method should be used in preference to a more traditional parametric one (e.g., analysis of variance vs. randomization tests). For example, Roff presents three different methods for calculating confidence intervals on maximum likelihood estimates of parameters and six different methods for confidence intervals on bootstrapped estimates. Discussion of when to use these methods is absent. When describing bootstrapped confidence intervals Roff concludes "Confidence intervals can be estimated by a variety of approaches but there is no way, in general, of deciding which method, if any, is appropriate except by simulation."

This statement echoes a recurring theme in the book, the need to verify the reliability of computer intensive methods via theory or simulation. For example, in the introduction to bootstrapping, Roff implores the reader "... the bootstrap should not be used without theoretical or empirical verification that in the particular circumstance proposed, it actually works." With respect to the jackknife, we are told, "... this method is not without its assumptions and should not be used without justification, either from a theoretical or numerical analysis." I appreciate the need for such cautions. However, once cautioned, the reader is not given much help in how he or she would develop a theoretical or empirical evaluation of the reliability of the methods described. There are examples of simulations, but most of these presume an underlying statistical distribution to the data. If you are considering using bootstrapping, or jackknifing, or randomization methods for a *particular* set of data, then it would seem that you don't know the distribution from which the data arise. Otherwise, why would you consider these techniques? I think most readers will not know when they can reliably use the techniques Roff presents.

The treatment of likelihood and Bayesian methods is not sufficient to allow readers to use these methods or to understand them. The theoretical underpinning is particularly weak. For example the reader is never told the fundamental basis for parameter estimation by likelihood,

$$\mathcal{L}(\theta \mid x) \propto P(x \mid \theta),$$

i.e., that the likelihood of a hypothesis (or parameter value, θ) given the data (x) is proportional to the probability of the data given the hypothesis. Without explaining this basic concept, the reader will never understand the general relationship between likelihood functions and probability density or mass functions. The reader is never urged to think about how the data arise and what that implies for choosing likelihoods. Roff simply offers an incomplete catalog of likelihood functions leaving to rote when each is to be used. On page 206, Bayes' law is unconventionally described as

$$\mathcal{L}(\theta|x) = \frac{\mathcal{L}(x \mid \theta)P(\theta)}{\int \mathcal{L}(x \mid \theta)P(\theta)}.$$

As Roff correctly tells us, Bayesian analysis focuses on the probability of a parameter θ given the data (i.e., $P(\theta \mid x)$ which is *not* equal to the left hand side of his version of Bayes' law, the likelihood of the parameter given the $£(\theta \mid x)$. This is confusing at best and wrong at worst.

The final shortcoming of the book is the surprising absence of treatment of topics that I would expect to be covered, or at least introduced. Other than a casual mention of AIC as a criterion for stepwise regression, there is no discussion of information theoretic approaches to model selection, multimodel inference, and model selection uncertainty. These topics have emerged as fundamental to the problem of deciding how many parameters to include in a model and rightly deserve treatment in the chapters on maximum likelihood and regression. Moreover, any contemporary source that treats computational methods and Bayesian analysis must include some coverage of Monte-Carlo Markov chains. At the very least, it must mention the exceedingly valuable tools for Bayesian statistical computation offered by the BUGS project ⟨http://www.mrc-bsu.cam.ac.uk/bugs/welcome.shtml⟩. The absence of even rudimentary coverage of these topics is a serous shortcoming.

So, the question emerges, does this book offer material that is not treated in a more useful way in other texts? In my view, it does not. For the audience targeted by this book, likelihood is covered in a much more accessible and useful way in Hilborn and Mangel (Hilborn, R., and M. Mangel. 1997. *The ecological detective: confronting models with data*. Princeton University Press, Princeton, New Jersey, USA) and Royall (Royall, R. 1997. *Statistical evidence: a likelihood paradigm*. Chapman and Hall, New York, New York, USA). A superior treatment of Bayesian analysis in biology can be found in other sources (Woodworth, G. G. 2004. *Biostatistics: a Bayesian introduction*. Wiley, Hoboken, New Jersey, USA; Clark, J. S. 2006. *Models for ecological data*. Princeton University Press, Princeton, New Jersey, USA). Randomization, bootstrapping, and the jackknife are methods are better treated in the classic text by Manly (Manly, B. F. J. 1971. *Randomization and Monte Carlo methods in biology*. Chapman and Hall, New York, New York, USA). It is perhaps unfair to compare one book to three or four, but my recommendation to those who want to learn these approaches is to invest in earlier treatments of the topics covered here.

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Ecology, 88(1), 2007, pp. 267–268

Practicing Scales

Wu, Jianguo, K. Bruce Jones, Harbin Li, and Orie L. Loucks, editors. 2006. **Scaling and uncertainty analysis in ecology: methods and applications.** Springer, New York. xviii + 351 p. $119.00, ISBN: 1-4020-4662-6 (acid-free paper).

Key words: characteristic scales; downscaling; ecosystems; space-time correspondence principle; uncertainty; upscaling.

Judging by the contrast between this book and T. F. H. Alan and T. B. Starr's classic (1982. *Hierarchy: perspectives for* *ecological complexity*. University of Chicago Press, Chicago, Illinois, USA), hierarchy theory is in the process of maturing from a stimulating collection of vague, but provoking, ideas to a rigorous and practical scientific endeavor. *Scaling and uncertainty analysis in ecology: methods and applications,* a recent compilation edited by Jianguo Wu, K. Bruce Jones, Harbin Li, and Orie L. Loucks, addresses six overarching themes: 1) integration of diverse scaling perspectives, 2) sources of uncertainty, 3) quantification of scaling error, 4) application of scaling principles, 5) the importance of recognizing scale effects, and 6) the use of scale-related understanding for public policy and decision-making.

One provoking idea addressed by the book is the space-time correspondence principle. "… For a variety of physical, ecological, and socioeconomic phenomena, large-sized events tend to have slower rates and lower frequencies, whereas small things are faster and more frequent." Results from several of the book's case studies seem to contradict this principle, which is the dominant paradigm of hierarchy theory. Jones et al. (Chapter 11) used regression tree analysis to examine the effects of regional watershed on water quality. Higher-level splits in the hierarchical model of local water quality were defined by variables measured on a long temporal scale (rare high-rainfall events), and a local spatial scale (e.g., riparian forest). In a second example, Lloyd et al. (Chapter 14) found that local patch-scale patterns overwhelmed any broader-scale biogeographic effects (corvid distribution) on ovenbird parasitism. Yet, they conclude that patch-specific responses to fragmentation are best understood in the context of a top-down spatial hierarchy, with biogeographic effects exerting constraints on landscape-level effects, which, in turn, constrain patch-scale edge effects. Johnston and Shmagin (Chapter 16) found the reverse: regional geology had a larger influence on the condition of individual lakes than did local land use, leading them to conclude that "A point observation such as Secchi transparency integrates the effects on lake eutrophication of ecological drivers operating at multiple scales, making it difficult to parse out the most influential scale...." Ambiguity regarding the space-time principle is illustrated by the fact that only one space-time diagram appears in the book, and this diagram includes plenty of arrows representing inter-scale communication (but no off-diagonal elements).

Perhaps, not all natural phenomena strictly obey the space-time correspondence principle, as suggested by Wu and Li (Chapter 1). Or, perhaps the counterexamples above merely reflect the difficulty in representing and combining influences from several scales on the phenomenon of interest. What statistical method distinguishes a top-down constraint from a bottom-up mechanistic influence? Three methods proposed for examining influences operating at different scales include multi-level modeling (Berk and de Leeuw, Chapter 4), regression tree analysis (Jones et al., Chapter 11), and ANCOVA applied to response variables at multiple scales and involving predictors at multiple scales (Lloyd et al., Chapter 14). Multi-level modeling, in particular, appears to be a promising approach for examining hierarchical relationships.

Downscaling and upscaling are important themes in the book and one of the book's primary goals is to advance methods for quantifying uncertainty associated with scaling. According to the editors, "Scaling, without considering uncertainty, is easy but relatively trivial; scaling with known uncertainty is challenging but essential." Some would argue with the first part of this sentence, but few would argue with the second part. One more unusual chapter describes a combinatorial model to predict a species' abundance from its spatial distribution (Chapter 5)—a downscaling operation. Sources of uncertainty are described by most chapters and quantified by a handful. Li and Wu (Chapter 3) provide a thorough review of methods, including several novel approaches. Upscaling is one recognized source of uncertainty (e.g., Hollenhorst et al., Chapter 15; Urban et al., Chapter 13). However, methods for quantifying this and other types of *spatial* uncertainty are not described.

The book explores contradictory themes of scale invariance and characteristic scales. Wu and Li (Chapter 2) review examples of self-similarity, ranging from physical systems (e.g., turbulence) to biological systems (e.g., allometric relationships with body size, the self-thinning rule). The notion of spatial allometry is reviewed by chapters that examine examine scaling relationships between species distribution and abundance (Li and Wu, Chapter 3) and between forest cover and areal extent (Urban et al., Chapter 13).

Several chapters seek to identify characteristic scales. Lloyd et al. (Chapter 14) found that percent area developed at the 5–10 km radius scale was a better predictor of nest predation among sites than the same quantity calculated for larger or smaller radii. Wickham et al. (Chapter 12) identified the largest spatial extent required to stabilize variance in nutrient export. The related pitfall of scale mismatch is often discussed. In particular, Hollenhorst et al. (Chapter 15) point out that the availability of remotely sensed data tempts researchers to use these data to understand finer-scale phenomena for which they are inappropriately coarse. Their study found that regional-scale, land-cover data were incapable of classifying streams or their buffers. Likewise, Urban et al. (Chapter 13) speculate that their predictive power in locating thrush habitat would be higher if it were possible to remotely sense the density of understory vegetation.

The research described in this compilation spans a broad range of ecosystems and addresses a diversity of scientific questions using a considerable variety of methods. The book includes research based on a variety of approaches: experiments, process modeling, geographic analysis, and empirical modeling. The collection is well organized and adheres to its central themes, a subset of which is likely to interest to any particular reader. This book is likely to be of greatest interest to landscape ecologists and those working at regional scales but also has topics of interest to ecosystem and experimental scientists.

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