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GfÖ Ecological Society of Germany, Austria and Switzerland
Basic and Applied Ecology 24 (2017) 98
Basic and Applied Ecology
www.elsevier.com/locate/baae

BOOK REVIEW

Ecological Forecasting. Michael C. Dietze. Princeton University Press, Princeton, NJ, USA (2017). 288 pp., $65.00 (hardcover), ISBN: 9780691160573 (hardcover), 9781400885459 (eBook)

Few of us will ever have looked at a regression result in someone else's paper and think: "Hm, that slope estimate is a bit low." Typically, we do not pay attention to actual estimates, but rather to significances or qualitative outcomes: "Yes, I knew this effect would be positive." No doubt we may learn a lot if we could compare slope estimates, but that requires commensurable responses, at similar scales, measured in a similar way. That would be physics, not ecology. Or would it?

Mike Dietze's book describes the mind-set and techniques that can make (some parts of) ecological research more commensurable. He weaves these partly statistical, partly modelling, partly field-observational issues around the theme of "forecasting", because that is the strongest selling point for mechanistic ecological modelling. In Dietze's terminology, which I like, forecasting is not necessarily in time, but can also mean prediction to situations yet un-encountered. A model does not need to run a time series into the future, but can also make a forecast for, say, a world with doubled atmospheric CO_2 concentrations. Such predictions would be quantitative and thereby testable. And tested they should be, because every mechanistic model can be improved by data from new parts of the parameter or input space.

The problem for ecologists is that methods routine to meteorologists in weather forecasting, or hydrologists in river-flow prediction, are absent from the ecological teaching curriculum in most universities. Thus, this book aims to fill the void and introduce both the statistical and the data-assimilation side of fitting mechanistic ecological models, from population dynamics over carbon cycles to epidemiology. While the text itself is largely concerned with generating the necessary background and understanding, each chapter is complemented with online resources (in R, on github) to implement and experiment with the introduced material.

Before looking in more detail at what we have to learn, it may be useful to explain the lament of ecological modellers interested in making actual useful, quantitative predictions: data and models hardly ever match each other, and hence many field observations and monitoring data are next to useless to inform mechanistic models quantitatively. Thus, it is neither modellers nor field ecologists who alone could solve this problem, but all ecologists together interested in a specific process or system. Such a concerted action requires a common thinking about how to progress science, how to learn from field experiments and models, how to accept our current lack of understanding about some processes without ignoring them. In a way, Dietze builds on the scientific method, which should be common ground for all natural scientists, but encourages us to add the rigour of mathematics.

The ecological forecasting curriculum comprises statistical and modelling techniques, data handling competences and a good deal of programming skills. The key framework is the quantification of (all) sources of uncertainty that affect a prediction, and hence a propagation of error through all modelling stages into the final forecast. To be able to do so, Bayesian statistics is the most convenient framework, and thus several chapters deal with Bayes, MCMC-methods, error propagation, data assimilation and model diagnostics, all for mechanistic, not statistical, models. These statistical topics are complemented by data handling concepts (data standards, big data, model-data fusion) as well as case studies that demonstrate the ideas in action.

Dietze is, by training, an ecologist with a strong numerical leaning. His main research system is the temperate forest and some examples in the book are taken from his work. Forest growth modelling is, similar to epidemiology and fishery science, ahead of many other disciplines, because mechanistic models have a long tradition there, and so have methods to assimilate observational data. This book is unique in its scope, and it will be for many years, until ecologists embrace its message: to understand how nature works, we have to propose mechanistic models and test them. Their uncertainties reveal what we do not know, and where prediction error can be minimised by future work.

Probably most ecological modellers will know some of the material in the book's 18 chapters. But it will give any reader a wider view of the data-model tandem, and dense information on how to step up to the next level of ecological forecasting.

Carsten F. Dormann
Freiburg, Germany
E-mail address: carsten.dormann@biom.uni-freiburg.de
Available online 10 October 2017

http://dx.doi.org/10.1016/j.baae.2017.09.010
1439-1791/