



Do environmental systematic reviews impact policy and practice? Author perspectives on the application of their work

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ARTICLE INFO

Keywords:
Decisions
Evidence
Systematic review
Synthesis

ABSTRACT

Environmental decisions related to policy and practice should be based on the best available evidence. Given the vast amounts of information of varying reliability, an ongoing challenge for decision-makers is how to access, collate, and use this information. The Collaboration for Environmental Evidence (CEE) is dedicated to the synthesis of environmental evidence via systematic reviews (SRs) to advance evidence-informed policy and practice. The CEE has now published 79 completed SRs (as of August 2019), building a wealth of experience and expertise among authors of these works. This article reports meta-data from the 79 completed SRs, as well as findings from a survey of authors (N = 18) regarding their perspectives on the application of the SRs that they have produced (representing a total of 26 SRs). The survey asked authors to evaluate the extent to which the findings from their SRs have been applied, as well as possible facilitators and barriers to application. Based on author-reported perspectives, 13 of 25 cases were identified as having an impact on policy and practice. Respondents felt their work was most successful in identifying research gaps, transferring knowledge, and informing policy and/or practice. The most common barriers experienced by respondents were challenges in communication and engagement with stakeholders, challenges with evidentiary ambiguity arising from SR findings due to overly broad research questions, and limited financial resources. Our findings lead us to posit that, in order to maximise the impact of future SRs, evidence syntheses should: (1) be based on well-defined and policy relevant research questions; (2) involve extensive collaboration among evidence-synthesizers and end users throughout the entire process; (3) create opportunities for partners to build “end user” capacity and awareness of the principles of evidence-based management; (4) develop formal and (eventually) standardized measures and indicators of impact for long-term tracking and comparability purposes. Future research should extend to understanding the perspectives of end users and stakeholders on the relevance of SRs to inform environmental policy and practice.

1. Introduction

Environmental policy and practice should be guided by relevant, reliable and robust information (Dicks et al., 2014). Environmental decision-making is typically guided by principles and considerations about how best to manage the complex, reciprocal links between society, economy, and the environment (Benson and Jordan, 2015). However, environmental policy and decision-making have not always been based on reliable research findings and evidence. A seminal case study in the United Kingdom, for example, found that many decision-makers rely on common sense and personal experience as their main source of information, and that less than 25% of decision-makers consult expert

advisers, primary literature, or secondary publications to guide their decision-making (Pullin et al., 2004). Other case studies of environmental decision-making have found similar tendencies (e.g., Ntshotsho et al., 2015; Young et al., 2016). It is clear that there is a need to improve the integration of reliable, relevant, and updated information into environmental decision-making if we are to fulfill the promise of evidence-influenced environmental policy and decision-making (Sutherland et al., 2004; Howlett, 2009). Or to put it more simply, we need to reinforce the links between better evidence, better decisions, and a better environment (Cooke et al., 2017).

While it is imperative that environmental decision-makers be empowered with the necessary tools, this has not been an easy task given

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<https://doi.org/10.1016/j.envsci.2021.12.019>

Received 19 February 2021; Received in revised form 11 September 2021; Accepted 17 December 2021

Available online 13 January 2022

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that the research they need is not always available, applicable, relevant or reliable (e.g., Cook et al., 2010, 2013; Young et al., 2016; Nyboer et al., 2021). Decision-makers may also have doubts about the methodology, objectivity, transparency, and scope of specific studies and journal articles (O'Leary et al., 2016). Furthermore, the volume of research in even the most specialized fields is expanding rapidly. According to Scimago (2020), a total of 52,714 environmental science articles were published in the year 1998. Ten and twenty years later, there were 108,716 (in 2008) and 271,080 (in 2018). The volume of published academic research continues to increase as new journals of varying quality are launched around the world (Godet and Devictor, 2018). This worsens problems of search and interpretation for decision-makers, as it increases the time required for evaluating individual publications, as well as the possibility that essential information to guide decision-making is lost in the sea of scientific publications. In turn, these difficulties may encourage decision-makers to rely solely on their experience, rather than the research, to guide them (Sutherland et al., 2004; Cook et al., 2010).

Systematic reviews (SRs) offer a potential remedy for these problems. SRs were pioneered in the health and medical fields to evaluate large volumes of research and assist in translating findings into practice (Khan et al., 2011). Environmental SRs are similar in design, adopting a methodical and transparent approach to collating, reviewing, evaluating, and synthesizing existing scientific information. Following guidelines established by the Collaboration for Environmental Evidence (CEE, 2018), a team of topic and evidence synthesis experts starts an SR by developing a protocol that identifies the purpose of the study and defines a specific research question that is answerable in this fashion (i.e., the question must have a subject, intervention, and outcome elements) (Pullin and Stewart, 2006). It also defines the strategy for identifying articles suitable for synthesis and the method for evidence synthesis (CEE, 2018). This critical first step allows the review team to focus on more relevant articles, and to identify consistent themes across individual studies (or the lack thereof) as well as potential biases (Haddaway and Pullin, 2014). This step typically involves consultation with stakeholders, relevant user groups, and decision-makers – all of whom are potential end users of the evidence synthesis (Pullin and Stewart, 2006). Once the protocol is peer-reviewed by the CEE flagship journal *Environmental Evidence*, researchers search for relevant articles and critically appraise the evidence for their eligibility and validity (i.e., internal validity with respect to study susceptibility to biases, and external validity with respect to study relevance to the review question) prior to synthesis (Haddaway et al., 2015). This critical appraisal step distinguishes SRs from other evidence syntheses as it places an emphasis on reviewing evidence in relation to its reliability (Haddaway et al., 2015; Cooke et al., 2017). After critical appraisal, data are synthesized using a narrative synthesis approach, accompanied with a meta-analysis when possible/appropriate, and are interpreted to inform readers about the available evidence related to the research question.

The CEE is an authoritative body on environmental syntheses and has spent 13 years establishing an international community of researchers, policymakers, managers, and stakeholders dedicated to synthesizing environmental evidence in the form of systematic reviews and developing a community of practice. The role of CEE SR authors is to present and communicate environmental evidence to inform decision making rather than provide specific recommendations or advice. Assessing the extent to which SR findings have been applied (e.g., used in decision making or informed practice) is difficult because “successes” and “failures” often go unreported and are rarely discussed with the broader community. Essentially, when a SR is complete, many authors simply move on to the next project. Usual metrics, like the number of citations, fail to illustrate meaningful impact or success (Cooke et al., 2020). This article draws on the experience, expertise, and perspectives of SR authors to investigate applications of their work. This includes their views on possible barriers and facilitators for application. It is our hope that this investigation will help improve how SRs are designed, as

well as how authors of SRs engage with stakeholders and communicate findings to maximize the impact of environmental SRs. It will also serve as a first step in framing how future studies can assess the perspectives of SR end-users (i.e., decision-makers, policy-makers, practitioners) and stakeholders to better meet their evidence needs.

2. Methods

This paper refers to all the SRs registered in the Environmental Evidence Library of Evidence Syntheses (<http://www.environmentalevidence.org/completed-reviews>) prior to August 2019, a total of 79 SRs. Two forms of information were collected regarding these works: (1) meta-data extracted directly from the SRs; and (2) the author's perspective on the application of their work by decision-makers obtained from an online survey. The extraction and coding processes were performed by the primary author of this article with guidance from co-authors.

2.1. Meta-data extraction

To describe the current landscape of CEE SRs, meta-data were extracted from each identified SR. The purpose of this exercise was to provide a characterization of the current SR landscape, with the intention for it to serve as a baseline for further study; as such, no analyses were performed with these data (i.e., we did not investigate associations between SR descriptors and results from the surveys that are described below). These data were also used to identify and develop a survey invitation list of SR authors. The information extracted for each SR included six broad categories: (1) bibliographical information (i.e., title, year of publication, was the SR published in the CEE evidence library or *Environmental Evidence*, the primary investigator and senior and corresponding authors' names, contact information); (2) review focus [e.g., topic area (coded following the scope of the topics covered by the CEE journal *Environmental Evidence*), biome, environmental issue or concern (coded following common types of policy problems and concerns in *Environmental Management* outlined in Table 2.1 from CEE (2018), and spatial scope]; (3) advisory team attributes (if used) (e.g., number of members and the number of organizations and countries represented); (4) SR size and timeline (e.g., start date and number of articles and studies identified); and (5) quantitative synthesis (e.g., was a quantitative synthesis performed, if so, what type and the number of studies extracted). The meta-data extraction table and descriptions are provided in the [Supplemental material](#) (see Appendix A).

2.2. Online survey

We invited authors from the 79 reviews published on the CEE website to provide insight on their experience in authoring their CEE SRs through an online survey formulated via Microsoft Forms. As our intended population was 103 authors encompassing 79 SRs, an online survey was deemed an efficient method to collect data internationally and within time restrictions. The survey questionnaire was designed to elicit information regarding background information on the authors (e.g., profession or role during SR time period, role on the review team), the factors that contributed to the topic identification and development of the research question(s) and the authors' perspective on the use of their SRs by environmental decision-makers. We also considered perceived barriers to the application of SR findings and the actions that were taken to facilitate the use of their results [Appendix B in [Supplemental material](#)]. Some of the factors that were explored were: who commissioned or requested the project and how was the project funded (e.g., government, intergovernmental organization, academic institutes, Indigenous groups, industrial organizations, non-government organizations, other researchers, or independently initiated or personally funded), what was the main purpose of the SR (i.e. was it to inform management, for policy development, or scientific curiosity?), and was an advisory team established for the SR. A similar approach has been

recently used to assess fisheries scientists' perspectives on how their research has been used by fisheries managers (Nguyen et al., 2019). Recruitment and data collection followed protocols approved by Carleton University's Research Ethics Board B (ID # 111564). Responses are presented in the aggregate or anonymously, in the case of direct citation.

We limited our initial sample population to the first, last and corresponding (if different) authors indicated in each SR as they were most likely to be aware of applications of the SR over time. In cases where the contacted author had indicated that another co-author was more appropriate to respond to the survey, the suggested author was then sent an invitation. Overall, we intended to send 2–3 invitations for each SR, except in cases where there was only a single contributing author (1 SR). However, a single person was identified as either the first, corresponding, or last author on 31 SRs. Our team engaged directly with this author to identify suitable co-authors who could represent the opinions of the review team for some of these SRs.

The email addresses of the selected authors were primarily obtained from the systematic review document, supplementary Internet searches, and professional networks. This process began September 2019. Of the 109 authors identified as either first, last, or corresponding authors of the 79 SRs or were recommended by another author (i.e., 103 intended authors + 6 recommended), we were only able to locate a valid email address for 98 of these authors. However, some authors were not available during the data collection period. Therefore, a total sample frame of 92 authors was identified from 79 of the SRs from whom we were expecting 121 survey responses (note, 19/92 identified authors were either the first, last, or corresponding author on >1 SR and were therefore sent >1 survey invitations).

The first round of invitations was sent through emails between November 15 and 22, 2019. The second round was sent between November 26 and December 5, 2019 when updated emails were found or contacted individuals recommended fellow co-authors who were better equipped to respond to the survey. Two reminders were sent out December 11–13, 2019 and January 9–10, 2020 before the survey closed on January 17, 2020. Five authors, including the author with whom we engaged, had recommended other co-authors. Overall, we had a response rate of 21% (i.e., 25 responses from 121 survey invitations).

2.3. Approach

Given the small sample size of responses (i.e., 25 responses from 18 authors), we could not – as originally intended – undertake any quantitative analyses to explore the influence of factors influencing the application of SR findings to policy and management from SR author perspectives. Instead, we took a more qualitative approach to summarize author perspectives on the application of their review findings and to gain a better understanding of some of the potential factors influencing the use of their work in informing policy and management. Analysis on the role of the advisory group was also not feasible due to the conflicting information provided by a small number of respondents.

2.4. Perspectives of the application on policy and practice

Respondents were asked to identify, from their perspective, whether they observed any evidence that their review findings were used in policy and management. Additionally, they were asked to provide a rationale to support their position which were classified into common categories when applicable. Respondents were also asked to identify the type of organization(s) that requested each SR. Participants were then asked to rate their perceived level of success in “identifying research gaps”, “transferring knowledge”, “changing, developing or affirming a policy or practice”, “enhancing adoption by stakeholders”, “creating trust among stakeholders”, “generating media interest”, and “building capacity, or raising awareness for evidence production and use” as *not at all successful*, *somewhat successful*, *very successful*, *unsure*, or *not applicable*.

To summarize the diversity of modes of communication used for transfer of knowledge, respondents were asked to select from a pre-defined list which communication methods were used to help facilitate the dissemination of their review findings to policymakers: executive summary, use of plain language in review, use of visuals, available through digital-friendly formats, translated into different languages, social media campaigns, media appearances and comments, press release, presentation to stakeholders, and events with stakeholders. Responses were further classified into non-exclusive categories: text-based communication methods in their SR, enhanced accessibility of their SR findings, and the use of presentations, events, and social and news media. Furthermore, participants were also asked in a separate question how often they used media-based (e.g. social media, press release or media appearances and comments) and in-person (e.g. presentation or events with stakeholders) communication tools before, during and after the review process to describe communication frequency with stakeholders and end users. To explore the potential impact of communication frequency of the various communication methods on the application of their results, the frequency categories of Several (5 + times), Often (3–5 times), Few (1–2 times) and Never/No response were converted into 3, 2, 1, and 0 respectively for each type of media-based and in-person communication method used. These were then summed to determine the overall frequency of media-based and in-person communication method used by each respondent. The overall frequency of 4 + was identified as Very Often, 3 as Often, 2 as Seldom, 1 as Rarely, and 0 as Never/No response. The overall frequencies for each communication method were then compared qualitatively between respondents who indicated that they observed any evidence that their review findings were used in policy and management with those that did not observe an evidence of application.

2.5. Barriers experienced by respondents in dissemination of review findings

Respondents were asked to identify key barriers they encountered that affected the incorporation of their review findings into environmental policy and management. In instances where no barriers were experienced, they were asked to identify and explain what factors had facilitated the application of their results. We used this information to synthesize the common barriers that participants indicated in the responses, and some of the strategies they implemented to overcome barriers. NVIVO 12 was used to identify key themes and trends in their responses; categories were not considered to be mutually exclusive. The occurrence of each theme across all survey responses was counted to determine which barriers were most experienced by CEE systematic review authors.

3. Results

3.1. Landscape of CEE systematic reviews

The CEE library includes 79 systematic reviews from 2005 through August 2019. Though all are available through the CEE library, only 28 articles were published in the *Environmental Evidence* journal since its establishment in 2011. Typically, 2–6 reviews were published per year, except for 2010 and 2013 where 14 and 9 SRs were published respectively (Fig. 1).

The main topics explored in these reviews were biodiversity and conservation (53 reviews), resource management (20 reviews), environmental economics (10 reviews), and human health (10 reviews) (Fig. 2). Furthermore, 52 systematic reviews explored these four main topics in terrestrial biomes (e.g., forests and agriculture), 18 reviews in freshwater biomes (e.g., streams, lakes, and rivers) and 8 reviews in marine biomes (e.g., ocean, estuaries, and marshes) (Fig. 2). The remaining 15 systematic reviews on the above listed topics did not investigate biomes (i.e., atmospheric chemistry) or did not make it clear

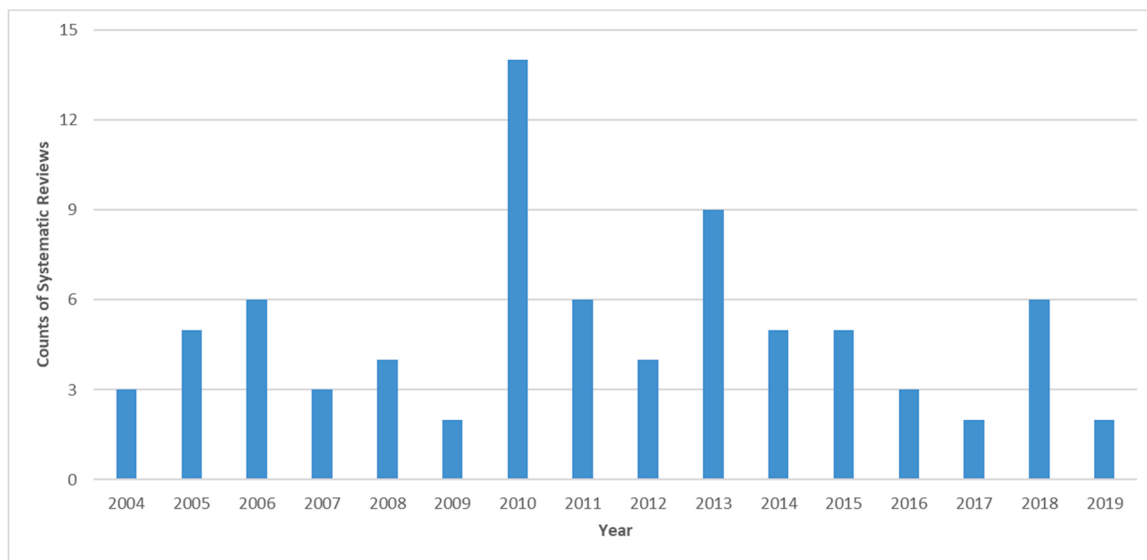


Fig. 1. The frequency of SR publications from 2004 to August 2019 in the Collaboration for Environmental Evidence library.

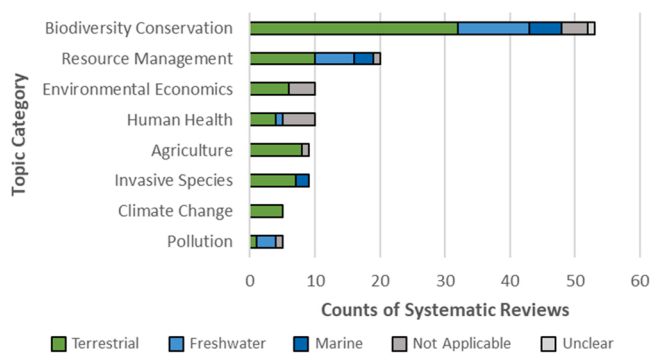


Fig. 2. The counts of biomes and topics explored in the systematic reviews published in the Collaboration for Environmental Evidence library. Note: The total number exceed 79 as some reviews studied multiple biomes and/or topics.

which biomes were investigated (Fig. 2).

CEE systematic reviews were generally conducted to develop a better understanding of the impacts of human activity on the environment (45 reviews) and the effectiveness of interventions (39 reviews), while 4 reviewed changes in distribution and abundance of indicators of environmental health over time (Fig. 3A). Reviews predominately inquired about global-scale trends (60 reviews), while others were focused on local or regional trends (12 reviews) and national or federal trends (7 reviews) (Fig. 3B). Of the 79 reviews, 60 included a quantitative synthesis, of which 46 involved a standard meta-analysis using formal meta-analytical procedures and 14 involved a more qualitative or less rigorous quantitative approach (e.g., one-sample t tests of study-level mean effect ratios) (Fig. 3C). The remaining 19 articles relied mainly on a narrative synthesis to summarize the evidence base (Fig. 3C).

3.2. Responses from the survey

A total of 25 responses were received between November 2019 and January 2020. They represented 26 systematic reviews from a total of 18 authors. Two authors responded to the survey multiple times for different SRs and one author referred to two of their works together in one survey response; the latter were considered as one systematic review in the analyses. Some authors were unable to respond within the time frame provided. Our response rate of 21% is considered a normal level of response for online surveys (Lefever et al., 2006).

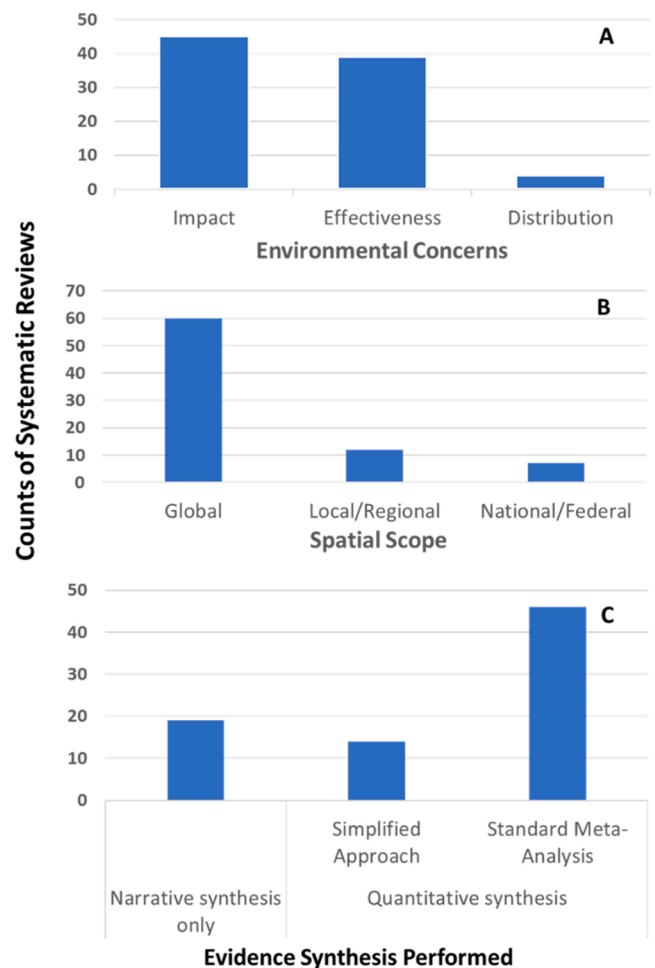


Fig. 3. The counts of systematic reviews that (A) inquired about the impact of human activity, the effectiveness of interventions and the changes in distribution and abundance of environmental factors; (B) explored their research questions at the global, local/regional scales, or national/federal scales; and (C) performed narrative or quantitative evidence synthesis. Note: The total number exceed 79 as some reviews studied multiple biomes and/or topics.

3.3. Characteristics of the sample population and the systematic reviews

The sample population comprised of systematic review authors, of whom 48% were the first authors and 40% the last authors. Forty-six percent of the respondents identified that, at the time of the review, they considered themselves evidence synthesis experts, 29% as topic experts, and 25% as both an evidence synthesis and topic expert (Appendix C in Supplemental Material). At the time of the review, 42% of the respondents were affiliated with academic institutes, 23% were undergoing graduate or post-doctorate studies and 31% were research scientists – of which one was affiliated with a government organization, and another was also a project manager (Appendix C in Supplemental Material).

Of the 79 systematic reviews available through the CEE library, 26 reviews (32%) were represented in this survey. Of those 26 reviews, the majority (54%) were published from 2011 to August 2019. Most reviews were commissioned (50%) and funded (42%) by government organizations only, although many were commissioned (19%) and funded (31%) by both government and non-government organizations together (Appendix C in Supplemental Material). Sixty-two percent of the reviews represented in the survey had an advisory team.

3.4. Perspectives of the application on policy and practice

Of the 25 responses, 13 authors indicated that they had observed evidence of the application of their results on policy and practice, 9 were unsure if there was sufficient evidence and 3 identified that there was no evidence. They identified that their SRs were most successful in identifying research gaps for future primary research (24 responses), transferring knowledge (i.e., information policy and/or findings being used by decision-makers) (18 responses), and building capacity/raising awareness for/of evidence production and use (including awareness of critical appraisal and/or evidence synthesis) (18 responses) (Fig. 4). In their opinion, their SRs were least successful in generating media interest (11 responses), creating trust among stakeholders (3 responses), and changing, developing or affirming a policy or practice (3 responses) (Fig. 4).

For those who identified that they observed a successful uptake of their results, they cited literature citations (2 respondents) and the changes in policy and practice of the commissioning organization or other agencies (9 respondents) as evidence. While the majority did identify why, in their perspective, their findings were leveraged or not, there were 6 respondents who did not provide supporting evidence, two of which indicated that they observed successful uptake and 4 who were unsure if there was any evidence. However, it is important to note that, while 2 respondents identified that literature citations demonstrate a successful uptake of the results, one respondent (Survey 2) identified that, although their work is “very well cited”, they indicated that they were unsure if this constituted as evidence of a successful uptake. This suggests that there is a lack of a standardized measurement of a successful uptake of SR findings.

As noted earlier, due to the small sample size of 25 responses, it was

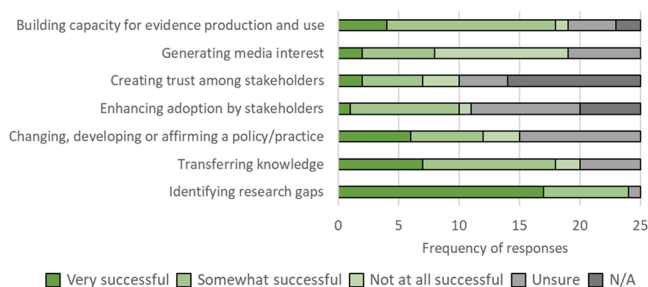


Fig. 4. The frequency of responses that indicated the levels of success in various metrics for application of systematic review findings.

not possible to perform suitable statistical tests to study the influence of commissioning organization on the application of SR findings, nor the influence of communication diversity and frequency on the transfer of knowledge. Instead, we provide a qualitative exploration of these data below.

Sixteen responses were included when exploring the potential influence of invested stakeholders on the application of results as nine respondents had indicated that it was unclear if their results were incorporated in decision-making. Ten respondents indicated that their review was commissioned and had evidence of application, 3 respondents indicated that their SR was not commissioned but had evidence of impact on policy and practice, 2 SRs were commissioned and no evidence of impact, and 1 SR was not commissioned, nor did it have any evidence of application. Furthermore, 16 respondents indicated that they implemented text-based communication methods to their SRs; 14 increased the accessibility of their findings via visuals, translation into other languages, and availability in other digital formats; and 21 leveraged presentations, events and social and news media to communicate their findings. Of the respondents who found evidence of impact on policy and practice, 6 had used all three types, 4 used two types, and 3 used one type. Of those who found no evidence, 2 respondents used three types and 1 did not use any.

In studying the effects of the diversity of the communication methods, of those who identified evidence of application, 1 respondent used media-based communication methods Seldomly, 3 Rarely, and 9 Never. Furthermore, 4 used in-person communication Seldomly, 6 Rarely, and 3 Never. Of those who observed no evidence of impact, 1 respondent each indicated that they used media-based communication methods Often and Seldomly, and 1 Never. In addition, 1 Seldomly used in-person communication methods and 2 used them Rarely.

3.5. Perspectives on communicating results to end users

Respondents indicated that, to communicate their findings to end users, they more commonly shared their findings through a presentation or by developing an executive summary using scientific and/or plain language (Fig. 5). Furthermore, it was evident that respondents most often relied on presentations to communicate their review findings to end users (Fig. 6).

3.6. Barriers experienced by respondents in dissemination of review findings

Respondents were asked to comment on the barriers they had experienced in the review process and during the dissemination of their findings. The main challenge experienced was in communicating with and engaging stakeholders (4 SRs with evidence of application, 1 without evidence and 6 whose authors were unsure whether their review findings were used in decision-making). The most-cited reason for this was the lack of funding or resources to develop or implement a

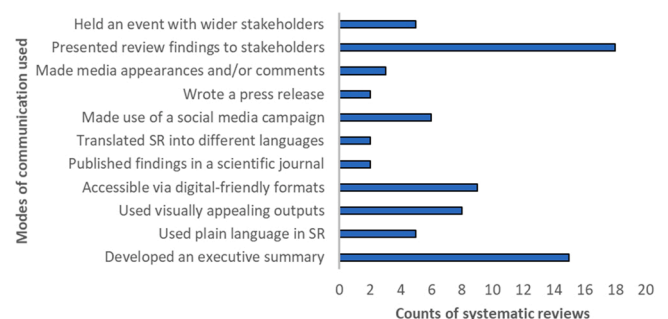


Fig. 5. The frequency of responses that used each method of communicating with stakeholders and end users.

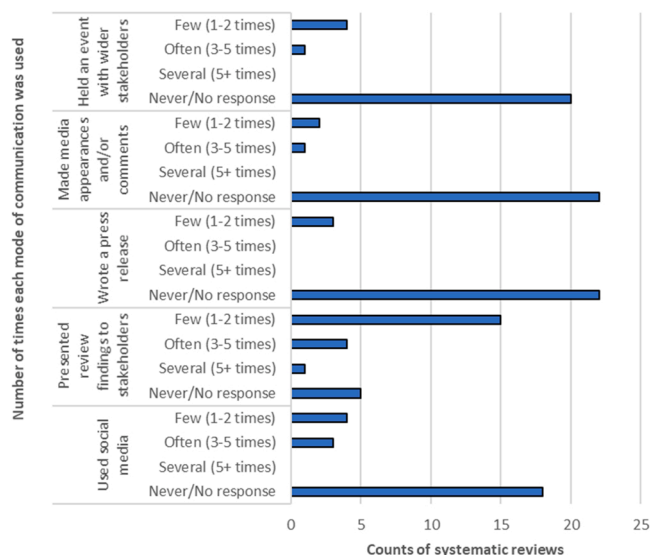


Fig. 6. The number of times each mode of communication was used to communicate review findings with stakeholders and end users. Note: No Responses and Never were combined due to the ambiguity between the two responses.

communication strategy (7 respondents representing 7 SRs, 3 who observed evidence of application and 4 who were unsure). Many identified that the lack of funding and resources dedicated specifically for communication and developing relationships with end users resulted in these important practices “being ‘extra’ to the day job” (Survey 17) and researchers “moving onto other projects” (Survey 2) immediately after publication. Specifically, five of these respondents had indicated that this affected their ability to engage policy makers and disseminate their findings.

Other factors that contributed to the challenge of communicating with and engaging stakeholders were accessibility issues, including language barriers, inability to publish in a high-impact journal and the length and complexity of SRs; conflicts with stakeholders; and a lack of an effective communication strategy (11 respondents, representing 11 SRs). One respondent who was unsure of the impact of their review found that it was difficult for managers to completely benefit from the results of SRs as they are often written in English, which may not be their first language. Two respondents – one who observed evidence of the application of their findings and another who was unsure – highlighted that it was difficult to communicate their work as it was “too long, too detailed, without simple and clear messages about what to do [and that it] was never going to be read by any actual managers and policy-makers” (Survey 23). Two respondents – one who observed evidence of application and another who was unsure – had indicated that they were unable to publish their work in a high-impact journal, which “would have given it more visibility” (Survey 23). One respondent who did not observe any evidence of application had noted that, because of conflicts with the stakeholders and inconsistent representatives from the stakeholders, the research question could not be refined efficiently and as such, the outcomes of their review did not support the expectations of the funders. As a result, they had experienced “a lot of issues and constraints [...] with regards to publishing and promoting the reviews’ findings” (Survey 21). Four respondents (two with evidence of application and two unsure) had identified that they did not have an effective communication strategy, two specifically highlighting that there was “no guidance available” (Survey 23) and “tools are lacking to transfer findings of SRs to managers” (Survey 22).

Respondents for 7 reviews – 3 having no evidence of application, 2 with evidence and 2 whose authors were unsure if there were evidence of application – reported that the research question and/or the spatial

scale was too broad, which resulted in a lack of substantial evidence (i. e., the conclusions drawn from the SR were limited by evidentiary ambiguity; see Rytwinski et al., 2021) to influence policy and practice. Respondents representing three reviews indicated that the systematic review process was too novel, limiting the stakeholders’ ability to collaborate efficiently in question development and to incorporate review findings into their decision-making process. There were also policy-related issues identified by four respondents – of which two had observed evidence of the application of their findings – that limited the application of results, such as the rapid turnover of policy priorities and the influence of additional factors (e.g., economics and social) that influence decisions. Two authors representing two SRs indicated that they did not experience any significant barriers that hindered their process, crediting their successful application to the strong interest and involvement of stakeholders (Fig. 7).

It is important to note that, of the 5 respondents who had indicated that they had developed strategies to overcome the aforementioned barriers, 4 had observed evidence of application of their findings. One strategy adopted by two respondents was to develop a network that allowed them to send their work to “relevant people” (Survey 20) and to “bring the work into additional projects” (Survey 23). This practice enabled them to bring the findings of their SRs directly to the attention of end users. Two respondents adopted various communication techniques to their review (i.e., “further synthesis of the results, putting messages into the language of policy and practice, designing simple information sheets, giving many talks” (Survey 23), and publishing their work in a journal (Survey 13)), enabling them to ensure that they are easily understandable by stakeholders and end users, and further promote their findings. Two respondents had highly invested stakeholders, with one noting that engaging the end users throughout the process ensured that “the question being asked is relevant and will be used in policy and management” (Survey 17).

3.7. Key themes to improve the application of findings for policy and practice

Respondents emphasized the importance of a collaborative approach and engaging stakeholders to facilitate the successful application of SR findings into policy and practice. Two of our respondents indicated that they did not experience significant challenges in the application of their findings because their end users were heavily invested in the research and were engaged from start to finish (Surveys 17 and 18). Another respondent attributed their success to identifying and reaching out to the key and relevant individuals who would use or could benefit from this information (Survey 20). Other strategies mentioned include the use of targeted executive summaries (Survey 25) and integrating the “language of policy and practice” (Survey 23) in their work.

Another theme that was emphasized was the importance of resolving conflicts within the review team and between the review team and end users through the review process. A respondent who did not observe any evidence of application of their findings (Survey 21) shared their experience being unable to come to a common understanding with their stakeholders. As a result, the findings were perceived “to be too wide and not specific enough [...] and therefore not robust enough to facilitate policy change” and resulted in “issues and constraints [...] with regards to publishing and promoting the review findings”.

Some respondents have provided suggestions that they believe could improve the application of findings by end users. Two recommended (Survey 22 and 23) the need to develop tools to guide systematic review practitioners with communicating their findings to end users. One respondent (Survey 2) indicated that “a summary step before going into decision support” would also help improve the application as clearer results would be found with potential to better support decision-makers. Another respondent (Survey 16) also indicated that raising awareness of the SR process would be beneficial as it would help end users better “grasp the importance of [the] research”.

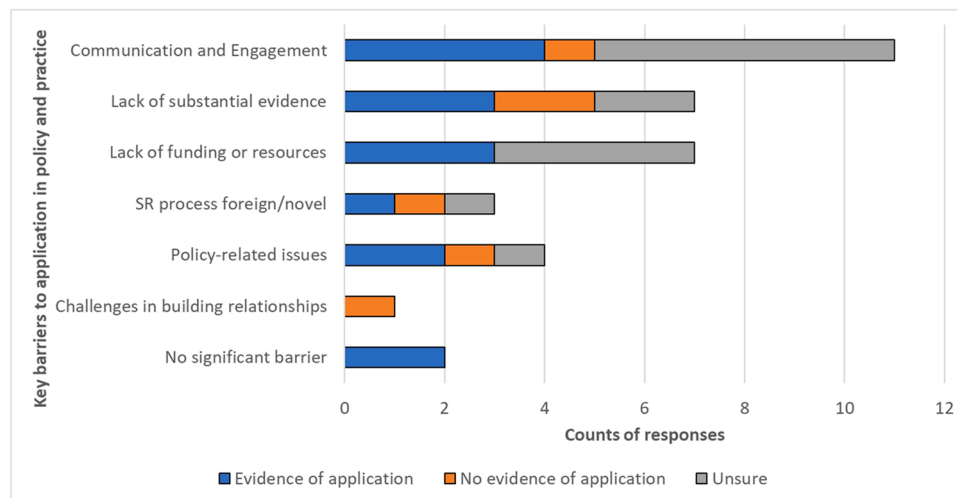


Fig. 7. The counts of responses that identified the key barriers SR authors encountered that influenced their perceived use of their findings in policy and practice.

4. Discussion

It is important to investigate the experiences and perspectives of SR authors to develop a better understanding of how they perceive the impact of their work on policy and practice and to enhance the application of their results into decision-making. Doing so helps to identify the key challenges that SR authors experience in the dissemination of their findings and approaches to enhance the application of evidence syntheses in the future.

4.1. Landscape of CEE systematic reviews

The review of the SRs indicated that there was a wide diversity of topics and biomes explored and the literature for the synthesis were collected at various scales and were typically synthesized using meta-analysis. However, there is an absence of SRs synthesizing evidence for questions regarding environmental economics, agriculture, and climate change in aquatic biomes, invasive species in freshwater biomes, and human health and pollution in marine biomes. Our exploration identified that over half of the SRs assessed encompassed global geographic dimensions and very few were scaled to the local/regional or national (country-wide) level. As identified by Cook et al. (2013), this could limit application to policy and practice as syntheses performed over broad questions and spatial scales may be difficult to interpret due to the lack of control for intervention conditions. This notion was echoed by three respondents who indicated that their findings had poor correlations, were not conclusive or robust enough, or were “two steps removed from practice” (Survey 14) due to the broad scales of the review. This suggests that questions should be more specific (and ideally localized at least in terms of context and ideally evidence base) to improve applicability to policy and practice. Systematic mapping is a tool that could be leveraged to help develop an overview of the distribution and abundance of evidence (CEE, 2018). Although procedurally similar to a systematic review, systematic maps do not aim to provide a quantitative or qualitative answer to a particular question, but instead, a descriptive overview of the evidence base is developed that could inform decision makers of further research and synthesis (e.g., by revealing knowledge gaps and identifying more specific questions suitable for systematic review). These mapping exercises could help refine questions and evidence to be more specific and localized. However, it is also important to recognize that the robustness of the SR findings (and thus extent to which they can reduce uncertainty for decision makers) is entirely dependent on the characteristics of the evidence base (e.g., robustness of scientific methods, volume of evidence; Rytwinski et al., 2021).

4.2. Perspectives on barriers of application

Of the 25 responses received, about half had noted that they observed no evidence or were unsure that their results were utilized in policy and practice. This suggests that a good deal of intellectual and research effort to generate SRs is potentially not having the impact that would be expected. This is consistent with the aforementioned studies of environmental decision-makers who are often more comfortable drawing on personal experience than external research (e.g., Pullin et al., 2004; Ntshotsho et al., 2015; Young et al., 2016). SRs have been promoted as a method to improve the use of evidence in decision-making, but our results show that this is not always the case (at least as viewed from the perspective of those doing the SRs). Yet, a recent survey of environmental decision-makers in Canada revealed that if provided access to SRs, they would be used preferentially relative to other forms of evidence synthesis (Thomas-Walters et al., 2021). The extent to which that sentiment is observed in other jurisdictions is unclear. Nonetheless, we suggest that more could be done to improve communication of, and comfort with, these tools (we present recommendations below). All together, this highlights the need to understand barriers to communication and application as a critical step towards enhancing the influence and efficacy of the SR process. Furthermore, understanding the practices that facilitated the adoption of SR findings would help develop best practices for SR practitioners.

Overall, regardless of evidence of the application of the results, majority of the respondents have identified problems with communication and engagement as key barriers that may have influenced the application of their results. Of those who used strategies to overcome said barriers, the majority had observed evidence of application of their findings. While it is unclear if there is a causal relationship, this suggests that it is important to provide evidence synthesizers with the necessary training (see Downey et al., 2021) and support to overcome the barriers they experience to enhance the likelihood of the application of their reviews. Such training should also extend to the end users of evidence syntheses so that they better understand the value of SRs relative to other methods and understand biases and limitations (Downey et al., 2021).

4.3. Effect of review characteristics and communication on application

While we were unable to perform a suitable statistical analysis due to the small sample size, we had expected that commissioned reviews would have been more likely to have informed policy and practice than those that were not commissioned as the act of commissioning indicates a level of vested interest by the end users. We also anticipated that

authors of reviews who had communicated their results more frequently to stakeholders, and leveraged a greater diversity of communication methods would have observed a greater influence of their SR(s) on policy and practice. Many studies have found that researchers who actively engage with stakeholders are more likely to influence policy and practice (e.g., Campbell et al., 2015, Nguyen et al., 2019). Furthermore, we expected that authors who used a greater diversity of communication methods would have seen a greater influence of their SRs because, as explained by Moser and Dilling (2011), a “one size fits all” approach, or using a limited number of modes in engaging stakeholders, is unlikely to be successful. Though we were unable to quantitatively evaluate these ideas in this study, we found that commissioned SRs and those who leveraged a greater diversity of communication methods were more likely to declare that they had evidence of impact. There was no discernable impact of communication frequency on the impact of the SRs. Nevertheless, it would be beneficial for future reviews to study the influence of vested interest and frequency and diversity of communication media on the application of results into policy and practice. Doing so could provide guidance on better practices to enhance uptake and application in the future.

4.4. Perspectives on the transfer of knowledge and impact on policy and practice

4.4.1. Benefits of a collaborative approach and engaging partners

The responses we received in the survey included stories of successful application of the SR, from passive (i.e. literature citations) to active (i.e. changes to policy and practice) application. Our respondents repeatedly commented that interacting with and engaging stakeholders are factors that contributed to or limited their success. Studies have shown that involving stakeholders through various avenues, such as a collaborative approach or co-production, correlates with the increased likelihood that results will influence environmental policy and practice (Haddaway et al., 2017; Langer et al., 2017; Collins et al., 2019; Nguyen et al., 2019). Doing so ensures that the research question is appropriate and relevant to the needs of the stakeholders and it enhances the likelihood that the stakeholders trust the SR findings and adopt them (Langer et al., 2017; Collins et al., 2019). Other practical benefits include knowledge exchanges with interested parties, literature recommendations, more resources to perform the review, additional funding, and more (Haddaway et al., 2017).

On the other hand, many of our respondents identified that stakeholder communication and engagement was a barrier they encountered, in part due to the novelty of the SR process and the challenge in obtaining funds and resources to engage stakeholders and end users. In fact, many respondents indicated that these were the first activities to be affected during the review process when there was a lack of resources. As one respondent indicated, the process took too much time and effort without clear and applicable takeaways in the end. This notion is not new; such views have been advanced in the past as factors that limit the smooth transfer of knowledge from scientific literature to policy (e.g., Dedual et al., 2013; Young et al., 2016). As such, more rapid, flexible, and innovative approaches are needed to better incorporate the demands of decision-makers and the decision-making process into the systematic review process (Langer et al., 2017). For instance, an approach outlined by Langer et al. (2017) is to develop two products at the end of the SR process: an evidence synthesis tailored to the needs of the immediate stakeholders, and another that aligns more with the traditional SRs. Doing so allows the authors to meet the demands of the immediate and future end users.

Furthermore, as some issues investigated are very complex in nature, a single SR may not be enough to inform policy, which could create further challenges. A respondent had suggested that SRs should require a “summary step before going into decision support” (Survey 2) due to the complex nature of the question explored. Authors have also indicated that guidelines and tools to support authors in communicating key

messages and findings would be helpful.

4.4.2. Importance of resolving disagreement

Another key theme that arose was the need for resolving disagreement among stakeholders and the review team. When there are multiple stakeholders involved in a project, opposing perspectives can come into conflict, which may inhibit progress, affect the analysis, and reduce the study’s relevance. In a review of the barriers affecting adaptive management – a practice where various stakeholders come together to manage an ecosystem – Keith et al. (2011) argued that conflict resolution is integral to the success of a project and called for collaboration, co-operation and compromise between the parties involved. The SR process is not immune to this; one respondent indicated that they faced challenges with stakeholder interactions, most notably during the question development phase. Therefore, we recommend that organizations seeking to benefit from SRs follow the guidance of the review team to ensure that the question is refined enough to produce a SR that can effectively inform policy and practice.

4.4.3. Need to standardize determinants of impact

It is important to note that the respondents had different ideas of what a successful impact looks like. This is not surprising given the inherent challenges with defining success (Cooke et al., 2020). For instance, citations in other works and in forums were identified as evidence of impact by some respondents, whereas another author indicated that this was not necessarily a substantial indication of impact. This review suggests that there is a need for a standardized determinants of SR impact, a step to developing a “scalable impact evaluation framework” (Cooke et al., 2017), further enabling researchers to compare and evaluate impacts of various SRs on policy and practice.

4.5. Caveats and limitations

This study is a review of the perspectives and the experiences of CEE SR authors, and it is important to note that these results may not be reflective of the wider SR community or those who engage in environment decision-making. The survey represents 32% of CEE SRs, but only from the perspectives of 18 authors. Though the survey received a relatively low response rate of about 21%, that is considered normal for online surveys (Lefever et al., 2006). As many of the invited authors did not respond, their perspectives were not included in this study and therefore, this review may suffer from non-response bias. For instance, reviews that did not necessarily pertain to a specific biome, such as those that study the changes in atmospheric pollutant emissions, were not represented in the survey responses. Some authors responded to multiple surveys related to different SRs, which could have also influenced the results. Another limitation is the limited diversity of the those invited to participate in the study. End users of the findings and commissioners of the SRs were not consulted and their perspectives would offer an additional perspective on the impact of SRs. Fortunately, there have been some recent surveys focused on end-users that complement the work we did here (e.g., Thomas-Walters et al., 2021). Nevertheless, the perspectives captured in this study could help maximize the impact of SRs in the future. Future research should include efforts to survey the perspectives of the end users and commissioners in tandem with those who engage in SRs to assess alignment of perspectives on the impact of individual SRs. Doing so will be challenging given that identifying the population of potential and actual end users is much more challenging than identifying authors of specific SRs.

5. Conclusion

This study highlights the importance of understanding the influence SRs have on environmental decision-making and attempts to identify best practices that would enhance their impact. It is also the first to describe the landscape of CEE SRs published to August 2019 and to

examine a sample of CEE authors' perspectives on their experiences. The relatively small sample size limited our ability to quantitatively investigate the significance of the impact of commissioning a review or the frequency and diversity of methods used to communicate findings to end users on the application of reviews. Nonetheless, our results suggest that research questions should be more specific to local and regional scales in order to enhance the application of findings into policy and practice. Furthermore, our results reveal that there is variation in how authors view and evaluate the impact of their work. Some identified that their results were well leveraged by the end users, while others indicate that improvements could have been made. Respondents identified that engaging stakeholders throughout the review process would further enhance their impact, build capacity, and raise awareness for evidence-based management. More tools and resources should be given to SR authors and evidence synthesizers to support them in communicating results and building relationships with stakeholders (Pullin et al., 2020). Moreover, training for both evidence synthesizers and end users in best practices for conduct of SRs and their application would also be a useful activity (Downey et al., 2021).

CRedit authorship contribution statement

Evalynne Jacaban: Data curation, Formal analysis, Visualization, Writing - original draft. **Trina Rytwinski:** Conceptualization, Supervision, Formal analysis, Writing - review & editing. **Jessica J. Taylor:** Conceptualization, Supervision, Writing - review & editing. **Nathan Young:** Conceptualization, Writing - review & editing. **Vivian M. Nguyen:** Conceptualization, Supervision, Writing - review & editing. **Steven J. Cooke:** Conceptualization, Supervision, Funding, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Funding was provided by the Natural Sciences and Engineering Research Council of Canada, Carleton University, and the Canadian Centre for Evidence-Based Conservation. We are grateful to the survey respondents and the Collaboration for Environmental Evidence community. We are grateful to several anonymous referees for their valuable input on this manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.envsci.2021.12.019](https://doi.org/10.1016/j.envsci.2021.12.019).

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