875737-5 (paperback; also available in hardback).

Fifteen years ago, Sandra Lavorel and Eric Garnier revisited the ecological Holy Grail (Lavorel and Garnier 2002) and outlined how plant properties (traits) offer the opportunity to predict changes in community composition and ecosystem functioning. This quest for predictive understanding in ecology has only gained in urgency since that time. Globally unique biodiversity loss continues unabated and simultaneous environmental changes persist and, in some cases, accelerate, ultimately threatening human (as well as other organisms') well-being. This timely volume showcases and adeptly synthesizes much of the functional traits research undertaken since the oft-cited 2002 paper and that addresses issues of biodiversity loss and environmental change, while also paying homage, and acknowledging the debt owed, to botanical researchers of the 20th century and before.

The book's premise, and that of functional trait research in general, is that to understand the structure and functioning of ecosystems, ecologists must take account of the functional components of organisms (*functional diversity*), both vegetative and reproductive, and that such structures transcend differences related to taxonomic boundaries (*taxonomic diversity*) or degree of relatedness (*phylogenetic diversity*). Consequently, a functional understanding offers a good chance of reaching the Holy Grail of predictive ecological understanding across scales. The first chapter outlines this fundamental premise and details why the authors concentrate on plant traits in particular, highlighting that (pp 7) "The [book's] aim...is to show how taking into account the functional facet of biodiversity improves our understanding of important questions that are at the core of current ecological research...the distribution of organisms along environmental gradients, the identification of rules governing community assembly, and understanding how the functioning of organisms translates to effects at the level of the ecosystem and how [the functional facet] controls certain services that ecosystems provide to human society".

The subsequent structure of the book follows the core topics identified in the aim, progressing from the functional characterisation of the organism, to communities, and thence to ecosystem functions and services, all within a traits-based response-effects framework i.e. a framework that posits that organisms respond to the environment (and this response is dictated by their functional traits) and that organisms also have effects on their environment (and these effects are contingent on their traits too). These five core chapters are sandwiched by a chapter presenting a brief history of comparative ecology and outlining the conceptual framework in more detail (adroitly summarized by their Figure 2.6 and accompanying legend), and by three important subsequent chapters focussing on: a) applied questions that can be tackled through the functional trait approach, concentrating on agronomic research in the context of permanent grasslands and crop weeds; b) the management, opportunities and pitfalls provided by an era of functional diversity data from across the globe; and, c) perspectives on where functional diversity research is heading. Each chapter has a useful "Key Points" section, summarizing the main arguments (but the reader would miss much if they only read these sections).

I found the book to be a refreshing synopsis with a strong line of argument running through its pages with clear subheadings and sections. I appreciated that hypotheses, and their underlying assumptions in particular, were clearly articulated, such that a reader can form their own judgement as to the merits of the authors' thesis from the presented evidence, mainly from grassland research. In addition, the authors do not shy away from highlighting where further questions remain, not just in their 'Perspectives for functional diversity research' chapter, but throughout the text. Each chapter is attractively illustrated with useful summary tables, generally clear conceptual figures and pertinent graphical results from key references, as well as stand-alone boxes where mathematical derivations and/or important concepts are presented in detail.

I did have some concerns that could likely be addressed in any future edition. Applications of the framework beyond agriculture, particularly ecological restoration of ecosystems, could be explored (rather than just acknowledged) given the recent increase of literature in this field. Further consideration could also be given to other ecosystems, trophic levels, belowground traits and change in functional diversity across environmental gradients in time as well as space, with associated key references e.g. Bardgett et al. (2014) and Dwyer et al. (2014). Debates around ecosystem multi-functionality, its meaning and its measurement, and its connection to the trait framework, could also be usefully elucidated. Chapter 6 included an apparently peripheral section on ecosystem allometry that offered a new perspective to the conceptual framework mainly presented. This could be more fully explored, with connections made to the metabolic scaling theory outlined in the Perspectives chapter. Minor quibbles included that some figure legends were on different pages to the figures which makes interpretation a little awkward, while Figure 4.2 in particular required further explanation.

Overall, the aim of predictive ecological understanding appears closer with the evidence and conceptual arguments presented in this book. As the authors themselves make clear, a formal theoretical framework, of a quantitative and mechanistic nature that fully accounts for intraspecific, as well as interspecific, variability and accurately identifies environmental gradients as perceived by organisms, remains to be developed. As functional comparative ecologists set about that task, their work will be invigorated by the synthesis and concepts presented by the authors. Not only will researchers and students find much of merit in this excellent volume, but the book will, as Prof. Terry Chapin states in the Foreword (page x), also be of value to managers and policy makers “who seek to understand why vegetation is changing and how this affects biodiversity, ecosystems and society as a whole”.

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