

# Accounting for uncertainty in ecological analysis: The strengths and limitations of hierarchical statistical modeling

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## Abstract

Analyses of ecological data should account for the uncertainty in the process(es) that generated the data. However, accounting for these uncertainties is a difficult task, since ecology is known for its complexity. Measurement and/or process error are often the only sources of uncertainty confronted when addressing complex ecological problems, yet analyses need to account for uncertainty in sampling design, in model specification, in parameters governing the specified model, and in initial and boundary conditions. Only then can we be confident in the scientific inferences and forecasts made from an analysis. Probability and statistics provide a framework for accounting for multiple sources of uncertainty. Given the complexities of ecological studies, the hierarchical statistical model is an invaluable tool. This approach is not new in ecology, and there are many examples (both Bayesian and non-Bayesian) in the literature illustrating the benefits of this approach. In this article, we provide a baseline of notation and technology from which discussion on hierarchical statistical modeling in ecology can emanate. We have also planted some seeds for discussion and tried to show where the practical difficulties lie. Our thesis is that hierarchical statistical modeling is a powerful way of approaching ecological analysis in the presence of inevitable uncertainties, even if practicalities sometimes necessitate pragmatic compromises.