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## book review

## Species distribution models for species distribution modellers

Ecological niches and geographic distributions, by Townsend A. Peterson, Jorge Soberón, Richard G. Pearson, Robert P. Anderson, Enrique Martínez-Meyer, Miguel Nakamura & Miguel B. Araújo, 2011, Monographs in Population Biology 49, Princeton University Press, 328 pp. \$49.50 (paperback) ISBN: 078-0-691-13688-2; <http://press.princeton.edu/>

The statistical analysis of apparent environmental preferences of plants and animals is enjoying much attention in the ecological literature. Variably known in the early days as “habitat suitability modelling” and later “niche modelling”, it is currently most often referred to as “species distribution modelling” (SDM). Given the extreme methodological dynamics of early research fields, it is not surprising that it took around two decades before the first synthesising book on the topic was published (Franklin 2009). Apart from some edited books of varying quality, the book by Town Peterson and six co-authors is the second book-length synthesis. The authors develop a theoretical framework as the foundation for their review of methods and applications, which leads to a substantial expansion beyond the mere methodological points usually receiving most attention in this field.

The book is composed of three parts. “Theory” first defines most phrases commonly used in niche modelling, including a historical review of niche concepts. It then formalises the “BAM” concept proposed by the second author in an earlier publication. BAM stands for biotic interactions, abiotic conditions and migration as key determinants of the presence or absence of a species in geographic space. In this book, the BAM framework serves as an Ariadne's thread for all further discussions, from data quality to the simulation of dispersal. BAM is based on the premise that a species can occur in an abiotically suitable site only if it can migrate (disperse) there and if negative biotic interactions (e.g. competition, predation) do not preclude its existence. The fundamental challenge of SDMs is that available data on species' distributions are an unknown proportion of the species' fundamental niche and hence an intersection of B, A and M. Mathematically, B, A and M are sets of environmental conditions and

the intersections are described by set theory. The authors use set theory to clarify different niche definitions and synthesise discussions on what SDMs actually analyse. While mathematically rigorous, this framework is tedious and over-defined. The usefulness of any concept suffers when it becomes too vague (thus lacking stringency) or too precise (narrowing the range of cases it can be applied to). In this case, the book features a 7-page appendix with definitions of the various symbols representing elements of BAM sets. At the same time, a 12-page glossary seeks definitional clarity but lacks the relevant BAM-based definitions. Since the book also has no index, it is nigh impossible to discover the set-theoretical definition even of important terms such as “scenopoetic niche”. Here the clarity sought by part 1 evaporates because of a lack of editorial completeness. More problematically, the authors reveal that the BAM framework has profound weaknesses, such as a possibly fundamentally inestimable set B (p. 38), or the observation in coarse-scale data that biotic interactions are largely irrelevant for distributional patterns (p. 40). With respect to M, dispersal processes, the book remains completely (and incomprehensibly) silent. Also, the framework does not consider within-species variability of niches, nor adaptability (physiological or evolutionary sense) of individuals and populations. Overall, the conceptual value of the BAM framework is, in my opinion, questionable.

Part 2, “Practice”, reviews data and statistical methods related to SDM. While covering essentially the same ground as Franklin (2009), this part is clearer in what the actual target of an analysis is, profiting from the BAM framework of part 1. “Practice” touches on many important statistical and interpretational points of SDMs (e.g. whether actual habitat preferences of a species are detected, or only those different from avail-

ability, p. 98; extrapolation mistakes, p. 128; optimism in cross-validation, p. 130). The book shies away from actual evaluation and recommendation, however. The authors do not communicate the results of many of the comparative papers cited in the book, possibly because they deem them too preliminary or because they do not want to pass judgement. Personally, I regard this as the main flaw of Part 2: SDM is not a post-modernist anything-goes area of data crunching. When data sources such as GBIF are exhibiting huge spatial biases (chapter 5), when relevant environmental variables are not available for analysis and hence omitted without substitution (chapter 6), when modelling approaches have failed time and again (chapter 7), then this should be clearly pointed out and detailed. Technical details are obviously a huge field and will probably always remain an incomplete part of any book on SDMs. Still, it seems odd to allocate five pages to discussing how to convert probabilities to 0/1s (which I regard as a redundant step, and one with very clear best practice at that: p. 120), but not mentioning that prevalence should be maintained in cross-validation, that data can be weighted by sampling intensity, or how to quantify uncertainty emerging from the analysis.

Part 3, “Applications”, features five chapters from the authors' own research portfolios exemplifying the use of SDMs for specific questions. “Discovering biodiversity” discusses using SDMs to increase efficiency in sampling geographic space for populations of a target species, or for detecting new species. “Conservation planning and climate change effects” (Chapter 12) illustrates the use of SDMs for extrapolating from current to future distributions and hence evaluation of adaptation strategies. “Species' invasions” (Chapter 13) touches on very recent developments of SDMs for introduced species, but remains too uncritical of current practice. Regrettably the book went into press slightly too early to be able to accommodate some very important new publications in this field. “The geography of disease transmission” (Chapter 14) presents a case study not very different from the previous two chapters, i.e. attempts to extrapolate from

current knowledge, this time in the context of diseases. This field is dominated by population models, which have classically ignored correlative suitability approaches, but can potentially benefit from SDMs. Finally, “Linking niches with evolutionary processes” (Chapter 15) offers a sketchy introduction to the interesting but challenging area of connecting SDMs with evolutionary ecology. Specifically, it investigates whether the (realised) environmental niche is conserved through ecological and evolutionary time.

Overall, this book is the most comprehensive review of the niche modelling literature to date. It does not, however, provide an easy entry-point for researchers new to the field because it fails to clearly identify the current best practice or precisely highlight areas of methodological uncertainty. The set-theoretical interludes make for occasionally awkward reading and to me this rigorous approach is in stark contrast to the vagueness of statistical descriptions in part 2. Also, the book fails to report on the existing mechanistic approaches to SDMs, ecophysiological investigations into environmental niches and community ecological considerations behind biotic interactions. Thus, while SDM seems to offer itself as a tool to many areas of ecology, this book does not link the statistical analysis of species distributions to ecological theory. As a consequence, *Ecological niches and geographic distributions* is more an interesting interim report than a comprehensive treatise.

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