Soil Fauna Assemblages

Global to Local Scales

This volume provides a modern introduction to the soil fauna and its contributions to ecosystem function, the mechanisms that structure soil fauna assemblages from local to global scales, and the potential impacts of global change on soil fauna assemblages. Written as an accessible primer, this book is a high-level overview of current knowledge rather than a detailed tome of all existing information, with emphasis placed on key findings and general patterns. It focusses on the soil fauna but contextualises these assemblages in relation to the microbial assemblages belowground and the vegetation aboveground.

It is clear that our knowledge of soil fauna assemblages is ever increasing, but there is still a lot to discover. Key areas of research are highlighted, with particular reference to the future of soil fauna assemblages.

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The world's biological diversity faces unprecedented threats. The urgent challenge facing the concerned biologist is to understand ecological processes well enough to maintain their functioning in the face of the pressures resulting from human population growth. Those concerned with the conservation of biodiversity and with restoration also need to be acquainted with the political, social, historical, economic, and legal frameworks within which ecological and conservation practice must be developed. The new *Ecology, Biodiversity, and Conservation* series will present balanced, comprehensive, up-to-date, and critical reviews of selected topics within the sciences of ecology and conservation biology, both botanical and zoological, and both 'pure' and 'applied'. It is aimed at advanced final-year undergraduates, graduate students, researchers, and university teachers, as well as ecologists and conservationists in industry, government, and the voluntary sectors. The series encompasses a wide range of approaches and scales (spatial, temporal, and taxonomic), including quantitative, theoretical, population, community, ecosystem, landscape, historical, experimental, behavioural, and evolutionary studies. The emphasis is on science related to the real world of plants and animals rather than on purely theoretical abstractions and mathematical models. Books in this series will, wherever possible, consider issues from a broad perspective. Some books will challenge existing paradigms and present new ecological concepts, empirical or theoretical models, and testable hypotheses. Other books will explore new approaches and present syntheses on topics of ecological importance.

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Contents

Preface

Ecologists have long been fascinated by the diversity of life in soil (e.g. Anderson 1975, Bardgett 2002, Nielsen et al. 2010b), but the intricate nature of soils and small size of the organisms therein have made progress slow compared with other terrestrial ecosystems. Still, our knowledge of the ecology of soil fauna has been accumulating relatively rapidly over the past few decades, particularly due to an increased recognition of their role in ecosystem functioning and service provisioning, improved sensitivity of analytical equipment, and the application of molecular tools. It is thus well established that soil fauna assemblages are abundant and highly diverse, representing a broad range of life history strategies and feeding types, and that this fauna plays an essential role in ecosystem functionality, plant community dynamics, and even human health (e.g. Nielsen et al. 2015b, Wall et al. 2015). Determining how the diversity and composition of soil fauna communities influence ecosystem functioning, particularly in the light of global change, is one of the key research questions in contemporary soil ecology. Answering this question, however, requires a basic and robust understanding of soil fauna assemblages.

It is becoming increasingly clear that many soil invertebrates (including the unicellular protists) are not cosmopolitan, and that most taxa have restricted distributions and show distinct biogeographical patterns (e.g. Bates et al. 2013, Decaëns 2010, Nielsen et al. 2014, Wu et al. 2011a). The work by Decaëns (2010) in particular shows that it is possible to define macroecological patterns of belowground communities. His work confirms that many types of soil fauna show altitudinal, latitudinal, or area gradients in the same way as described for aboveground organisms, but that different mechanisms may structure aboveground and belowground assemblages at smaller scales. This builds on conceptual frameworks such as the one presented by Ettema and Wardle (2002) that illustrates the mechanisms that govern soil fauna diversity and assemblage structure at scales ranging from very fine spatial scales to regional scales. Such

syntheses of knowledge and development of conceptual frameworks are highly important for progressing soil fauna ecology as a field.

This book is intended to provide an overview, rather than a detailed account of all studies, of patterns of soil fauna assemblage structure through time and space at local to global scales, with an explicit consideration of global change impacts and potential implications for ecosystem functioning. Our knowledge of soil fauna assemblages has accumulated rapidly over the past few decades, but there have been few attempts to unify and consolidate this knowledge to date. Although there is still much to learn, it thus appears timely to synthesise the knowledge we do have to take stock of what we currently know about soil fauna assemblages at local to global scales and the mechanisms that govern these, identify and describe biogeographical and macroecological patterns, and assess how soil fauna assemblage structure might be influenced by global change. This will broadly make it possible to provide evidence-based recommendations for more sustainable land management regimes harnessing the benefits of soil fauna and for conservation of soil faunal biodiversity. It will also help us identify key knowledge gaps and future research directions. The inclusion of global changes will be a critical component of the book given that a substantial part of Earth's terrestrial ecosystems has already been impacted by human activities. The book considers soil fauna very broadly, ranging from the oft-overlooked unicellular Protista to the abundant and diverse nematodes and microarthropods and the larger multicellular organisms such as earthworms, ants, and termites that act as ecosystem engineers. Protista will be included because they are an essential part of the soil food web, and although generally considered microbial given their single-celled nature, they are rarely considered in assessments of microbial assemblages which generally focus solely on archaeal, bacterial, and fungal components. A basic understanding of soil fauna ecology and its contribution to ecosystems is fundamental to appreciate the value of studying soil fauna assemblages; hence, the first couple of chapters will be dedicated to this topic. The book will not discuss in detail assemblage patterns of vertebrates and organisms that only spend part of their life history in soils (e.g. many insect larvae pupate in soils), but their role in Earth's ecosystems will be highlighted where relevant.

The book can be broadly divided into four virtual sections that address specific aims. First, Chapters 1 through 3 aim to provide the reader with a broad introduction to the soil fauna (Chapter 1), its functional roles in ecosystems (Chapter 2), and how soil fauna and its functional roles

can be studied, with a particular focus on recent technological developments (Chapter 3). These chapters thus provide a strong foundation for contextualising the rest of the book. Second, Chapters 4 and 5 present an overview of our current understanding of patterns and drivers of soil fauna species distribution and assemblage structure and composition at global to local scales. These chapters will thus cover topics ranging from soil fauna biogeography and macroecology (Chapter 4) to patterns of assemblage structure at landscape scales to fine scales (Chapter 5). This should provide the reader with a robust understanding of why soil fauna assemblages look the way they do and a strong fundament for predicting the future state of soil fauna assemblages. Third, Chapters 6 through 8 will cover global change impacts, with Chapter 6 mostly focusing on direct impact (i.e. land use, management practices, invasive species) while Chapter 7 will focus on climate change impacts. Chapter 8 is focused on ecological restoration, which aims to restore ecosystems following global change impacts. I have included succession in this chapter because ecological restoration practices fundamentally rely on the process of succession to restore ecosystems. Finally, Chapter 9 will synthesise this information and look to the future of soil fauna assemblages. A particular focus will be given to the potential benefits we can gain from better management of soil fauna assemblages in natural and human-influenced ecosystems.

Finally, I would like to thank all of the people who have been involved directly or indirectly in making this book a reality. First, I would like to acknowledge Michael B. Usher, Dominic Lewis, and Cambridge University Press for their invitation to write this book and their support throughout the process. Without their encouragement I would not have taken on a project of this size to begin with. Second, I would like to thank all the people who have taken their time to provide feedback on drafts of one or more chapters, including Stef Bokhorst, Tancredi Caruso, David Coleman, Stefan Geisen, Patricia Gilarte, Christian Mulder, Casper Quist, Heikki Setälä, and Diana Wall. Their constructive feedback has been crucial to produce the final version of the book. Several people, including Byron J. Adams, Steven Chown, Stefan Geisen, Hans Petter Leinaas, Michael Plewka, Johan Six, and Kenneth Tinnesen, have also been kind enough to share their photos, which has made for a more visually pleasing book. Finally, I would like to thank my family and friends for understanding my dedication to research, long hours in the office and at home, and accepting my 'mental absence' while working on the book. Special gratitude goes to my partner, Ashley King, for her

encouragement and support throughout the process, and for interpreting my crude sketches into professional diagrams.

To the reader – I hope you enjoy this book and that it will spur or increase your interest in the soil fauna, both in and of itself, and because of its importance to our ecosystems.