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# Figuring out what counts: evaluating the effect of data quantity and quality on the performance of integrated population models

Integrated population models (IPMs) are an increasingly popular tool for population modeling in ecology. By combining datasets in a unified analysis, integrated population models link demographic rates with population dynamics and can thereby reduce bias, improve precision, and estimate parameters that would otherwise be unidentifiable using traditional approaches. However, the conditions under which IPMs outperform singular data analyses are poorly understood. In this study, we assessed the performance of IPMs across a range of life history parameters, population trajectories, and data availability scenarios using simulated count, mark-resight, and productivity data typical of a passerine bird monitoring program. We examined relative bias and root mean squared error across models when all three datasets were included versus when one or two datasets were omitted. We varied detection probabilities in the count and mark-resight datasets to evaluate the effect of data quality on IPM performance. In general, higher bias was observed in parameters when datasets that directly informed those parameters were omitted. Higher detection rates alone did little to reduce bias in demographic rate parameters; however, higher detection rates in count surveys were more effective at reducing uncertainty in abundance trends compared with integrating other datasets. Our results suggest that the unique context of a given monitoring program and study species will largely determine whether the collection of additional data versus improving the quality (i.e., detection rates or sample sizes) of existing data streams more effectively improves model performance. Practitioners should carefully consider the best ways of answering the specific ecological or management questions of interest (i.e., estimating demography versus detecting abundance trends) given the life history of the species and the costs of additional data collection. This work provides a foundation from which to further explore the performance of IPM frameworks and for designing monitoring programs and considering the trade-offs between the costs and benefits of collecting additional data when monitoring resources are scarce.