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Taking on the intimidating task of mycorrhizal biogeography

Biogeography of Mycorrhizal Symbiosis, by Leho Tedersoo 2017, Springer, 566 pp., ISBN: 9783319563626, www.springer.com

While a bit of a cliché, soils remain a black box in ecology, in part, because you cannot see the organisms you are studying – they are literally in a black box. Thus, relative to other areas in ecology, the biogeography of organisms in soils remains largely unknown and under researched. Leho Tedersoo's edited volume, Biogeography of Mycorrhizal Symbiosis, takes on the enormous task of reviewing the patterns and potential drivers of mycorrhizal fungal distributions around the world. Mycorrhizal fungi are clearly important for plant nutrition and patterns of plant diversity across landscapes. Thus, relative to other soil taxa, we know quite a bit about them. This knowledge makes them a good set of test cases to explore the drivers and patterns of soil organism biogeography. The preface of the book outlines the objective of the text - "to cover all topics related to the biogeography of mycorrhiza" including definitions, methods, dispersal, gene flow, local and global patterns, overviews and synthesis. This is a lofty objective for any text because it crosses so many different areas and scales across all mycorrhizae – and mycorrhizae differ from one another evolutionarily and in ecological trait space. In principle the book was arranged to start off discussing methods and small-scale process and then work its way to regional and global processes with a number of chapters on specific mycorrhizal groups. The authors do a good job of highlighting areas of research that they think will pave the way forward to a better understanding of the patterns of and processes that contribute to the distributions of mycorrhizal fungi – including environmental filtering, evolutionary history, community assembly, co-existence, competition, and dispersal. These issues are echoed in the plant community literature as well, which I find a heartening given the plant literature has developed over a much longer period of time. However, I found that the level of detail in each of the chapters varied considerably from fine-scale focus to broad-scale patterns making this feel like a book of independent chapters and less like a synthesis of the field. That being said, I enjoyed many of the chapters- so if you approach the text as a series of independent chapters that you can cobble together to focus on your interest, and less as a synthesis of the field, you will not be disappointed.

The book starts off with a nice and broad overview of phylogenetic approaches and would be a good introductory chapter for a graduate student seminar or senior undergraduate course on mycorrhizal fungi or biogeography. It clearly presents the basics and highlights how the increasing number of genomic data collected from sites around the world are beginning to shed light on mycorrhizal fungal distributions. It ends by making the case that the next step forward is to better integrate our emerging understanding of mycorrhizal phylogenies with ecological data such as physiology, environmental, and climatic data – an important



message. Many chapters focused on ectomycorrhizal fungi and broadly covered a wide-range of topics from evolution and population biology to fungal coexistence. For example, Chapter 2 presented a nice introduction to the population biology (dispersal, isolation, host specialization) of ectomycorrhizal fungi. It highlights the knowledge gained from, as well as the limitations of, the rich fungal fruiting body datasets collected over many years for determining fungal distributions. Chapter 3 takes a bit of a deeper dive into the details and focuses on how ectomycorrhizal fungal traits influence the dispersal and establishment of fungi at local and regional scales. It ends with an interesting discussion on ectomycorrhizal invasion biology and how ectomycorrhizal life history traits may shed light on the debates in invasion biology writ large - a compliment to Chapter 20 which focuses on this topic. Chapter 4 (one of my favorite chapters – Figure 4.1 would be great for introductory soils/ ecosystem classes) explores how mycorrhizal fungi co-exist at fine spatial scales and how fine-scale interactions may contribute to mycorrhizal diversity patterns though the lens of selection, drift, dispersal and speciation. Chapter 6 highlights how new genomic data has led to an increase in ectomycorrhizal fungal lineages.

Some chapters focus more on scaling data as well as our understanding from the plot- to regional- to global-scales and highlight that doing this may enable us to link the distributions of fungi with ecosystem function. For example, Chapter 7 takes a macroecological view of arbuscular mycorrhizal fungi and uses species distribution models to hypothesize the distributions of arbuscular mycorrhizal fungi, now and in the future. They highlight that taking a taxon-specific approach could be the first step in understanding how changes in community composition now and in the future might lead to changes in function across regions. Chapter 11 takes a global perspective of mycorrhizal distributions across all groups of mycorrhizae and underscores that using large databases such as GBIF can lead to predictions about what might impact their distributions as well as how shifts in their distributions may impact functions.

Most of the chapters in the middle of the text explore the evolution, diversity and distributions of specific groups both broadly (e.g., ericoid mycorrhizae) and more specifically (e.g., Tullasnellaceae). Some of the content of these chapters overlaps with that of previous and later chapters but, in general, they tend to go into more detail. Many of the chapters underscore just how little we know about specific groups; for example, Chapter 10 takes a speculative approach to exploring the biogeography of root endophytes and nicely highlights that these groups are poorly defined due to poor taxonomic frameworks. However, the maps, as well as the reference lists, presented in many of these chapters will be useful to ecologists thinking about working on specific mycorrhizal groups. In general, the chapters highlight the difficulty of working with organisms that are hard to impossible to culture, yet, also highlight the excitement that emerging genomic data and techniques will help to propel the field forward in the near future.

At their best, edited volumes are great for graduate/ advanced undergraduate student reading groups as a way to spark new ideas and discussions among divergent groups of students. This book hits that mark in some ways because the chapters cover such a variety of topics and some of the chapters are excellent on their own: however. I found some of the chapters were too detailed and organism focused for a book with such a broad set of topics to be covered. Overall, I can see using a chapter here or there to illustrate ideas or points we are discussing in classes or as a lab group, but I don't see reading it as a body of work that represents a synthesis or overview of soil biogeography. Of course, my desire for more synthesis across the book likely reflects my own bias as an ecosystem and soil ecologist and, given that this is an emerging field, it may to too much to ask for. It's possible that readers more focused on specific fungal groups or fungal ecology specifically will have a different experience with this text and I imagine the maps and reference lists will be very useful to beginning mycorrhizal ecologists. This text will certainly make a good addition as a reference on the bookshelves of many fungal ecologists.

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