

conservation fields have been challenged in developing and implementing measures that facilitate documenting conservation outcomes in ways that are specific, compelling, and visible.

Our findings suggest a need for future focus on several key areas of programmatic and research-and-evaluation emphasis. First, we find a need to develop and implement robust evaluation systems that more effectively track conservation and environmental quality outcomes. Within this context, a need exists to delve into the harder-to-measure ecological outcomes, such as short-, medium-, and long-term direct environmental impacts, as well as socioecological outcomes (Jacobson et al., 2015; Krasny and Roth, 2010; Mellish et al., 2019; Shirk et al., 2012; Thomas et al., 2018). Second, with regard to individual actions with direct impact, we find a need for more innovative ways to measure observable individual behaviors, as prior research suggests caution when relying on self-reported behavioral measures (Chao and Lam, 2011; Kormos and Gifford, 2014). Additionally, when environmental education programs are part of larger conservation efforts, or are one in a suite of interventions, few measures exist that effectively and specifically characterize environmental education efforts within the broader system (cf., Trewbella et al., 2005). Finally, as conservation and the behavioral sciences increasingly emphasize scaling up, recognizing and accounting for the importance of collective action, in addition to and/or in support of individual efforts, becomes increasingly important (Ardoin et al., 2013).

#### 4.4. Conclusion

When we initially started this review, we intended to include only articles that reported measured changes in an ecological indicator or a composite suite of indicators. We envisioned surfacing studies of environmental education programs that provided quantified data describing a change in, for example, air quality, water quantity or quality, acres of land with tree cover, or population numbers of a threatened species. We quickly realized, however, that few studies included all of the components originally sought. This gap in the literature spotlighted not as much a shortcoming in environmental education itself as a failure in our thinking: We failed to account for the nuance of operating within a complex coupled social-ecological system (Catalano et al., 2018). By redesigning the review to allow for more diverse pathways to, and robust understandings of, our outcomes of interest, we discovered the many varied ways in which environmental education can and does address environmental and conservation issues. In the articles surfaced in this review, conservation and environmental education researchers shared an increasing knowledge about the development and implementation of educational programming that has a range of outcomes across temporal and spatial scales. We found little support for a simple, linear model suggesting that, once an environmental education program is implemented, knowledge is shared, skills are developed, proenvironmental actions are undertaken (and documented) in clear, straightforward, and measurable ways—and, as a result, ecosystems are changed. Relatedly, we did not find support for a straightforward model suggesting that, when researchers share findings from research-and-evaluation reports and articles, the outcome is a commensurate shift in ecosystem quality. Instead, our findings suggest a collaborative path that creates an implementation space open to various stakeholders. In such a space, partners can negotiate meanings, co-design initiatives, innovate measures, and in this way enhance the likelihood that their shared undertakings will achieve concrete, measurable conservation and environmental quality outcomes.

Overall, the data and themes that arise from this review encourage intentionality, creativity, and inclusivity when developing and implementing programs that impact environmental quality and conservation outcomes and, relatedly, that glean data demonstrating this impact. The diversity of outcome data—knowledge, attitudes, capacity, opportunities for action, behavior, and ecological—suggests abundant options for researchers wishing to measure and report impacts. As

evidenced in the discussed themes, our recommendations emphasize practical, straightforward strategies, such as incorporating an action-project component into a discussion-based program; connecting with researchers to set parameters for ecological monitoring and ensure the data collected are useful in ongoing conservation research; basing programs in local natural areas; and designing conservation initiatives based on community needs. Reviewed studies highlight hands-on approaches, such as citizen science, and collaborative processes, such as participatory action research, which demonstrate ways in which the thematic findings apply to achieve educational and conservation outcomes.

Although publication bias may inflate reporting of overwhelmingly positive outcomes, overall literature-review findings remain unequivocal: environmental education can create synergistic research-implementation spaces that invite participation, collaboration, and co-production among diverse stakeholders (Lemos et al., 2018; Toomey et al., 2017). Through engagement in those generative spaces, environmental education research and practice contribute to transformative activity that can impact environmental quality through a variety of avenues—and, indeed, we can all benefit from those impacts, in the short and long term.

#### Acknowledgments

Thanks to eeWORKS advisors, for their insights during study conceptualization. We appreciate the research assistance provided by numerous Stanford Social Ecology Lab members, especially Lauren Oakes and Indira Phukan.

#### Funding

This study was supported by eeWORKS, a collaborative project led by the North American Association for Environmental Education (NAAEE), with foundation and government partners, including the U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Gray Family Foundation, Pisces Foundation, and George B. Storer Foundation. While representatives from these organizations and agencies served as advisors at the conceptualization stage, they were not directly involved in data collection, analysis, interpretation, or write-up of results.

#### Appendix A. Bibliography for the 105 final sample studies

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.biocon.2019.108224>.

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<sup>1</sup> Note: A complete bibliography of the 105 studies included in the final sample is available in an online supplement.

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