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COMMENT

Decision context as a necessary component of population viability analysis assessments

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Article Impact Statement: Decision context is necessary to include in population viability analysis quality assessment to ensure transparency in conservation decisions.

INTRODUCTION

Populationviability analysis (PVA) is a widely used tool that applies demographic data in simulation frameworks to assess extinction risk for species or populations. It is used in diverse conservation applications, including evaluating management effectiveness, relative risk of threats, and potential changes to protective status (Beissinger & McCullough, 2002), and can be a critical tool for making decisions with imperfect knowledge of the system state, often on limited timelines (Meine et al., 2006).

Chaudhary and Oli (2020) recently developed a framework to appraise the quality of PVAs based on the presence of essential background, model, and analysis components. They evaluated 160 published PVAs and reported a decline in the quality of PVAs over time (1990–2017). We agree PVA studies should report unambiguous descriptions of their essential components (Table 1 in Chaudhary and Oli) and explicitly state the model's biological and statistical assumptions. The need for increased transparency in PVAs is evident. Morrison et al. (2016) reported that only 50% of PVAs published in peer-reviewed and gray literature were both reproducible and repeatable. Further, in an examination of 67 studies that used matrix population models (widely used in PVAs), Kendall et al. (2019) reported that models frequently contained misspecification errors. Given the rapid advancement of simulation techniques, updated guidance for PVA construction is warranted.

However, we believe the essential PVA components identified by Chaudhary and Oli contain a critical omission: the decision context in which the PVA was created and its usefulness in that context. Quality and utility are not mutually exclusive; however, some models that do not meet idealized quality standards might still be valuable because they are useful and represent the best available science for a given decision context (hereafter, decision-support models). The definition of quality for decision-support models should be different than models developed for the purpose of learning (hereafter, heuristic models) and should incorporate how useful the model was, despite information gaps. We further argue that assessment questions should be used prospectively to guide modeling projects, rather than for retrospective comparison of model quality.

WHY DECISION CONTEXT IS ESSENTIAL

Most PVAs can be broadly designated into one of two categories. Heuristic PVAs reflect contexts in which there is no imminent decision to be made, alternative scenarios in the model may not reflect specific actions under consideration by managers, and learning is the primary motivation. Conversely, decision-support PVAs are developed with decision makers and tailored to maximize the relevance of essential components (e.g., alternatives, spatial and temporal extents) and output to a decision. The PVAs evaluated by Chaudhary and Oli spanned both categories. A heuristic PVA by Gaona et al. (1998) compared alternative scenarios of source-sink dynamics on population persistence of the imperiled Iberian lynx (*Lynx pardinus*). We consider this model heuristic because it was not connected to a decision context, such as a protective status evaluation or choosing among conservation actions to prevent further isolation (e.g., assisted migration). Heuristic PVAs are valuable because they add to knowledge of species ecology, identify future research questions, and may ultimately increase the quality of future decision-support PVAs. In contrast, a decision-support model by Hunter et al. (2010) evaluating polar bear (*Ursus maritumus*) population viability under different climate-change scenarios was the basis for the species' U.S. Endangered Species Act (ESA) listing decision. Though we acknowledge some overlap may exist—a decision-support PVA could also elucidate life-history patterns; for example, the distinguishing criterion for decision-support PVAs is the context of a specific, imminent management decision.

Conditions under which heuristic and decision-support PVAs are developed may generate differences in model attributes that could be conflated with quality under the Chaudhary and Oli framework. Specifically, timelines and available data for model development often limit the type or complexity of a PVA. Although some decision-support models may be limited in their complexity due to time constraints and data deficiencies or other uncertainties, we believe this does not detract from their usefulness. For example, with ESA listing decisions, there are rarely sufficient time and resources to collect data required to precisely estimate demographic parameters in complex models. In contrast, the existence of high-quality data may motivate heuristic PVA development, which can occur on timelines unconstrained by management deadlines. Model quality should be judged relative to information available at the time, not to idealized conditions more likely to be available for heuristic PVAs.

We identified three potential unintended consequences of appraising all PVAs based on heuristic conditions. First, compared with well-studied species, PVAs for data-deficient or cryptic species are more likely to be deemed low quality under the Chaudhary and Oli framework due to limited background information and unavailable or imprecise demographic parameter estimates. Life-history patterns, demographic parameters, and their drivers for data-deficient species are, by definition, poorly understood (Beissinger & McCullough, 2002), which may necessitate the use of simplified models. Second, holding PVAs to heuristic standards could reduce the transparency and quality of conservation decisions. A rigid assessment framework that ignores conditions under which a PVA was developed may erode confidence in model predictions among decision makers. Specifically, a perception that decision-support models are of low quality could breed undue skepticism in model outputs and ultimately generate inaction or lead to the use of qualitative assessments that tend to be subjective, nonreproducible, and lacking in explicit acknowledgment of uncertainty (McCarthy et al., 2004). Similarly, such skepticism may reduce the willingness of practitioners to publish decision-support PVAs in peer-reviewed journals that have a wider audience than government reports. Third, an overemphasis on improving model quality could lead to wasted resources focusing on miniscule model improvements that are unlikely to change the outcome of a decision. Alternatively, value of information approaches, a form of sensitivity analysis that identifies sources of uncertainty that have the strongest influence on decision outcomes (Runge et al., 2011), could be used to identify model components with both high uncertainty and high sensitivity.

AMENDED GUIDANCE FOR PVA DEVELOPMENT

Chaudhary and Oli evaluated PVAs based on the presence of specified objectives, species background information, and management scenarios. These elements alone are insufficient to describe the context in which a PVA was constructed. We propose several changes to Chaudhary and Oli's framework to assess PVA quality while considering the purpose and context in which they were created. First, we recommend determining the PVA's purpose as decision-support or heuristic. We then recommend employing the questions in a sequential manner to assess the quality given those different purposes, which may deem certain questions irrelevant. We created additional questions for the beginning of the assessment that describe the appropriateness of the model given the decision context (if present) and available data (questions i–v in Appendix S1). Athough these questions are tailored to decision-support PVAs because they emphasize practicality and decision context, they may be relevant for some heuristic PVAs that seek to inform potential future management decisions. First, was the decision context motivating the development of the PVA well described? Second, if a decision was present, were the model outputs relevant to the decision? Third, if multiple scenarios were evaluated, was the connection to management actions or concerns clearly described and relevant to the decision context? Fourth, were information gaps in model parameters addressed with sensitivity or expected value of information analyses? And, fifth, were available data omitted from the viability model and, if so, were reasons given for their exclusion?

Our questions, while not exhaustive, exemplify issues that could demonstrate the quality of a decision-support model otherwise designated as low quality by heuristic standards. We recognize that some of our questions are impossible for outside observers to address retrospectively (e.g., fifth question) in published papers and therefore recommend use of the amended framework to prospectively guide model development and supporting documentation.

To demonstrate that some heuristically low-quality PVAs are valuable to decision makers and may be considered "useful models," we reviewed the 10 lowest-ranked papers from Chaudhary and Oli and designated each as decision support, heuristic, or unclear based on the presence of a decision context (first question) and how the model relates to the decision. Our post hoc designations are imperfect because the original purpose of the model may be obscured by omitting a decision context or because a manuscript is framed to match a journal's scope. Therefore, we used the unclear category in our classification, but urge researchers to make the model's purpose explicit in future PVAs.

Of the four decision-support PVAs we identified (Appendix S2), the majority excelled at providing a clear application that motivated model development. Agostini et al. (2014) described the background on the protection of brown howler monkeys (*Alouatta guariba clamitans*) by the International Union for Conservation of Nature and developed a PVA to inform future conservation strategies and research priorities. Model scenarios represented uncertainties about disease transmission and were used to identify important metrics for monitoring (third question). Linkie et al. (2006) developed a model to help reserve managers evaluate the effects of antipoaching measures on tiger (*Panthera tigris*) persistence. They presented extinction probabilities of subpopulations within a reserve under different antipoaching and connectivity scenarios (second and third questions). These examples illustrate that the context is as important as the model itself and that simple models can be useful for conservation management despite failings by heuristic standards.

DISCUSSION

Within the mission-driven discipline of conservation science, PVAs are used to predict future population trajectories and assess management strategies (Beissinger & McCullough, 2002; Meine et al., 2006). Given the expansion of PVA application in conservation decision-making (Smith et al., 2018) and simulation approaches, maintaining a current prospective checklist can guide practitioners in developing PVAs that are statistically rigorous and relevant to managers. However, the standards proposed by Chaudhary and Oli may only be attainable under idealized conditions that do not reflect those in which decision-support PVAs are frequently developed (Smith et al., 2018). Therefore, decision-support models should not be judged against an idealized heuristic model, but instead by the value they add to the decision-making process. Using uniform standards to define model quality for both heuristic and decision-support PVAs is inappropriate given their contrasting objectives. We proposed additional considerations that describe the decision context of PVAs, their relevance to management decisions, and leveraging of existing data. We encourage practitioners to apply the assessment framework prospectively so that PVAs constructed under diverse decision contexts can advance both understanding of population dynamics and improve conservation decision-making.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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