

DECADE OF ECOSYSTEM RESTORATION

Registered Report Stage 1: Study Design

Is the methodology used in reviews of restoration outcomes reliable? A systematic map protocol

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Abstract

1. Over the past decades, evidence-based research has become increasingly important in restoration ecology. Evidence synthesis can be a powerful tool to identify the most effective strategies to conserve and restore ecosystems. However, reviews in the environmental sector have been described as non-systematic and exhibit a diverse range of approaches. While it is known that environmental syntheses can substantially improve in quality, the reliability of restoration reviews (i.e. the level of confidence an end-user may place in their methodology) remains poorly known.

2. Given the importance of literature reviews of restoration practice and outcomes for informing management and policy, as well as research, this systematic map protocol aims to scrutinize the peer-reviewed literature for an assessment of the methodological reliability and reproducibility of restoration reviews. We will use bibliographic databases and search engines to collect studies published in peer-reviewed journals dealing with the ecological restoration of terrestrial ecosystems.

3. Through a scoping exercise, a search string was developed which was based on a previously prepared test list. The search string was then tested for validity with one independent reference list. After searching, the screening process will be done on the title, abstract and full-text level and consistency checking will be done on a random subsample by a second assessor, with decisions being compared using the kappa test of agreement. After retrieving studies and checking for relevance to the synthesis, we will appraise the methodological reliability of restoration reviews by applying the Collaboration for Environmental Evidence Assessment Tool – CEESAT. Lastly, we will collect bibliometric information to qualitatively describe the retrieved body of literature, and then key trends in data will be synthesized according to a range of generic questions.

4. To conduct the resulting review, we will follow the procedures specified in this protocol, considering guidelines from the Collaboration for Environmental Evidence and ROSES form. The resulting review will yield a useful overview of applying systematic reviews principles for various end users. At the same time, it will help restoration

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practitioners to identify critical points where restoration evidence syntheses must be improved to move forward.

KEYWORDS

evidence-based restoration, reproducibility, restoration ecology, restoration reviews, review methodology

1 | INTRODUCTION

1.1 | Background

The relentless drive for economic growth and the increase in global population has resulted in several societal challenges and environmental degradation such as climate change, food and water security, social equity, human health, and socioeconomic development, biodiversity loss and pollution (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016; WWF, 2016). These unprecedented challenges have pressed the field of restoration ecology and conservation biology to re-envision the way they set goals, and how they manage ecosystems to conserve biodiversity and ecosystem services globally (McEuen & Styles, 2019; Suding et al., 2015).

Evidence of the proximity of a critical tipping point for the survival of all species (Cohen-Shacham et al., 2019; Intergovernmental Panel on Climate Change, 2018; Steffen et al., 2015) have created an urgent need for comprehensive scientific research approaches (Brancalion & van Melis, 2017; Cohen-Shacham et al., 2019) to subsidize environmental management at large scales and to mitigate the consequences of decades of rapid degradation (International Union for Conservation of Nature, 2016; Holl, 2017; O'Leary et al., 2016). In the recently declared UN Decade of Ecosystem Restoration (2021–2030; <https://www.decadeonrestoration.org/>), evidence-based research represents an important tool for advancing with the scientific field and practice of ecological restoration.

Traditionally, observations and field experiments have been the main way of obtaining knowledge about empirical patterns in ecology and ecosystem sciences (Cadotte, Mehrkens, & Menge, 2012). Primary studies provide vital insights into the real-world application of a specific intervention or conservation strategy under particular conditions (O'Leary et al., 2016), but they can be limited in time and spatial scale (Wortley, Hero, & Howes, 2013), designated as 'provincial case studies' (Cadotte et al., 2012; Lawton, 1999).

The increasing number of published primary studies has resulted in ever-increasing evidence of variable quality for decision makers to draw from Li and Zhao (2015), O'Leary et al. (2016) and Pautasso (2012). Specifically, the scientific field of restoration ecology is facing a considerable expanding volume of primary research (Guan, Kang, & Liu, 2018; Romanelli, Fujimoto, Ferreira, & Milanez, 2018), reaching a point where is necessary to apply effective and well-documented strategies to produce reliable synthesis (Fazey, Salisbury, Lindenmayer, Maindonald, & Douglas, 2004; Lawler et al., 2006; Brancalion & van Melis, 2017; Trimble & van Aarde, 2012; Woodcock, Pullin, & Kaiser, 2014).

Evidence syntheses may substantially boost the effective power of individual studies (Cooke et al., 2018; Stewart, 2010). Here we use the concept of 'evidence synthesis' to describe the whole methodology used to gather and collate evidence, for instance, systematic review or systematic maps (James, Randall, & Haddaway, 2016). These are rigorous, transparent and reproducible methods for cataloging, collating and synthesizing all available documented evidence on a topic of interest (Berger-Tal et al., 2018). Thus, allowing us to investigate and reveal knowledge gaps, trends, effects modifiers and the sources of heterogeneity in the field experiments that cannot be easily identified in isolated studies (Stewart, 2010) (see considered review terminology in Table S1; Appendix A in the Supporting Information).

Evidence reviews have proved to be effective in guiding conservation and restoration strategies (Diefenderfer et al., 2016; Grames & Elphick, 2020; Jeusset et al., 2016; Slodowicz, Humbert, & Arlettaz, 2019); however, without a credible and consistent method for conducting evidence synthesis, not all reviews can be considered equally reliable (Berger-Tal et al., 2018; Pullin & Stewart, 2006; Pullin et al. 2018). Unsurprisingly, there are numerous examples of reviews reporting conflicting results (Berlin & Golub, 2014). In the broad field of conservation and environmental sciences, most reviews are non-systematic and exhibit a diversity of methods, objectives and approaches to reporting evidence (Woodcock et al., 2014).

While it is known that environmental reviews can substantially improve in quality (Diefenderfer et al., 2016; Grames & Elphick, 2020), the methodological reliability and reproducibility of restoration reviews remain poorly investigated. As a consequence, restoration practitioners must be prepared to critically evaluate each relevant literature synthesis that may be used in decision-making and policy-relevant questions (Cooke et al., 2018; Pullin & Knight, 2012; Woodcock et al., 2014).

The variation in the methodological rigour of restoration reviews may lead to inaccurate conclusions and biased results (Lajeunesse & Forbes, 2003; Reid, Fagan, & Zahawi, 2018; Stewart, 2010; Whittaker, 2010). For example, in the restoration sector, several recent meta-analyses aimed to determine whether natural regeneration is more effective at recovering tropical forests than active restoration (Bonner, Schmidt, & Shoo, 2013; Crouzeilles et al., 2017; Meli et al., 2017). Reid et al. (2018) reviewing this literature found that comparisons between strategies were biased by positive site selection. Likewise, discrepancies have been reported concerning the conclusions of the syntheses produced in the field of conservation biology, because the methods used to gather evidence are not reproducible as in primary studies (Grames & Elphick, 2020).

Given such problems, the systematic map protocol proposed here will yield a useful overview of systematic review principles for various restoration practitioners. Moreover, the resulting paper will help researchers and decision makers to identify critical points where restoration evidence reviews must be improved to move forward. We will apply the Collaboration for Environmental Evidence Assessment Tool – CEESAT – to assess the methodological reliability (in terms of objectivity, comprehensiveness and transparency) of restoration reviews (see definitions in Table S1; Appendix A).

1.2 | Primary question

- How reliable is the review methodology across restoration evidence syntheses addressing terrestrial ecosystems?

1.3 | Question components

The question components were structured according to the PICO-structure (population, intervention, comparator and outcome), according to Collaboration for Environmental Evidence (Pullin et al. 2018).

- *Population*: Reviews should be a synthesis of primary research, being described by their authors (in title, abstract, or keywords) as a systematic review or a meta-analysis.
- *Intervention*: Reviews should address the ecological restoration of terrestrial ecosystems.
- *Comparator*: Reviews published by the CEE journal *Environmental Evidence*.
- *Outcomes*: Any outcome will be eligible for inclusion.

1.4 | Secondary questions

- What is the level of confidence that restoration practitioners can place in restoration reviews based on information reported within each study, through CEESAT?
- What is the relationship between SCImago Journal Rank (SJR) and reliability scores?
- Are journal impact factor and more reliable reviews correlated?
- What is the relationship between reliability scores and synthesis type (narrative synthesis vs. meta-analysis)?
- How reproducible is the evidence review methodology in restoration ecology?
- How restoration reviews can improve in reliability and reproducibility?

1.5 | Generic questions

- What are the main research topics addressed among restoration reviews?

- What are the main bibliographic sources reported in restoration reviews?
- Are discrepant the review concepts among restoration authors?

2 | MATERIALS AND METHODS

2.1 | Searching for articles

Restoration ecology is the scientific field that supports the practice of *ecological restoration* (Aradottir & Hagen, 2013; Romanelli et al., 2018); thus, we will use the terms ('ecological restoration' and 'restoration ecology') to retrieve titles, abstracts and keywords of related publications. We will also combine the above-mentioned terms with ("*meta-analys**" OR "*meta analys**" OR "*metaanalys**" OR "*metanalys**" OR "*systematic* review**") to define our population of reviews. We have selected only two terms to retrieve publications related to ecological restoration. Therefore, the total number of all available evidence may be underestimated. Documents described with other terms (e.g. forest restoration, ecological rehabilitation, ecosystem reclamation or habitat restoration) could also be relevant for analysis. For clarity, terminology related to evidence synthesis used in this paper is defined in Table S1 (Appendix A in the Supporting Information).

We have selected four widely used bibliographic sources in the field of conservation biology and environmental sciences to test our pre-established questions: (i) Web of Science (WoS Core Collection: SCI-E, SSCI, ESCI); (ii) Scopus, (iii) CAB Direct and (iv) SciELO; we also used Google Scholar as a search engine. We chose these bibliographic sources because they are subject of several comparative studies (e.g. Harzing & Alakangas, 2016; Meho & Yang, 2007) and are often used to evaluate researcher's productivity and whole disciplines, as well as undertake bibliometric analysis and evidence reviews (e.g. Harzing & van der Wal, 2008; Jacsó, 2011; Côté, Curtis, Rothstein, & Stewart, 2013). We will include the term 'forest restoration' to restrict the search on Google Scholar to exclude the most unwanted documents.

2.2 | Search string

The final search string is shown in Table 1.

2.3 | Grey literature

For our analysis only peer-reviewed articles that are relevant are selected.

2.4 | Languages

Searches in bibliographic databases will be conducted only in English using the above-mentioned search string. However, we will consider

TABLE 1 Search strategy for locating reviews

Bibliographic sources	Search terms
Web of Science (core collection: SCI-E, SSCI, ESCI); all years; all documents)	TOPIC ("meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "systematic review*") AND ("ecological restoration" OR "restoration ecology")
Scopus (all years, all documents and access type)	TITLE-ABS-KEY ("meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "systematic review*") AND ("ecological restoration" OR "restoration ecology")
Google Scholar (all years and document type)	Hit 1: "meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "systematic review*" AND "ecological restoration" AND "forest ecosystem" Hit 2: "meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "systematic review*" AND "restoration ecology" AND "forest ecosystem"
SciELO Citation Index (all years, all documents)	TOPIC "ecological restoration" OR "restoration ecology" OR "restauração ecológica" OR "ecologia da restauração" AND "meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "review*" OR "meta análise*" OR "metanálise*" OR "meta analyse*" OR "metanalise*"
CAB Direct (all years, all documents)	All FIELDS ("meta-analys*" OR "meta analys*" OR "metaanalys*" OR "metanalys*" OR "systematic review*") AND ("ecological restoration" OR "restoration ecology")

possible retrieved documents published in English, Spanish or Portuguese.

2.5 | Article screening and study eligibility criteria

The review team conducted a scoping exercise to assess the effectiveness of search terms (Table 1), testing them against a set of about 20 articles known to be relevant. All retrieved reviews will be first screened on their title and keywords to remove irrelevant documents. Posteriorly, each retained paper will be screened for relevance on the basis of the abstract.

We will use the following inclusion criteria at the full-text screening stage: (i) reviews should be described by their authors (in the title, abstract or keywords) as a systematic review or a meta-analysis – although this searching strategy is partly dependent on how the authors describe the review, our purpose is to detect possible misuses of review concepts; (ii) reviews should be directly related to ecological restoration of terrestrial ecosystems; and (iii) reviews should be a synthesis of primary research.

Studies that do not match our research question or inclusion criteria will be excluded at the title, abstract or full-text levels. Reasons for exclusion will be provided for all articles excluded at the full-text assessment. A second and third assessor will perform the same screening process for a sample of ~20% of the retrieved papers on the full-text screening process and Cohen's kappa will be used to check for inclusion consistency. Cohen's kappa coefficient is a statistic that is used to measure inter-rater and intra-rater reliability for qualitative (categorical) items (Cohen, 1960). If the kappa score will reach < 0.6, the inconsistencies among the reviewers will be discussed and the inclusion criteria possibly redefined. We will list all excluded papers to ensure transparency (Pullin et al. 2018). The list will be provided in an additional file (in the Supporting Information) along with the reasons for exclusion. If inclusion consistency is met, the main reviewer will finish the screening with the remaining articles.

2.6 | Study validity assessment

We will not be undertaking a conventional study validity assessment of studies since we will perform the methodological assessment of reviews through CEESAT criteria. In this stage, all documents that fit our eligibility criteria will be considered for analysis.

2.7 | Data coding and extraction strategy

Regarding the primary question (i.e. the reliability assessments) selected publications will be evaluated according to the CEESAT (O'Leary et al., 2016; Woodcock et al., 2014). CEESAT consists of a set of 13 criteria projected in alignment with environmental systematic review methodology (O'Leary et al., 2016; Pullin et al., 2018). A random selection of 20 screened articles will be double scored by two reviewers (scorers). We will analyse the scoring decisions between scorer 1 and scorers 2 and 3 by considering the magnitude of disagreement between scorers using a weighted kappa test of agreement. Potential disagreements will be discussed until a consensus is reached before continuing with the full list of screen articles.

In this stage, the key variables that will be analysed based on the content of reviews include:

- Presence or absence of an a priori protocol,
- Analysis of the use of a comprehensive range of bibliographic sources,
- Analysis of repeatability and transparency of search strings,
- Analysis of inclusion criteria to all potentially relevant studies,
- Repeatability of inclusion/exclusion decisions,
- Transparency of inclusion/exclusion studies decisions,
- Assessment on critical appraisals of the methods of each study,
- Analysis of objectively, according to the methodological quality,
- Repeatability and consistency in data extraction,
- Analysis of quantitative synthesis,

- Analysis of the heterogeneity in the effect of the intervention/exposure and
- Consideration of publication bias.

Each article will be coded with keywords and expanded comments fields describing various aspects of the reviews. These keyword and comment fields were developed among members of the Laboratory of Ecology and Forest Restoration (LERF) at the University of São Paulo and are designed to provide the summary information required to answer generic questions. We will create bibliometric network maps with the VOSviewer software (version 1.16.15), using the text mining functionality to construct and visualize co-occurrences of keywords, and then to present trends across the included literature. VOSviewer is a software tool expressly designed for the analysis of bibliometric data (van Eck & Waltman, 2010).

In this stage, key variables will include:

- Study type (narrative synthesis or meta-analysis),
- Bibliographic sources used by studies (e.g. Web of Science, Scopus, Google Scholar, CABI, Grey literature, etc.),
- Basic bibliographic information (authors, title, publication date, journal, DOI, etc.)
- Language (English/Spanish/Portuguese) and
- Research topics according to the synthesis type.

As far as possible, controlled vocabulary will be employed to code the variables using thesaurus or concepts employed in academic reporting. We will use the Guidelines and Standards for Evidence Synthesis in Environmental Management (Koricheva and Gurevitch 2014; Pullin et al., 2018) and Koricheva, Gurevitch, and Mengersen (2013) to categorize concepts and align reviews terminologies.

2.8 | Data synthesis and presentation

The resulting paper will include summary figures and tables of the CEESAT results that cover specific points for review improvements. Concerning our primary question, we will not provide a list of included reviews that will compose our database and either the individual scores obtained by the analysis of each one. We are focused on the methodological quality of restoration reviews to identify strengths and weaknesses in this literature body and offer guidelines for the improvement of future review works, not to criticize individual papers. Nonetheless, we ensure transparency and repeatability of our search strings so other researchers can access our retrieved information. Furthermore, we will provide the complete results of all repeatability tests (kappa test) for inclusion/exclusion decisions and CEESAT criteria assessment. We will discuss any point that needs to be improved in restoration syntheses methodology by providing groups of scores obtained through CEESAT. We will also discuss the main causes of disagreements about the inclusion/exclusion of articles and the attribution of scores through CEESAT criteria.

Concerning generic issues, at the data-gathering stage, we will provide an overlap analysis from the bibliographic sources' information (percentage of duplications among these sources) to demonstrate the proportion to which each contributed to the initial retrieval of publications. We will also provide graphs of network analyses based on the keywords co-occurrence criterion to assess which are the main research topics covered by restoration reviews, considering both review types separately. From these results, restoration practitioners will be able to check the recent status of research involving restoration syntheses and seek to develop fields that are still little explored. This joint analysis of network analyses and CEESAT scores recommendations will allow us to reveal future research topics on which the most robust studies may focus. The number of articles by publication year and important mark points in the literature body (e.g. the establishment of concepts such as 'evidence-based restoration') will be provided in graphs.

We will use descriptive statistics (median, mode and mean) to enable comparisons between synthesis types. Differences in the mean scores obtained by each review assessment and assigned to different categories (narrative syntheses vs. meta-analyses) will also be tested statistically. A Mann-Whitney U test may be applied for pairwise comparisons. Pearson's correlation coefficient may be used to analyse the relationship between journal impact factor (SJR) and CEESAT scores. Network analysis based on the co-occurrence of the author's keywords will be developed using VOSviewer software. The entire protocol complies with the ROSES reporting standards (see Appendix B in the Supporting Information).

2.9 | Limitations

Systematic reviews and systematic maps must have, as one of the main tenets of their methodologies, comprehensive search strategies (Haddaway, 2017; Pullin et al. 2018), to capture as much of the relevant evidence to the synthesis as possible (Abdulla, Abdulla, Krishnamurthy, & Krishnamurthy, 2016; Bayliss & Beyer, 2015). Reviews according to the CEE standard search a mean of nine bibliographic databases (± 8.2 SD) and 18 grey literature sources (± 15.9 SD) (Haddaway, 2017). Here, we place our search strategy by using three databases into the Web of Science platform, besides CAB Direct, SciELO, Scopus and Google Scholar as a search engine. We will not search for grey literature because they are not relevant to answer our review question.

3 | DISCUSSION

The main objective of this review is to gather restoration evidence syntheses published across environmental journals to assess their methodological reliability and reproducibility, and therefore the confidence that end users can place in the conclusions of these syntheses. To better serve the environmental policy and management communities, this assessment can enable researchers and decision makers to select reviews that are most likely to accurately reflect the evidence base.

AUTHORS' CONTRIBUTIONS

The protocol was written by JPR and edited by RRR, DRAA and RSB. All authors read and approved the final manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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This article does not contain data.

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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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