Evidence-based conservation in a changing world: lessons from waterbird individual-based models

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Drivers of environmental change are causing novel combinations of pressures on ecological systems. Prediction in ecology often uses understanding of past conditions to make predictions to the future, but such an approach can breakdown when future conditions have not previously been encountered. Individual-based models (IBMs) consider ecological systems as arising from the adaptive behavior and fates of individuals and have potential to provide more reliable predictions. To demonstrate potential, we review a lineage of related IBMs addressing the effects of environmental change on waterbirds, comprising 53 case studies of 28 species in 32 sites in 9 countries, using the Drivers-Pressures-State-Impact-Response (DPSIR) environmental management framework. Each case study comprises the predictions of an IBM on the effects of one or more drivers of environmental change on one or more bird species. Drivers exert a pressure on the environment which is represented in the IBMs as changes in either area or time available for feeding, the quality of habitat, or the energetic cost of living within an environment. Birds in the IBMs adapt to increased pressure by altering their behavioral state, defined as their location, diet, and the proportion of time spent feeding. If the birds are not able to compensate behaviorally, they suffer a physiological impact, determined by a decrease in body energy reserves, increased mortality, or decreased ability to migrate. Each case study assesses the impact of alternative drivers and potential ways to mitigate impacts to advise appropriate conservation management responses. We overview the lessons learned from the case studies and highlight the opportunities of using IBMs to inform conservation management for other species. Key findings indicate that understanding the behavioral and physiological processes that determine whether or not birds survive following a change in their environment is vital, so that mitigation measures can be better targeted. This is especially important where multiple hazards exist so that sensitivities and worse-case scenarios can be better understood. Increasing the involvement of stakeholders to help inform and shape model development is encouraged and can lead to better representation of the modeled system and wider understanding and support for the final model.