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Maximizing the effectiveness of qualitative systematic reviews: A case study on terrestrial arthropod conservation translocations

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ABSTRACT

Systematic literature reviews are frequently used in biodiversity conservation to identify knowledge gaps and strategies for improvement. Despite their important role, systematic reviews are not standardized and often use different methods, standards for success, and data sources. We compared two systematic reviews on terrestrial arthropod conservation translocations, unknowingly conducted by two research groups at the same time. Both studies found geographic and taxonomic biases, with most projects focusing on certain countries (e.g., United States, United Kingdom) and taxa (e.g., butterflies, grasshoppers), and found similar success rates (range: 52–58%). However, the studies had different conclusions about which factors significantly influenced translocation success, driven by the data sources used (published literature vs. data from corresponding authors). Release numbers reported by corresponding authors were approximately double those in the published literature, causing the two studies' data sets to differ dramatically. The results show that improved communication among researchers and practitioners is needed to ensure access to current data and prevent duplication of efforts. We recommend that: i) planned, ongoing, and unpublished work be integrated as best possible in reviews; ii) expert perspectives be included alongside quantitative measures; iii) online tools be used more to promote communication; iv) an online catalogue of translocation projects be established to facilitate awareness and contact among researchers; and v) standardization of translocation reporting be increased. We provide practical pathways and actions to help achieve these recommendations. These improved review practices can benefit both systematic reviewers and conservation practitioners by increasing the quality and accuracy of systematic reviews.

1. Introduction

Systematic reviews rigorously summarize an area of scientific literature using explicit methods to identify, select, and critically analyze relevant research (Koricheva et al., 2013). Systematic reviews often use methods of quantitative research synthesis (e.g. meta-analysis); however, when insufficient data are available a qualitative approach can be used to identify gaps in knowledge, especially in young fields of research such as reintroduction biology (Bellis et al., 2019; Brichieri-Colombi and Moehrenschlager, 2016; Fischer and Lindenmayer, 2000; Seddon et al., 2014; Swan et al., 2016; Wolf et al., 1998). The use of systematic reviews is particularly critical to hypothesis validation in ecology because the exact replication of ecological studies is often difficult or impossible (Kelly, 2019; Nichols et al., 2019). There is an impetus to make this learning process efficient in the case of conservation, as practitioners are often attempting to take time-critical actions to save species that are in rapid decline. Conservation also often requires action based on limited or incomplete information, and it is therefore necessary to leverage existing information in order to make educated decisions. The results of such decisions can have important consequences (i.e., the protection or loss of species, habitats, and/or ecosystems), and there are often only limited resources to support alternate courses of action if adaptive management is needed. Systematic reviews help to address the above problems by accelerating the learning process and providing guidance

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for informed conservation decision-making (Côté and Stewart, 2013).

Despite the important role that systematic reviews play in supporting effective conservation actions, there is little standardization in the approaches to such reviews. Studies often use disparate methods, including varied standards of conservation success.

There are many aspects of conservation science that are not well defined or have been historically misunderstood (Dalrymple and Moehrenschlager, 2013; Seddon et al., 2014), and the definitions of key study components used within a systematic review can have a significant impact on how the results of the review are presented and interpreted. For example, translocation success may be defined quantitatively (e.g., "individuals persisted for more than one generation"; see examples in Bellis et al., 2019; Dumeier et al., 2018) or qualitatively (e.g., corresponding author of translocation study provides their subjective assessment, often called "perceived success"; see examples in Brichieri-Colombi and Moehrenschlager, 2016; IUCN and SSC, 2018). Different definitions of success among translocation studies and reviews could cause the results of systematic reviews to differ from one another, creating uncertainty about the current status of conservation efforts and where to prioritize actions in the future. Differing thresholds for success could also affect other important aspects of study interpretation. For example, when analyses are used to identify which factors are associated with translocation success or failure, interpretations of the factors that matter could be different between studies if success is not consistently defined.

We use a case study of two simultaneously conducted systematic reviews on conservation translocations of terrestrial arthropods (Bellis et al., 2019 and Nason et al., 2019, unpublished) to examine how methods for systematic reviews might be standardized and refined to provide repeatable, high-confidence results. The reviews were unknowingly conducted at the same time by two independent research groups, members of which had previously collaborated on other work together (Dalrymple and Moehrenschlager, 2013) and sat on the IUCN Task Force to develop reintroduction guidelines from 2010 to 2012 (IUCN/SSC, 2013a). Multiple recent studies show that terrestrial insect populations are declining globally (Hallmann et al., 2017; Seibold et al., 2019), yet this taxonomic group receives little conservation attention compared to vertebrate taxa (Bajomi et al., 2010; Brichieri-Colombi and Moehrenschlager, 2016; Cardoso et al., 2011; Seddon et al., 2005). By examining similarities and differences in the methods and results of each study, we identify future directions for terrestrial arthropod conservation research, as well as key areas of review methodology where increased standardization could help improve conservation outcomes generally. We conclude by providing a suite of recommendations to maximize the effectiveness of systematic reviews for conservation translocations, thereby expanding the value of this paper beyond the arthropod conservation community.

2. Methods

2.1. Methods in Nason et al. (2019) (unpublished)

Nason et al. (2019) was a draft manuscript for publication. Before submission, the authors noticed a paper by Bellis et al. (2019) on a similar topic but using different approaches. To capitalize on the dual opportunity to present novel data for terrestrial insect conservation translocations and compare systematic review methodologies, both research groups decided to combine efforts and authorship for the current paper. Data from the draft Nason et al. (2019) manuscript are published here for the first time, capitalizing on unique comparisons to Bellis et al. (2019) to help further improve conservation review practices.

A brief summary of the methods used to complete a systematic review of terrestrial arthropod translocations in Nason et al. (2019) are described below. The full manuscript and methods can be found in Appendix A.

Keyword searches were performed in SCOPUS and Academic Search Complete to identify documents (e.g., peer-reviewed articles, government reports) relevant to terrestrial arthropod conservation translocations (see Appendix B for list of key words). Other relevant documents were added from the grey literature (IUCN/SSC, 2008, 2010, 2011, 2013b, 2016, 2018), bibliographies of papers retrieved from keyword searches, and other key regional reviews available to us that were not captured by our keyword searches. The global Zoo Information Management System (ZIMS) database was also queried for translocations, but did not provide any new cases when cross-referenced with other sources.

This search yielded a total of 1476 articles, which were inspected for inclusion in our review based on the following criteria: i) a translocation was performed or was planned; ii) the translocation was conservation-motivated; and iii) the translocated species was a terrestrial arthropod. In total, 109 articles were retained for review, representing 86 species. Descriptive data (e.g., taxonomy, geography, IUCN translocation type, year of release; for a full list of the descriptive data collected, please see Appendix A) were extracted from each of these articles.

To complement the literature review, a survey (Appendix A) was distributed to the corresponding authors of the translocation studies identified to acquire additional details related to each translocation and to obtain a qualitative assessment of translocation success (i.e., perceived success). In total, 58 responses were received from the 88 surveys delivered (i.e., 66% response rate).

To analyze factors influencing translocation success, success was defined as a categorical variable with three levels (successful, partially successful, and failure), as reported by corresponding authors in the survey. Translocation success was cross-tabulated and chi-square contingency table tests performed on the following categorical predictor variables: IUCN translocation type, source of individuals (e.g., captive-bred, wild), motivation for translocation, motivation for selection of source population, motivation for selection of recipient site, type of measure(s) used to monitor the translocated population, and types of obstacles encountered. To assess the differences driving significance, post-hoc tests using adjusted residuals were performed. An ANOVA test was used to see if two continuous variables (number of releases and number of individuals released) influenced translocation success. All statistical tests were deemed significant at $\alpha = 0.05$.

2.2. Methods in Bellis et al. (2019)

A brief summary of the methods used by Bellis et al. (2019) are described below. The full methods can be found in Bellis et al. (2019).

Keyword searches were performed in Thomson Reuters Web of Science, Directory of Open Access Journals, and Conservation Evidence Individual Studies repository to identify projects related to insect conservation translocations (see Appendix B for list of key words). The titles and abstracts of all papers were screened for relevance to insect translocation, resulting in a data set of 62 articles. Inclusion of studies was based on the following criteria: i) the article was relevant to insect translocation; ii) the translocation was not conducted for biological control purposes; and iii) the translocation was primarily motivated by conservation (i.e., translocations that were motivated by research, mitigation, and functional restoration were excluded). Bellis et al. (2019) inferred translocation motivations; if the motivation was uncertain, the corresponding author was contacted for clarification.

The following descriptive data were then extracted from each article: taxonomy, geography, IUCN translocation type, motivation of translocation, and year of release. The following additional data were collected for conservation translocations only: most recent year of monitoring, population status at most recent year of monitoring, origin of source population, number of release years, life stage of released individuals, total number of each life stage released across all years, distance between release site and source population (if wild-to-wild), and perceived cause of project failure (if applicable). It was also noted if captive-bred individuals were released. In cases where the descriptive data could not be acquired from the article, Bellis et al. (2019) contacted the corresponding author.

To define translocation success, a quantitative definition of success was used. A translocation was considered successful if two criteria were met: i) the time elapsed between the most recent release and the most recent post-release monitoring exceeded the life cycle duration of the species; and ii) the most recent monitoring results indicated population persistence at the release site. If a translocation did not meet these criteria, it was classified as one of the following: i) if there was a lack of post-release monitoring, the translocation success status was considered to be "undetermined"; ii) if the lifecycle of the species was unknown, a minimum threshold of five years was used to determine success; and iii) if the criteria were otherwise not met, the translocation was considered a failure.

To analyze factors influencing translocation success, Bellis et al. (2019) defined success as a binary response variable (i.e., success or failure) and used a binary generalized linear model to test the following predictor variables: life history (hemimetabolous or holometabolous), life stage at release (e.g., adult, egg), total number of years that releases occurred, total number of individuals released, and origin of source population (wild or captive-bred). The models were ranked using Akaike's information criterion corrected for small sample size (AICc), with the model having the lowest AICc being considered the best fit to explain the data.

2.3. Comparing Bellis et al. (2019) and Nason et al. (2019)

The methods and results of each study were compared systematically by summarizing the key elements of each study and recording whether the method/result was the same or different with differences being explicitly described. Where relevant, quantitative comparisons of the two studies were made using descriptive numerical summaries (e.g., visually comparing the total number of translocations, mean number of animals released, etc.).

3. Results

A summary of our comparison of the two studies is provided in Appendix B. Bellis et al. (2019) documented 134 translocations of 74 species and Nason et al. (2019) documented 171 translocations of 86 species. Forty-eight species were identical between the two studies. In total, accounting for these overlapping species, 112 species were evaluated across both studies.

Seven non-insect arthropod species identified in Nason et al. (2019) were not within the defined taxonomic scope of Bellis et al. (2019). In addition, 14 species identified in Nason et al. (2019) (n=4 non-insect arthropods) came from planned, ongoing and/or completed translocations and were not included in the completed translocations outlined in Bellis et al. (2019). The remaining ten species included two Orders not identified in Bellis et al. (2019): Blattodea and Phasmatodea. Nason et al. (2019) identified translocations of Diptera from IUCN case reports, while Bellis et al. (2019) identified translocations of Ephemeroptera and Plectopera from Web of Science. Through the survey by Nason et al. (2019), corresponding authors voluntarily identified 20 additional translocation projects that were unpublished.

3.1. Main findings on terrestrial arthropod conservation translocations

Both research groups found the majority of translocations were conducted within the United States, the United Kingdom, and New Zealand with little representation in the literature of efforts in Asia, South America, and Africa (Fig. 1). Lepidoptera (moths and butterflies) and Orthoptera (grasshoppers and allies) were also over-represented compared to other diverse taxa (e.g., Diptera, Hymenoptera, and Hemiptera; Fig. 2).

Nason et al. (2019) were able to classify 128 out of 171 translocations by IUCN type and found that reintroductions were most common (n=91 [71%]), followed by assisted colonizations (n=21 [16%]) and reinforcements (n=18 [14%]). No translocations were classified as ecological replacements.

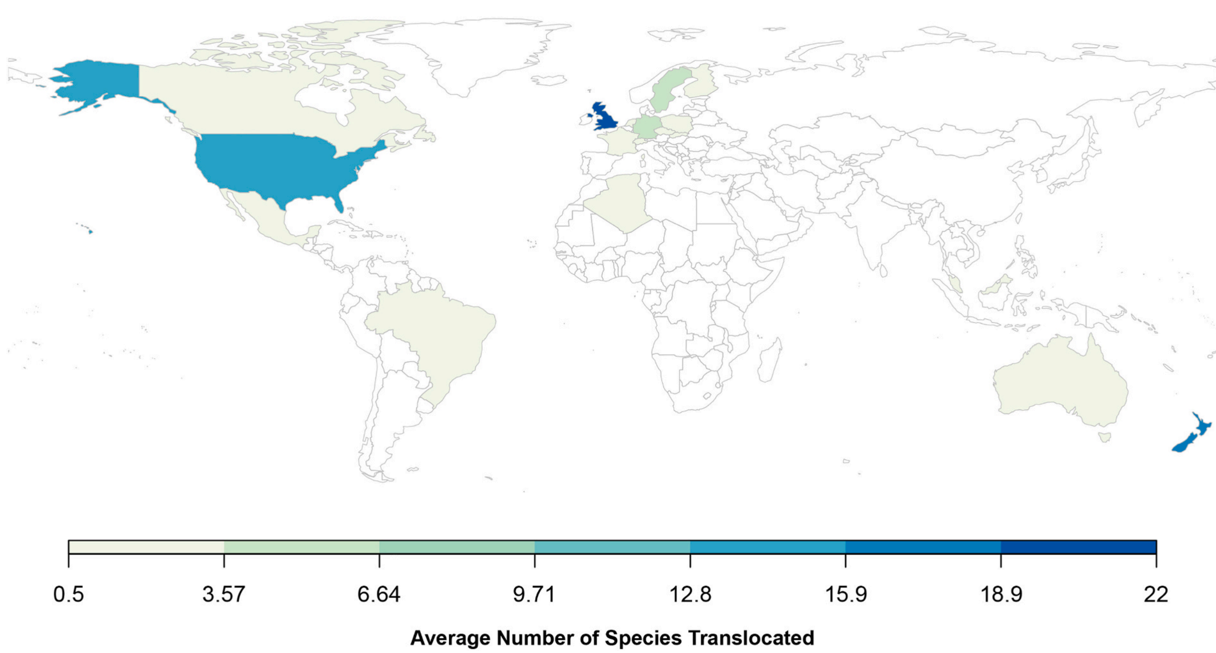

Fig. 1. Geographic bias in terrestrial arthropod translocation projects based on the average number of species translocated in each country. Averages were calculated using data sets from two replicated systematic reviews (Nason et al., 2019; Bellis et al., 2019). Three translocation 'hotspots' emerged within each review: the United Kingdom, the United States, and New Zealand.

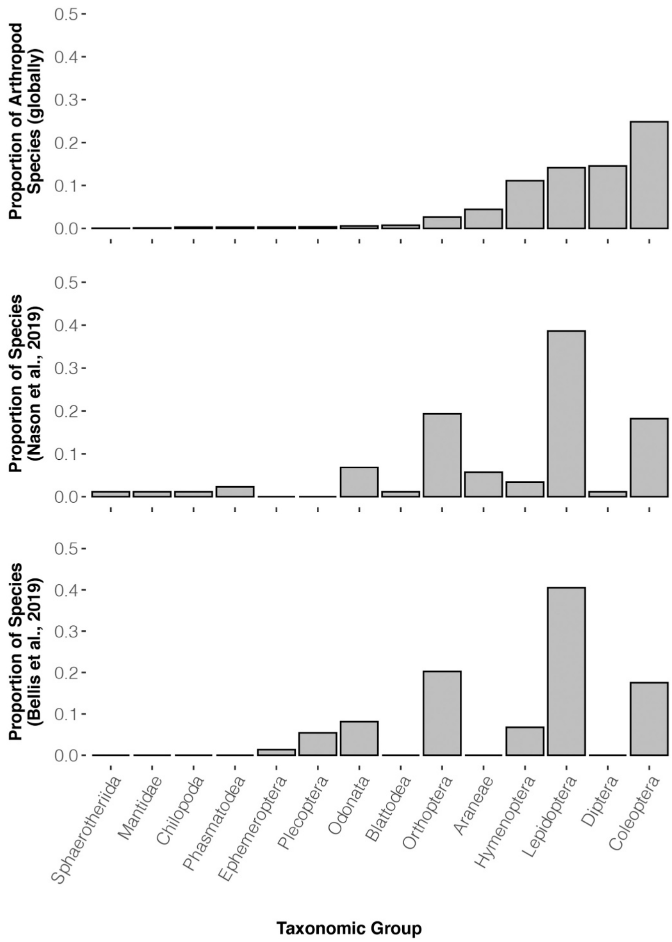

Fig. 2. Taxonomic bias in terrestrial arthropod translocation projects, as evidenced in two systematic reviews. Each review shows that Orthoptera and Lepidoptera are over-represented relative to their global biodiversity, while taxonomic groups such as Diptera and Hymenoptera are under-represented. Top: species richness of the taxonomic groups reviewed, expressed as a proportion of total arthropod species (retrieved from Catalogue of Life, 8 March 2020). Middle: number of species within each taxonomic group recorded in Nason et al. (2019), expressed as a proportion of total species in that review. Bottom: number of species within each taxonomic group recorded in Bellis et al. (2019), expressed as a proportion of total species in that review.

3.2. Comparison of literature review methodologies

Both research groups used similar search terms to retrieve their studies (Appendix B). Search terms were at a high taxonomic level (Phylum, Class) and Bellis et al., 2019 reported that using more specific search terms at the level of Order did not result in the identification of any additional studies. Both research groups searched the grey literature. Nason et al. (2019) reported that 40 out of 109 documents in their database came from grey literature sources (37%), while Bellis et al., 2019 retrieved 16 out of 77 documents from grey literature (21%). Nason et al. (2019) found that grey literature sources were significantly more likely to describe translocation programs with an "ongoing" status compared to published literature. Both research groups reported that they benefitted from additional information from the corresponding authors of the translocation studies being evaluated (e.g., email inquiries and surveys).

The two studies differed in how they defined translocation success and the variables associated with it. Bellis et al. (2019) examined success quantitatively, whereas Nason et al. (2019) used qualitative perceptions of success provided by the authors that they surveyed. The qualitative and quantitative success definitions produced broadly comparable findings with regards to identifying successful projects, as both studies identified overall success rates in the range of 52–58%. However, since project outcomes in terms of success/failure were stratified into several categories in Nason et al. (2019) and defined as binary in Bellis et al. (2019), the two studies made different conclusions about the estimated rate of translocation failure (Bellis et al. (2019): 31%; Nason et al. (2019): 15%). The categorical and binary classifications of success also resulted in different types of statistical analyses being used between the two studies: Nason et al. (2019) used chi-square contingency table tests (categorical) and Bellis et al. (2019) used generalized linear models (binary).

Nason et al. (2019) gathered much of their data for analysis of factors driving translocation success from their survey to corresponding authors, while Bellis et al. (2019) collected these data directly from the literature and supplemented this with data from grey literature and unpublished datasets provided by authors. The data sets used for analysis therefore differed between the two studies. In particular, Nason et al. (2019) reported that the number of individuals released per translocation were approximately twice as large on average in the survey (2640±857, n=92) compared to the numbers reported in Bellis et al. (2019) (1281 ± 423, n = 101). Three predictor variables used in each study's analysis of factors driving success were the same: number of individuals released, source of individuals, and number of releases. Each study included additional unique predictor variables (Appendix B).

4. Discussion

4.1. Lessons for terrestrial arthropod conservation

The comparison of these two studies reveals a number of key insights that can inform the conservation of terrestrial arthropods and future research.

Further work is required to understand why terrestrial arthropod translocations are geographically and taxonomically biased and to address these biases. Both studies show that terrestrial arthropod translocations are geographically and taxonomically biased; this may be due to publication bias, actual bias in conservation effort, or both (Jennions et al., 2013). Additionally, the use of English search terms may have biased our search results to English-speaking countries (Amano et al., 2016; Konno et al., 2020). While the addition of non-English language records in a recent review of amphibian and bird conservation did not significantly change results due to the scarcity of such studies in the evidence base (Christie et al., 2020), it remains important to better incorporate non-English records into the conservation literature, especially with respect to grey literature which is rarely translated. Evidence of similar geographic and taxonomic biases in conservation effort has also been recorded in other translocation reviews (Bajomi et al., 2010; Bossart and Carlton, 2002; Leandro et al., 2017; New and Samways, 2013).

With respect to geographic bias, the lack of conservation efforts and knowledge regarding insects in the southern hemisphere is well-established (New and Samways, 2013; Taylor et al., 2018). Community-based conservation projects providing both socioeconomic and conservation benefits may be a valuable avenue to increase global conservation efforts and their inclusion in the published literature (Berkes, 2007; Hamilton et al., 2011).

Several large taxonomic orders of arthropod were scarcely represented in either study's findings compared to their global diversity, notably the hyper-diverse Hymenoptera (bees, ants, and allies; 117, 847 species described in the Catalogue of Life) and Diptera (flies; 153, 293 species described in the Catalogue of Life). These findings are also supported by Leandro et al. (2017): at the time of publication, Diptera or Hymenoptera were absent from the evaluated European threatened species lists, despite these orders accounting for > 40% of European insect species. Both Bellis et al. (2019) and Nason et al. (2019) identified a need for more research and conservation effort for these under-represented taxonomic groups. The characterisation of life-histories and habitat requirements will be crucial to the recovery of terrestrial arthropod populations, enabling targeting of local and landscape-level drivers of decline (Cardoso et al., 2011; Seibold et al., 2019). Drivers of these taxonomic biases should be evaluated and addressed in future terrestrial arthropod conservation work. Questions that would be useful to answer include: Are there barriers to funding for these under-represented species groups? What is the conservation cost of not protecting them? Which under-represented group(s) may be most at risk?

Terrestrial arthropod translocations are likely underestimated because many planned and ongoing translocations are not yet published (e.g., *contained in grey literature or undocumented*). There is little documentation of terrestrial arthropod translocations, and the documentation that does exist is often incomplete. Both Nason et al. (2019) and Bellis et al. (2019) reported that they struggled to find all the necessary information to characterize and evaluate translocations based on the available documentation. Awareness of planned conservation efforts among conservation practitioners is useful, as this facilitates early knowledge exchange between conservation practitioners, more thorough documentation of overall conservation efforts, and collaborations to maximize conservation benefits or share experience in analogous settings (Forbes et al., 2020). The value of translocation reviews might therefore be increased by including planned and ongoing works into evaluations of taxonomic and geographic coverage.

Assisted colonization, a form of translocation that is controversial in the literature and largely untested in other animal taxa, has been trialed comparatively frequently in terrestrial arthropods. Literature on terrestrial arthropods may serve as a good source of insights on this infrequently studied form of animal translocation. Assisted colonizations may be used more frequently for terrestrial arthropods if they are seen as a low risk to the recipient ecosystem since they are unlikely to have large top-down effects, or at least, they are perceived to be unproblematic. Some species may need to be prioritized for assisted colonization if they have a low capacity to respond to rapid climate change: in the example of terrestrial arthropods, this may include species with poor dispersal ability (e.g., wingless species, such as weta) or those that are highly specialized (e.g., species dependent on mutualism, such as myrmecophilous butterflies) (Foden et al., 2013).

4.2. Lessons for systematic reviews

The current study highlights the weaknesses in the repeatability of literature review methodology. The majority of the methods and scope of Bellis et al. (2019) and Nason et al. (2019) are near-identical, yet some of the results as well as the overall interpretation of the results differ between the two studies. Similar conclusions were drawn regarding publishing biases and overall translocation success rates, but the studies differed in their conclusions about what factors drove translocation success. Bellis et al. (2019) found that the main important factor driving translocation success was the number of individuals released, while Nason et al. (2019) found that other factors reported by corresponding authors were the significant drivers (extent of post-release monitoring, habitat quality/restoration, number of source populations available, and distance from threats). In this section we synthesize the principal implications of the current study for methodology and interpretation of systematic reviews of conservation translocations, using the key similarities and differences between the two studies as supporting evidence.

Taxonomic identifiers at the level of Class are likely sufficient for systematic reviews of hyper-diverse taxa. In any type of literature review, the identification and selection of search terms are critical (Côté et al., 2013). Ideally, a literature search captures as many relevant terms as possible; however, with a taxonomic group as diverse as terrestrial arthropods, it is not possible to search all terms at a level more specific than Order. Both of the studies in this review successfully used high-level taxonomic identifiers (e.g., "insect", "insecta", "arthropod") to perform comprehensive searches, showing that thorough databases can be built with these broad keywords.

Inconsistent definitions result in variations in data classification, analysis, and interpretation. Differences in the definition of translocation success between the two studies resulted in different reported failure rates of translocations. This discrepancy is important because decisions about whether to initiate or participate in a translocation program are likely to be informed by expectations of success outcomes. Depending on the source, a conservation manager might form very different perceptions of the potential for failure of terrestrial arthropod translocations. Furthermore, managers may struggle to design and evaluate their own translocation projects when definitions are unclear.

To improve the consistency of reporting, researchers and managers should report outcomes that are directly comparable or that can at least be compared with full knowledge of the objectives of the project. If researchers and managers clearly define the objectives of their translocation project and provide the criteria for deeming the translocation to be successful, this would allow the results to be contextualized and potentially compared with other studies. For example, in plant reintroductions, authors have reported successful outcomes once plants have survived the translocation process; however, a translocation deemed successful by this standard may not qualify as successful under other criteria (e.g., success is achieved only if a new generation successfully recruits to the population) (Dalrymple et al., 2012). When success criteria are transparent, comparison and evaluation of studies becomes much more practical for both conservation managers and researchers compiling data for systematic reviews.

Small variations in methodology can "pile up" to cause large deviations in the final data sets used in systematic reviews. Differences in the composition of the species inventories assembled by each research group arose due to variation in the choice of grey literature sources, the taxonomic scope of the studies (i.e., inclusion of non-insect arthropods in Nason et al. (2019)), and the study exclusion criteria used (i.e., exclusion of planned translocations in Bellis et al. (2019)). Individually, any one of these variations would not have caused much difference, but in combination they resulted in two databases that differed in the number and identity of species and the number of translocations considered for analysis. These variations could be reduced in future studies by promoting awareness of each other's research efforts and collaborating as much as possible (i.e., producing one unified review paper rather than two differing ones).

Pre-registration of studies is a growing trend in health and allied sciences and is now being used in ecology and conservation (Parker et al., 2019; e.g., Ecological Solutions and Evidence: https://besjournals.onlinelibrary.wiley.com/hub/journal/26888319/registered-reports-author-guidelines). The equivalent process for systematic reviews is the generation and publication of a systematic review protocol which is peer-reviewed and published prior to the review being undertaken (e.g., the Collaboration for Environmental Evidence https://www.environmentalevidence.org/). Neither Bellis et al. (2019) nor Nason et al. (2019) published their review protocols prior to undertaking the work. If they had, they might have been able to collaborate and benefit from the insight of others in improving their search protocol.

Differences in data sources and analysis methods can lead to different conclusions about what factors drive success/failure. As stated above, Bellis et al. (2019) and Nason et al. (2019) differed in their conclusions regarding the main factor(s) driving translocation success. Both studies considered number of individuals released as a predictor variable, but where Bellis et al. (2019) thought this was the most important factor controlling success, Nason et al. (2019) found that other factors were more influential on translocation outcomes. This dichotomy likely arose for two main reasons. First, the different data sources used in the two studies resulted in divergent release numbers. Bellis et al. (2019) primarily gathered data from the literature and supplemented these data with information collected from a subset of corresponding authors, while Nason et al. (2019) contacted all corresponding authors directly to acquire information and data via an email survey and used these data as the basis for their analysis. The numbers from the corresponding author survey in Nason et al. (2019) were different than the published numbers in Bellis et al. (2019) because releases had continued after publication. Second, variables predicting success differed between the two studies. Specifically, Nason et al. (2019) included several variables that were reported by corresponding authors in their survey (e.g., post-release monitoring effort, reasons for choosing source/recipient populations), which had a stronger relationship with success ranking than other factors drawn from the original publications (e.g., number of individuals released, IUCN translocation type).

The differences in the results between the two studies reveal two important conclusions about conservation translocations: i) translocation studies are frequently published before conservation activities are completed; and ii) important practical details (e.g., reasoning for choice of source population, extent/type of post-release monitoring) might not be included in peer-reviewed publications. Acquisition of current and complete information will thus often require correspondence with authors (e.g., confirmation of number of releases, number of individuals released, etc.).

4.3. Recommendations to maximize review effectiveness

Based on the comparison of Bellis et al. (2019) and Nason et al. (2019), we submit five core recommendations to maximize the effectiveness of systematic conservation reviews.

4.3.1. Collate planned, ongoing, and unpublished work when reviewing conservation projects

Researchers should increase consideration of corresponding author surveys and grey literature searches as important approaches to gain more information on ongoing and unpublished work. Further, we recommend that researchers maintain up-to-date research profile pages (e.g., ResearchGate) to communicate planned and ongoing studies, which will increase access to unpublished information and opportunities for collaborations among researchers and practitioners. Some of the main differences between the two studies compared here could be traced to the fact that some planned and ongoing work was included in one study, which resulted in the identification of additional taxa and updated release numbers. Since conservation actions typically continue after articles are published, datasets are constantly evolving, and the numbers, results, and scopes of activity presented in published articles are frequently not reflective of current conditions. There is also good evidence that failures are an important learning tool in conservation and help to bridge the research-implementation gap (Catalano et al., 2019), but these are more likely to fall victim to publication bias and go unpublished.

4.3.2. Consider expert evaluations of factors driving conservation success and failure in addition to quantitative measures

Socio-political, cultural, and financial barriers are not often addressed in the published literature. To include such aspects in systematic reviews, direct correspondence with authors is needed. While it is important to note that expert evaluations are not a substitute for empirical evidence (and should not be cited as such), both studies benefited from the expertise of corresponding authors who provided valuable insight into their respective projects. Bellis et al. (2019) summarized causes of translocation failure reported by corresponding authors, and further investigation into one of the most often-cited factors has led to a subsequent publication identifying climate suitability as a cause of translocation failure (Bellis et al., 2020). Nason et al. (2019) were also able to identify several important predictor variables that were not available in the published literature by communicating with the corresponding authors of the translocation studies. Peer-reviewed publications are of key importance, as they enable information to be discovered (i.e., identification of translocation projects), but such publications often do not capture the types of nuances and details that can impact conservation success.

4.3.3. Improve communication and collaboration among systematic review research teams using online tools

Increased use of online tools, such as the Collaboration for Environmental Evidence (CEE) pre-registration system for systematic reviews, would allow researchers to communicate better and would result in less duplication of effort. Such online tools also enable more collaboration among researchers, as authors' names are made publicly available once review protocols are pre-registered, meaning that researchers interested in collaborating may contact the current authorship team. Increased uptake of the CEE system among conservation researchers is needed, and might be usefully promoted through other prominent conservation research organizations (e.g., IUCN Conservation Translocation Specialist Team).

4.3.4. Develop an online catalogue/registry of translocation projects

A catalogue of planned, ongoing and completed translocation projects would increase awareness of each other's work among researchers and practitioners, acting as a dynamic form of communication. The catalogue would enable researchers and practitioners to collaborate and retrieve expert input and current data from one another, thereby making data more available for review analyses while also improving on-the-ground translocation practices.

In an ideal world, a detailed database of translocation projects would be established with high data reporting standards such that data could be used for more rigorous reviews like meta-analyses; however, calls for such a database have been made for decades and have unfortunately been impractical to deliver due to the time-consuming requirements of database maintenance and the difficulty in retrieving standardized quantitative data from widely variable study systems. A descriptive catalogue would help overcome this limitation, as it would not require extensive data on each project or time-intensive maintenance to update numbers and therefore be easier to populate. We suggest that the catalogue would include the following information for each project: taxon, translocation objectives, types of data being collected, and contact information for two authors. Permanent identification numbers such as ORCID iDs could be used to ensure that contact information remains current and does not require regular updating.

The catalogue could also accept entries in all languages to help overcome English language bias in conservation review work (Konno et al., 2020). We suggest that the IUCN Conservation Translocation Specialist Group (CTSG) would be the most appropriate organization to spearhead this catalogue, as they are an international group with the necessary influence, resources, and mandate. The IUCN CTSG could also collaborate with a group such as the Transcending Language Barriers to Environmental Sciences (translatE: https://translatesciences.com/) project to increase language accessibility of the catalogue.

4.3.5. Increase standardization of translocation reporting to improve adaptive learning and management

In particular, we suggest the following components are consistently included in reports of individual translocations: IUCN translocation type (reintroduction, reinforcement, assisted colonization, and ecological replacement; IUCN/SSC, 2013a), clearly defined project objectives and success criteria, and key demographic milestones during post-translocation monitoring (e.g., survival to maturation, reproduction; specific measures will depend on study system and practicality/ability to collect data). The inclusion of this information would greatly improve the clarity and value of individual translocation studies for both conservation practitioners and systematic reviewers. We recommend that demographic milestones should be reported in a way that explicitly acknowledges the monitoring period with respect to generation time. For example, if monitoring exceeds the lifecycle of a species but no reproduction has occurred, this should be cause for concern and should not be announced as a successful translocation.

5. Conclusion

It is likely that systematic reviews will remain important strategies for the continuous evaluation and improvement of conservation translocation work in the future. In order to maximize the effectiveness and practicality of these reviews, it is important to recognize the limitations of relying on published literature to retrieve data.

Overall, we suggest that improved systems of communication among research teams and conservation practitioners are needed to support efficient conservation research and decision-making. Since studies are published at a fixed point in time, yet conservation efforts usually continue afterwards, conservation practitioners need to shift over to 'living' forms of communication such as online catalogues and direct correspondence. If researchers can adapt the way that they communicate and share data, systematic reviews can increase their accuracy and ability to reflect current realities. In turn, conservation practices can adapt and respond quickly to address conservation needs and knowledge gaps – a crucial ability for a discipline that must often act fast to ensure ecosystems and species are not lost.

Declaration of competing interest

The authors have no competing interests to declare.

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Appendices. Supplementary materials

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