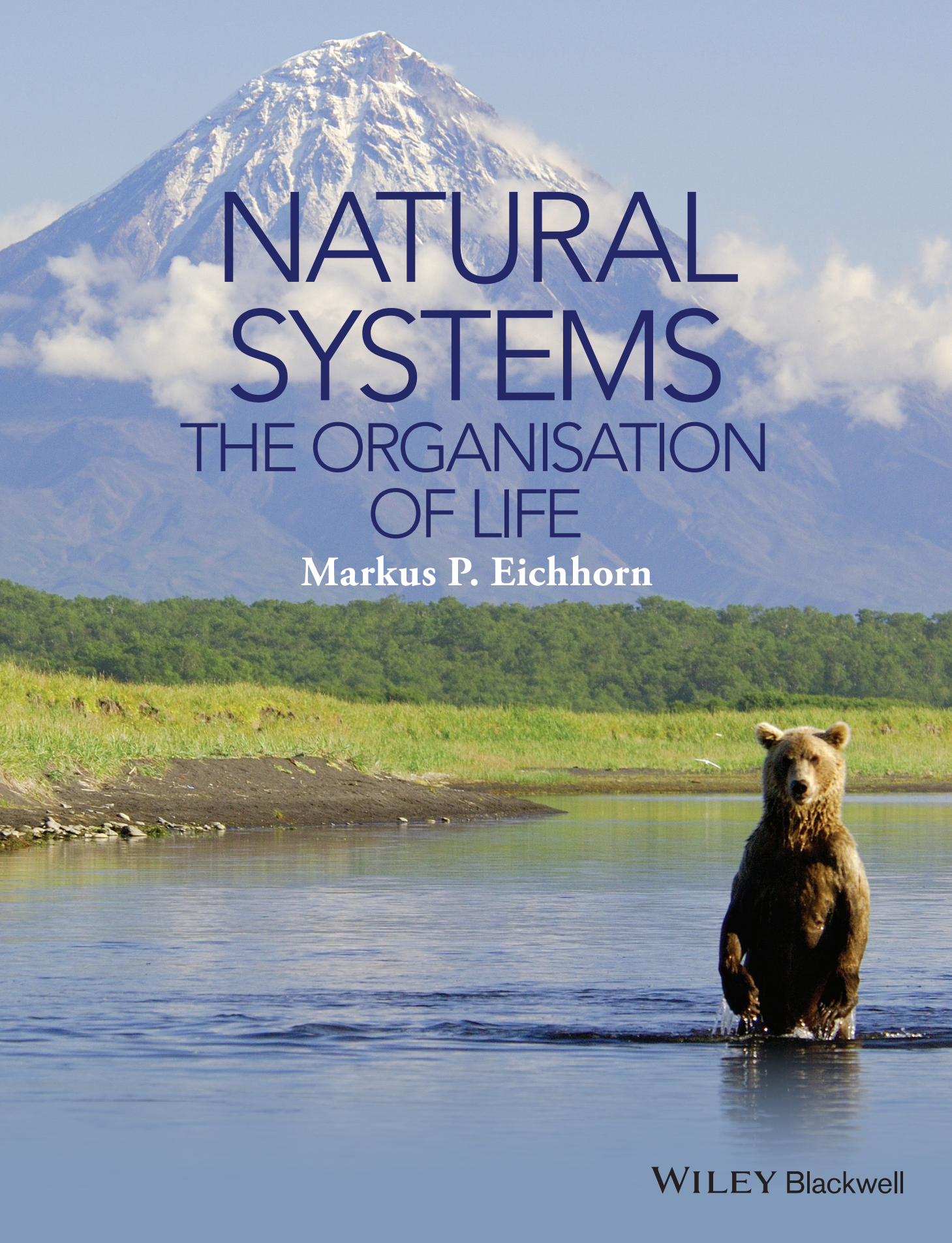
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SYSTEMS
THE ORGANISATION
OF LIFE
Markus P. Eichhorn
WILEY Blackwell

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The organisation of life

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Markus P. Eichhorn
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Preface

Ecology is the study of how the living world works. As a scientific field it has advanced in great strides over recent years, driven by a recognition of its central role in tackling some of the most pressing problems in the modern world. At the same time, however, the conventional ecology syllabus has remained relatively static, with a focus on theories dating from half a century ago. Even higher-level undergraduates can struggle to comprehend ideas under debate in the current literature, and the leap between undergraduate and postgraduate levels has become ever wider. This book is an attempt to bridge the gap.

The overall aim is to introduce the processes determining the structure and organisation of natural systems. The core questions can be expressed in two ways. In purely academic terms, they are to

- Understand patterns of species richness
- Interpret the composition of species in any given area
- Explain how processes at local (bottom-up) and regional (top-down) scales interact

It is perhaps better to reframe these in terms that capture more practical aspects related to current global concerns and are therefore more enticing to a general audience:

- What is biodiversity, and how can we measure it?
- If we wanted to create a natural system, how would we go about it?
- Can we predict what might happen to the natural world in the future?

The text builds sequentially from the concept and importance of species, through patterns of diversity, the interactions of natural systems with their abiotic environment and how species are organised within communities. This leads to consideration of global patterns of biogeography, concluding with the topic of islands, which are the closest analogues in nature to sealed systems. Standard ecology courses take a bottom-up approach, focussing on core phenomena such as population dynamics and simple interactions among a few species. Meanwhile biogeographers tend to stress the importance of speciation, extinction and dispersal in generating broadscale patterns. This book attempts to unite the two perspectives. Specialist terms highlighted in bold on first usuage are defined in the glossary at the end.

To students

In the coming years, ecology—and ecologists—have a crucial role to play. The great challenges facing humanity include feeding a growing global population, dealing with the consequences of climate change and controlling

the effects of a mass extinction event triggered by our own activities. The recent formation of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES[1]), intended as a parallel to the similar panel on climate change, reflects how seriously the world is beginning to take such concerns. This is long overdue—in the time since the Convention on Biological Diversity was signed by 193 countries in 1992, matters have only become worse (Butchart et al., 2010). These are all problems that will require an understanding of ecology and particularly how processes interact from local to regional and global scales. Learning how natural systems operate is the first step towards making a difference.

Much of the material in this book is recent, and some of the content remains controversial, so you are encouraged to follow up with wider reading and see how the debates are proceeding in the literature. Part of becoming a scientist lies in forming your own opinions and not taking everything you're told for granted, even in textbooks. Scientific understanding advances constantly and posterity will no doubt judge some of what is contained here to be incorrect; finding out which parts are wrong will be up to you. To learn more about any of the debates presented here and to keep pace with the field, I recommend scanning issues of the journals Ecology Letters and Trends in Ecology and Evolution. The most helpful articles will be short reviews. Many other journals include or focus entirely upon ecological studies.

As ecology grows as a science, it becomes increasingly important to understand the quantitative aspects. The best ecologists combine the enthusiasm of a natural historian with the mind of a statistician, and I entreat you to not skip over mathematical sections that might initially appear 'difficult'. Every effort has been made to make these as accessible as possible. A central set of skills to develop are techniques for the assessment and measurement of diversity, which will prove essential if you have aspirations to work in conservation, environmental consultancy or natural resource management. An appendix describes how to calculate and interpret a range of diversity measures using a real dataset from a butterfly conservation project in Colorado. These metrics are used routinely in the academic literature and applied fields. Remember that without strong numerical evidence, it is almost impossible to make a convincing scientific argument.

Finally, an occasional complaint from students on my courses is that there's too much material. If you feel this way then you're missing the point! Try to focus on underlying theories and concepts, rather than attempting to memorise specific information. You're unlikely to ever need to know the exact species of plant that make up a particular succession, but you should be able to explain how and why succession occurs. There are many examples contained in the book, but these are provided to illustrate ideas, not because the details themselves are essential. Take these concepts and see whether you can match them to natural systems wherever you find yourself—on holiday in an exotic country, walking in the park or even in your own garden. A true ecological rule should apply anywhere.

To instructors

Since 2008 I have taught an undergraduate module which has formed the spine of this book. My aim is to provide a bridge between conventional ecological teaching, covering the behaviour of individuals and populations, and global patterns of life. As such it begins where most ecology textbooks end, and takes a broad perspective on the organisation of natural systems. These themes make the book relevant to students of ecology, environmental science, geography and conservation. My hope is that it will be easy to use as a course text since each chapter is derived from a single 1-hour lecture (albeit expanded). Instructors should therefore be able to readily convert the text into a teaching resource, and students will be able to use it to enhance their

[1] http://www.ipbes.net.

overall understanding and support their learning. Each chapter commences by framing the big questions and concludes by outlining outstanding problems and avenues for additional enquiry along with some suggestions for additional reading. These could be used as starting points for class discussions or to stimulate interest in active areas of controversy.

Lately there have been several attempts to provide links from core ecology through to biogeography, usually via the nascent field of macroecology. Recent books targeting an exclusively academic audience include Scheiner and Willig (2011) and Loreau (2010). A growing drive to improve the connectivity between these research fields has however yet to be represented at an accessible level for a student audience. My hope is that this book will help to guide advanced undergraduates and postgraduates towards this exciting and vital issue.

In a single text it is impossible to cover all aspects of a topic, and therefore it is worth outlining what this book does not contain. There is a relatively limited emphasis on conservation, though many of the ideas and principles lie at the heart of conservation biology. The same can be said of restoration ecology, the field devoted to rebuilding natural systems where they have been altered by human activities. It has also not been possible to include much on abiotic processes operating at the ecosystem scale; a number of excellent texts already exist in this area though (e.g. Chapin III et al., 2012). A final known omission is the relatively limited coverage of the impacts of diseases and parasites (and parasitoids) on communities. This is a topic on which there has been a growing focus in the ecological literature, but as yet little synthesis, which means that it will hopefully be included in a future edition.

The book is intended to be a summary of the present state of the field which focusses on the most promising ideas for continued investigation. It is not written as a history of the development of ideas within ecology. My own experience as both a student and teacher is that diverting attention towards old arguments or superceded theories only serves to distract or confuse. There are many great names from the history of ecology, founding figures even, who are not mentioned in these pages. This is not meant as a slight, nor is it an accidental oversight, but a deliberate choice to avoid bloating the text with outdated arguments.

Finally, please note that a number of the concepts and theories that are referenced remain subject to dispute. I do not shy away from giving a personal opinion on the more contentious points, based on the balance of current evidence and in full awareness that some will disagree. The reference list has to stop somewhere, and I have not included anything published since the end of 2014. It is inevitable that by the time this book reaches your hands, something will have been contested or overturned. If you should find yourself disagreeing with anything, then I hope this can be turned into a productive means of introducing students to difficult questions. No textbook should ever be treated as absolute truth; my goal is to provide a reasonable starting point. Should you notice any errors or omissions, then please let me know.

MARKUS P. EICHHORN
Nottingham, UK
12 October 2015

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