

RESEARCH ARTICLE

Taking knowledge exchange to practice: A scoping review of practical case studies to identify enablers of success in environmental management

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Abstract

A gap exists in the literature on how to implement theories of knowledge exchange (KE) into practice within an environmental management context. To support the improved practice of KE, we conducted a scoping literature review evaluating 56 empirical case studies globally to identify enabling conditions for implementing effective KE. Identified enabling conditions were organized into a core capacities framework, which highlighted essential elements of effective KE from organizational, individual, financial, material, practical, political, and social capacity dimensions. Results show that major enablers to effective KE relate to practitioners' individual and organizational capacity including the ability of practitioners (often boundary spanners) to establish trust with relevant actors through their interpersonal relationships and possessing sufficient background knowledge and skills to facilitate collaborations across disciplines and sectors. We also identified main challenges to engaging in KE (e.g., insufficient long-term funding for projects, lack of interpersonal skills for KE practitioners to build relationships and network, and inadequate background knowledge for practitioners to exchange knowledge in an accessible manner), and the outcomes and impacts that can emerge from effective KE work. We find that practitioners often perform quantitative evaluations that provide instantaneous and measurable impacts for the effectiveness of KE, but do not capture the impact of interpersonal relationships and trust that are best achieved through qualitative approaches. Lastly, the synthesis of enablers, challenges, outcomes, and impacts presented in this paper can be a resource for practitioners to identify what enablers may be missing from their KE strategies and in what capacity the KE work can be strengthened.

KEYWORDS

boundary objects, boundary organizations, evidence-based practice, knowledge broker, knowledge mobilization, knowledge transfer, science communication, science policy

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1 | INTRODUCTION

A disconnect exists between knowledge exchange (KE) theory and practice such that scholars propose theoretical ways to improve KE practice (Karcher et al., 2021; Karcher, Cvitanovic, van Putten 2022; Rubenstein-Montano et al., 2001; Reed et al., 2014; Westwood et al., 2021). Scholars and practitioners alike propose that practicing KE will be most effective when there is multi-directional communication between knowledge producers and users to build capacity and the exchange of expertise from multiple sources (Cvitanovic & Hobday, 2018; Fazey et al., 2013; Hickey et al., 2013; Stewart et al., 2014). Although the literature presents ways to engage in effective KE, there are fewer empirical examples of how this can be done and what factors enable KE for impactful environmental and natural resource management (Reed et al., 2014; Reed et al., 2018; Walsh et al., 2019). As such, practitioners often perform KE based on what has worked in the past, emphasizing the need to identify the enabling conditions for practicing effective KE (LSE, 2019; Matzek et al., 2014; Reed et al., 2014).

As highlighted earlier, a recurrent theme for improving KE at the interface of environmental science and policy is transitioning away from linear modes of communication and engagement (i.e., generating and exchanging knowledge that does not specifically address a target audience and is not generally available or accessible to all knowledge users) (Beier et al., 2017; Cash & Patt, 2006; Rogga, 2021) towards more interactive multi-directional modes of KE (i.e., one that facilitates collaborative exchange between knowledge producers and users and engages knowledge users in all aspects of the research process, whilst also recognizing that all actors (academic or otherwise) have important knowledge that they can contribute to a process) (Bautista et al., 2017; Cook et al., 2013; Cvitanovic, Shellock, et al., 2021; Stewart et al., 2014). A range of approaches have been identified that enable more interactive and collaborative KE (most recent review by Karcher et al., 2024), and includes the use of science-policy intermediaries such as boundary spanners and boundary organizations (Bednarek et al., 2018), building relationships and trust between knowledge producers and users to maintain ongoing communication to produce useable science (Fazey et al., 2014; Cooke et al., 2020; Cvitanovic, Shellock, et al., 2021), improving organizational structures such as embedding knowledge producers within research organizations to conduct long-term research (Roux et al., 2019; Walsh et al., 2019), acquiring sufficient resources (such as funding, time, and staff) to complete projects (Meadow et al., 2015), and improving organizational culture to support the use of scientific evidence (Walsh et al., 2019). Although enablers to effective KE have been identified (e.g., Cvitanovic et al., 2016), little to no research has synthesized empirical studies examining the enabling conditions required for practitioners to effectively operationalize KE (Karcher et al., 2021; Meadow et al., 2015; Rose et al., 2018).

In their paper about enabling conditions for KE, Cvitanovic et al. (2016) first identified three core capacities required to support and facilitate KE (financial capacity, institutional capacity and individual capacity), through a case study evaluating the Ningaloo Research

TABLE 1 The seven core capacities that enable knowledge exchange (KE) work developed and defined by Cvitanovic et al. (2018).

Core capacity	Definition
Organizations	Organizations should have diverse teams, effective leadership, clear goals, a good culture, credibility, and appropriate reward systems.
Individual	Individuals require strong and diverse social networks, should be collaborative, open to new ways of doing things, resilient, self-motivated, honest, and strong communicators.
Financial	Funding should be sufficient, secure, long-term, autonomous (i.e., managed internally), and flexible.
Material	Organizations should produce publicly available policy briefs with recommendations and public summaries. They should also have an engaging website and utilize social media.
Practical	Organizations should provide employees with 'time' and 'space' to try new things, fail and learn; to think; and to pursue own interests
Political	The interface between science, policy, and practice will be most effective when there is high political interest in a topic.
Social	Organizations need to ensure that employees have opportunities for informal face-to-face engagement with external stakeholders.

Note: This table is an adaptation of figure 1 featured in Cvitanovic et al., 2018 and Cvitanovic, Shellock, et al., 2021.

Program which was designed to generate new knowledge to support the management of the Ningaloo Marine Park in northwestern Australia. Building on this, and through additional case studies from the EU, Cvitanovic et al. (2018), Cvitanovic, Shellock, et al. (2021) expanded this list to identify seven categories of core capacities. They include (1) *organizational capacity*—organizations should be diverse with effective leaders and clear goals; (2) *individual capacity*—individuals need strong social networks and should be collaborative with strong communication skills; (3) *financial capacity*—funding should be sufficient, flexible, and long term; (4) *material capacity*—organizations should make information publicly available with an engaging internet or social media presence; (5) *practical* and *process capacity*—organizations should provide employees with flexible time and space to learn and grow; (6) *political capacity*—high political interest will strengthen the science-policy interface; and (7) *social capacity*—informal face-to-face engagement with stakeholders is important (see Table 1 for full list of core capacities adapted from Cvitanovic et al., 2018 and Cvitanovic, Shellock, et al., 2021).

The seven core capacities presented in those papers provide an organized overview and framework of the factors that enable KE and align with those identified elsewhere in the literature (e.g., Bednarek et al., 2018; Karcher et al., 2024; Walsh et al., 2019). This is one of the few frameworks that organizes the enablers of KE based on empirical research. In this paper, we aim to understand the conditions that enable effective KE by synthesizing various empirical case studies



using a scoping literature review. We will be using the seven core capacities introduced by Cvitanovic et al. (2016), Cvitanovic, Shellock, et al. (2021) to inform, frame, and organize the findings from our scoping literature review. We further identify commonalities among the implementation process, challenges, and outcomes of practical KE case studies to assess how enablers can be implemented for practicing effective KE within environmental and natural resource sectors.

In undertaking this review, we hope to make two important contributions to the field of KE. First, as highlighted in a recent review by Karcher et al. (2024), while the scholarship in relation to KE is advancing quickly, much of the lessons learnt have been derived from a singular case study and/or context. Indeed, the paper by Cvitanovic et al. (2018) that forms the basis for our framework was derived from a single case study, a boundary organization in Stockholm, Sweden. As such, Karcher et al. (2024) call for further work to synthesize learning across case studies and contexts to enable collective learnings and advance the field. This paper does this by providing a comprehensive and global review of the core capacities that underpin effective KE at the interface of environmental science and policy. Specifically, reviews such as this are crucial as they serve to consolidate existing knowledge, guide best practices, and synthesize valuable lessons from diverse contexts, drawing from a wide range of experiences and case studies, and supporting the development of communities of practice. These communities can then, in turn, benefit from shared insights and strategies, fostering collaboration and innovation across different regions, contexts, cultures and disciplines.

Second, this paper not only highlights the critical elements necessary for successful KE, but also addresses the high costs associated with these processes. Given that KE initiatives are often resource-intensive (reviewed by Karcher, Cvitanovic, Shellock et al., 2022), understanding the fundamental capacities that drive their success ensures that the benefits of such endeavors outweigh the costs. This review, therefore, offers a valuable resource for researchers, policy-makers and practitioners alike, enabling them to design more efficient and impactful KE strategies. In making these two contributions, this paper is theoretically grounded in the tradition of Mode 2 research and its notion of pragmatism (Fazey et al., 2018) to provide practical insights into KE to improve its effectiveness.

2 | METHODOLOGY

Using a scoping review, we examined the current literature on practical examples of KE using case studies. Scoping reviews are highly regarded for their ability to synthesize research fields and highlight key areas for future research and engagement in a robust and transparent manner (Arksey & O'Malley, 2005). As such, they are widely applied in the medical sciences and are increasingly used to assess environmental and conservation issues, for example, to explore the connection between people and place (Duggan et al., 2023), KE outcomes in environmental science and policy (Karcher et al., 2021), and the factors that influence effective participatory research approaches (Ison et al., 2024).

To ensure we broadly captured the enabling conditions of KE, we included search terms describing enabling features that were informed by the core capacities. The core capacities of KE proposed by Cvitanovic et al. (2018) include: organizational, individual, financial, material, practical, political, and social dimensions (Table 1). The review followed a general framework applied to scoping literature reviews as outlined by Arksey and O'Malley (2005): *stage 1*: identify the research questions; *stage 2*: identify relevant studies; *Stage 3*: study selection, and *stage 4*: collate, summarize, and report results.

2.1 | Stage 1: Identify the research question

The research questions addressed three themes related to KE in the environmental and natural resource context: (i) *what are practical enabling conditions that support effective and efficient KE?* (ii) *what are the challenges to effective KE?* and (iii) *what are common impacts and outcomes of KE?* These questions also helped guide the development of search strings that were used to identify papers from online literature search engines (Web of Science and Scopus). The research questions were broad enough to provide extensive coverage when developing search strings while allowing the seven core capacities outlined by Cvitanovic et al. (2018) (i.e., the enabling conditions) to be included into the search strings.

Three team members (CB, VN, and TK) developed search strings using a search strategy worksheet (Table A2) to organize search terms into four main concepts derived from the research questions. The four main concepts included terms related to (1) knowledge exchange, (2) environmental or natural resource management, (3) the field of science, and (4) Cvitanovic et al.'s (2018) seven core capacities. A search string was developed for each concept using the terms from the search strategy worksheet, where concept four included seven separate search strings including possible keywords describing each of the core capacities. A total of seven search strings were developed where concept one, concept two, concept three, and each of the seven concept four search strings were used alongside the 'and' Boolean operator (Table A1). Note that we excluded the term climate change under concept two (environmental or natural resource management) due to the large volume of irrelevant results it yielded. An iterative eligibility test was conducted to assess the seven core capacity search strings from concept four for high specificity and low sensitivity (i.e., changes were made to the search strings after each test to ensure relevant papers were being identified). Papers were eligible for inclusion if they broadly described a core capacity in their title or abstract in relation to environmental or natural resource management.

2.2 | Stage 2: Identify relevant studies

We applied the finalized search strings to two literature search engines, Web of Science and Scopus, which resulted in a total of 1848 papers (706 from Web of Science and 1142 from Scopus). We removed 717 duplicate papers, resulting in 1131 papers to be

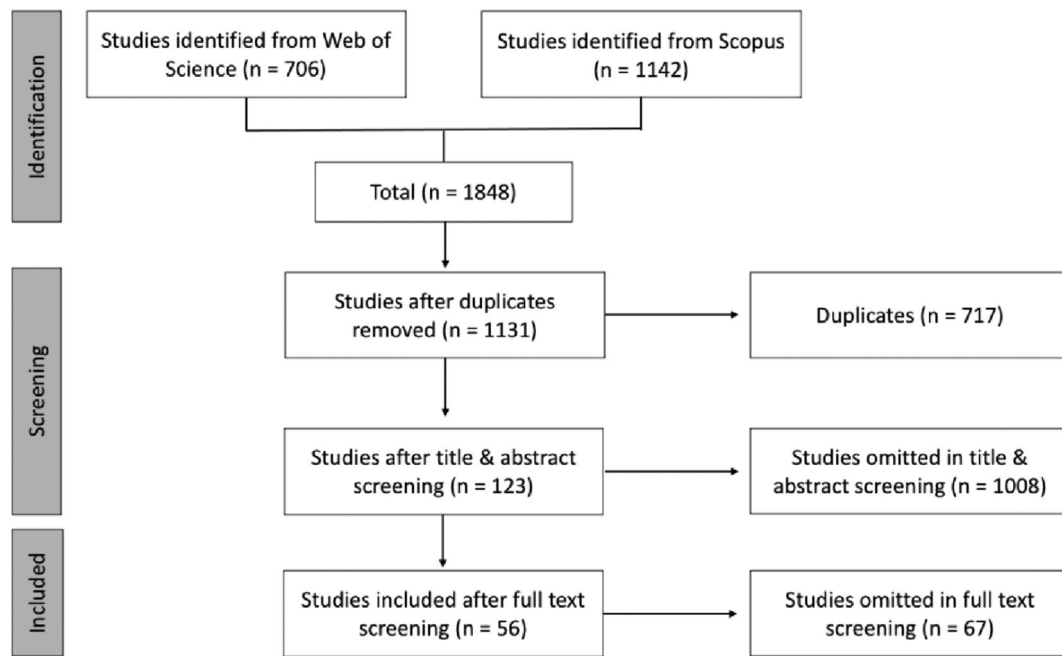


FIGURE 1 A visual representation of the number of papers that were included and excluded following title and abstract screening and full-text screening.

screened, which were uploaded to Covidence (2.0), a web-based tool used to organize the papers when performing full-text screenings and when extracting study characteristics.

2.3 | Stage 3: Study selection

Inclusion and exclusion criteria were developed (Table A3) to assist in the screening process as the review's main goal is to include papers that provide *practical* or *empirical* examples for implementing KE. This criterion was first used for a title and abstract screening, where all three questions (Table A3) must be answered 'yes' to pass. A total of 123 papers passed the title and abstract screening and proceeded to full text screening. Following full text screening, a total of 56 papers were included in this study using the same inclusion and exclusion criteria (Figure 1), where most of the 67 studies omitted in full text screening did not meet criteria three (i.e., is this study about implementation of KE or enabling conditions?).

2.4 | Stage 4: Collate, summarize, and report

We extracted data from the 56 papers that passed the full-text screening (Figure 1), where the data from each paper was sorted according to themes, key issues, and processes (Arksey & O'Malley, 2005) such as study objective, KE implementation process, KE enabling conditions, challenges, outcomes, and successes of the case study (see Table B1 for full list of data extraction items and definitions). The data extracted provided an overview of conditions that enable effective KE through practical case studies, and included

analyzing implementation strategies, challenges, and outcomes of case studies to bridge the gap between KE theory and practice. The data collected will provide valuable insight into functional and practical elements of KE for environmental and natural resource management.

2.5 | Qualitative text analysis

For each of the 56 papers, we extracted text relating to the KE implementation process, enabling conditions, challenges, outcomes, and successes. We compiled excerpts of relevant texts from the papers into a document to qualitatively code and determine: (1) what conditions enabled practitioners to implement KE, (2) what challenges impeded the implementation of KE, and (3) what were the outcomes of implementing KE.

An inductive coding approach was employed whereby each code served as a label for a theme present in the papers (Saldana, 2016). The codes were not determined in advance as this could misrepresent the data (Van den Hoonaard, 2011). One coder (TK) inductively coded all the relevant text from the papers available for KE implementation process, KE enabling conditions, challenges, outcomes, and successes. To verify the inductively derived codes, two coders (VN and CC) also individually followed an inductive coding approach by coding three random case studies (27% of the papers). Specifically, the two coders (VN and CC) inductively coded excerpts of texts from the three case studies related to KE implementation process, KE enabling conditions, challenges, outcomes, and successes. This was an important practice in ensuring that all possible themes were identified given the varied background knowledge and experience of the coders (Van den Hoonaard, 2011). The additional codes identified in the verification process

**TABLE 2** A list of the enabling conditions inductively coded from the 56 case studies.

Core capacity	Code	Definition of code	Frequency of mentions
Organizational Capacity: organizations should be diverse with effective leaders and clear goals	Align project objectives	The KE practitioner or group collaborates with stakeholders to modify research questions, KE activities, products, or processes to address the goals of the KE project.	22
	Co-production	An iterative and collaborative process involving diverse types of expertise, knowledge, and actors to co-design context-specific knowledge (Schneider et al., 2021).	8
	Shared value	All project stakeholders hold KE work and objectives to the same standard, level of importance, and usefulness.	7
	End-user history	Learning about end-user history and operational capabilities to better understand what knowledge is relevant or accessible.	6
	Boundary spanner characteristics: clear goals and objectives	A clear set of goals and objectives are established for a KE project by and/or for the boundary spanner.	3
	Boundary spanner characteristics: leadership qualities	Strong leaders who can lead, direct, and organize KE work.	2
	Boundary spanner characteristics: adaptable	Able to adjust to new conditions and modify work as a result.	1
	Boundary organizations: communities of practice	Facilitate collaboration between disciplines or sectors, such as scientific and non-scientific domains (Guston, 2001)	1
Individual Capacity: individuals need strong social networks and should be collaborative with strong communication skills	Collaboration	Collaborating with individuals internally or with individuals from other disciplines.	29
	Relationship building	Establishing and maintaining interpersonal relationships with all project stakeholders such that you can share information across organizations because of the relationships you have built.	29
	Networking	Importance of networks, partnerships, stakeholder engagements, or other ways of interacting within networks.	28
	Trust building	Establishing and maintaining trust such that all project stakeholders feel like they are a part of the team, they can communicate honestly and freely, and trust each other to work towards a shared goal or way of working.	24
	Tailored communication	Modifying data or experiences to make it relevant and accessible to the knowledge user.	22
	Shared language	Developing and using common words and phrases with project stakeholders to improve understanding and ensure accessibility.	5
	Transparency	KE practitioners receive the approval or acceptance of a community (Lowey, 2016) by sharing project information with all stakeholders.	3
	Establish credibility	Establish that KE practitioners and your organization are worth believing in and are trustworthy.	2
Financial Capacity: funding should be sufficient, flexible, and long term	Funding	Acquiring sufficient, long-term funding to execute KE work.	11
Material Capacity: organizations should make information publicly available with an engaging internet or social media presence	Boundary objects	They are adaptable to different knowledge domains and perspectives but maintain their identity across disciplines. They can help to overcome interpretive differences across disciplines (ex. definitions and standards, models that integrate scientific and political viewpoints, indicators that improve communication across knowledge domains).	8

TABLE 2 (Continued)

Core capacity	Code	Definition of code	Frequency of mentions
Practical Capacity: organizations should provide employees with flexible time and space to learn and grow	Evaluations	Conducting evaluations or receiving feedback from past work to improve KE strategies and practices.	12
	Social learning	Gaining a better understanding of a topic by observing or working with a community.	8
	Sharing expertise	Sharing personal or organizational expertise across disciplines.	6
	Peer to peer learning	Where knowledge users teach and train other knowledge users.	5
	Training	Can include hands-on demonstrations, teaching, and co-learning to improve the collective (i.e., all stakeholders involved) understanding of a topic.	3
	Research	KE practitioners engage in gathering data or conducting secondary research to aid in KE work.	3
Political Capacity: high political interest will strengthen the science-policy interface	Boundary spanner: KE broker	Individuals or organizations that actively facilitate the exchange between the production and use of knowledge to support evidence-informed decision-making (Bednarek et al., 2018).	27
	Boundary spanner characteristics: adequate background knowledge	Possess sufficient background knowledge and expertise on a topic to be able to exchange knowledge effectively and accurately between producers and users.	1
Social Capacity: informal face-to-face engagement with stakeholders is important	Informal communication	Based on the informal, social relationships that are formed in a workplace. Includes casual conversations to establish personal contacts, making friendships, influencing, and motivating others, etc.	17
	Face to face engagement	Importance of face-to-face interactions with stakeholders for developing interpersonal connections.	9
	Regular and sustained communication	Maintaining communication with end-users throughout a KE project and after it is completed to remain engaged and receive updates.	6

Note: Enabling conditions were organized into one of seven applicable core capacities (Cvitanovic et al., 2018; Cvitanovic, Shellock, et al., 2021). Frequency of mentions (not mutually exclusive) is the number of times a code was applied, where codes could be applied multiple times to a single case study.

were applied to all the relevant text and the codes were compiled into a codebook consisting of 89 codes (online Appendix C) where we provide samples of coded case studies for further transparency (online Appendix D). To develop a comprehensive inventory of the enablers of KE and to contextualize them, we used the seven core capacities identified by Cvitanovic et al. (2018) to inform and frame the inductively derived codes from the case studies (Table 2).

For this review, we considered the main themes related to enablers of KE that were identified during the inductive coding process and used concepts from existing KE research to classify the enabling conditions within a single core capacity. We acknowledge that many of the enabling condition codes can be conceptualized and operationalized differently in various disciplines, sectors, and settings (Bornbaum et al., 2015). For example, the enabling condition code *boundary spanner: KE broker* can fit into the *Individual* core capacity in addition to the *Political* core capacity (see Table 2 for example). This is because boundary spanners must possess excellent interpersonal skills

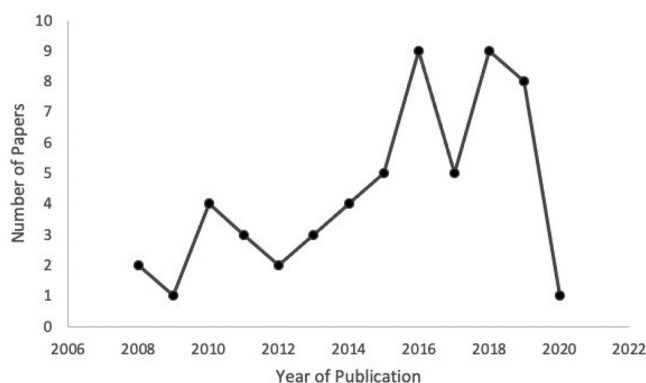


FIGURE 2 Year of publication for the 56 case studies on enabling conditions for knowledge exchange. The case studies for this review were collected in April 2020, and therefore represents an incomplete data set that does not accurately depict case studies published in 2020.

and possess knowledge and interest of multiple disciplines and sectors to communicate knowledge across boundaries effectively (Michaels, 2009; Saarela & Söderman, 2015). However, given how boundary spanners were interpreted during the inductive coding process, they best fit into the political core capacity for this review. We acknowledge that this work is not free from subjective interpretations and biases but nonetheless, the results of this review help illustrate the breadth of enablers to KE that will be useful in promoting how to engage in KE effectively.

3 | RESULTS

3.1 | General characteristics

The 56 case studies extracted for this study were published between 2008 and 2020, with 57% of these published between 2016 and 2020 ($n = 32$) (Figure 2). The case studies belonged to a variety of knowledge sectors within environmental management and natural resource conservation, including, for example, marine conservation, forestry, fisheries management, and climate science, (Figure 3, see Table B1 for full list of data extraction items). Note, the numbers for climate science are an underestimation due to the limitations of our search strategy where we excluded climate change in our search terms. The case studies varied in duration, ranging from 2 months to 3 years with the number of participants for a case study ranging from four individuals to approximately 500. The participants for the case studies included individuals and groups belonging to academic institutions, government, private industry, Non-Government Organizations (NGOs), and local communities. The knowledge producers and users identified for the case studies included a combination of individuals belonging to these groups who often collaborated to engage in KE together. The frequency of mentions for knowledge producers and users were not mutually exclusive. Knowledge producers belonged to

NGOs ($n = 27$), federal or regional government organizations ($n = 26$), private industry ($n = 10$), and local communities ($n = 10$). Knowledge users belonged to federal or regional government organizations ($n = 46$), NGOs ($n = 22$), local communities ($n = 17$), private industry ($n = 11$), and academic institutions ($n = 2$).

A variety of study approaches were applied to assess KE, including interviews.

(semi-structured ($n = 31$) and open-ended ($n = 14$)), focus groups ($n = 9$), surveys ($n = 7$), workshops ($n = 6$), ethnographies ($n = 4$), questionnaires ($n = 3$), discourse analysis ($n = 2$), and network analysis ($n = 2$). The frequency of mentions for study approaches are not mutually exclusive as multiple approaches were often used for a single case study. Eighty-six percent of the authors were from Canada ($n = 12$), Australia ($n = 11$), USA ($n = 11$), UK ($n = 8$), and the Netherlands ($n = 6$). Over half (55%) of the case studies took place in Canada ($n = 10$), Australia ($n = 8$), USA ($n = 7$), and the UK ($n = 6$). Nearly half of the case studies involved implementing and examining KE at a regional scale ($n = 27$), followed by case studies at a national scale ($n = 23$), and a single case study at the global scale ($n = 1$). A few case studies involved examining KE at both a regional and national scale ($n = 5$).

Most of the papers were written by an academic organization ($n = 44$), followed by government organizations ($n = 6$), private industries ($n = 4$), and NGOs ($n = 2$). Groups responsible for knowledge production within the case studies were identified to belong to private industries ($n = 1$), NGOs ($n = 9$), academic organizations ($n = 8$), government organizations ($n = 7$), and local communities and/or Indigenous communities ($n = 1$). Most often, knowledge production was identified to be a collaborative effort involving more than one of the knowledge producers listed above ($n = 30$). Similarly, KE work was often intended for more than a single knowledge user group with most knowledge users belonging to a combination of academic organizations, government organizations, private industries, NGOs, and local and/or Indigenous communities ($n = 29$). When KE work was

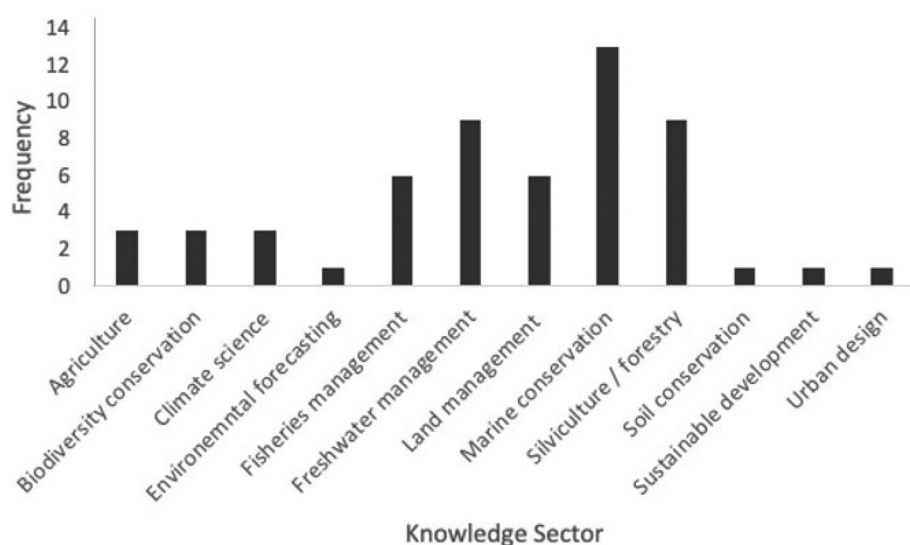


FIGURE 3 The knowledge sectors that were identified for the 56 case studies on enabling conditions for knowledge exchange.

TABLE 3 A list of the challenges to performing knowledge exchange (KE) that were inductively identified and coded from the 56 case studies.

Code	Definition of code	Frequency of mentions
Limited capacity	Limited number of staff or resources to perform KE work.	13
Mismatched timelines and project objectives	Differing timelines and project objectives between different disciplines (often between science and policy).	12
Funding	Insufficient funding to conduct KE work.	10
Lack interpersonal skills	A lack of social competencies required to interact with other.	10
Inadequate background knowledge (for KE practitioner)	KE practitioners did not possess sufficient background knowledge on a topic required to exchange complex information.	9
Few/poor interpersonal relationships	Difficulty establishing and maintaining interpersonal relationships with all project stakeholders.	9
Mismatched values	Differing perceptions of value placed on a project or KE work.	8
Lack of trust	Difficulty establishing and maintaining trust such that all project stakeholders feel like they are a part of the team, they can communicate honestly and freely, and trust each other to work towards a shared goal or way of working (Stern & Baird, 2015).	8
Difficulty communicating complex ideas and data	Difficulty modifying data or experiences to make it relevant and accessible to the knowledge user.	8
Maintaining regular communication	Difficulty maintaining regular communication with project stakeholders which can limit opportunities for feedback and to adapt work.	6
Power imbalances	Power dynamics that influence collaborative KE work such that the more powerful individual or organization influences many decisions.	6
Language barriers	Difficulties with communication due to languages spoken or language proficiencies.	5
Time	Time restraints on KE work.	4
Cultural barriers	Misunderstandings caused by cultural differences.	4
Institutional structures	An organization's aversion to risk, bureaucratic structure, or lack of communication channels.	4
Geographical limitations	Any barriers in accessibility associated with geographic location.	3
Little collaboration	Few opportunities to work with organizations from other disciplines or to share expertise across organizations and disciplines.	3
Difficulty implementing tools/technology	Difficulty implementing tangible changes once KE work has concluded.	3
Remaining impartial	Difficulty for KE practitioners to remain impartial, unbiased, and remove their emotions from KE work.	2
Few networking opportunities	Few opportunities to develop new partnerships or engage stakeholders.	1

Note: Frequency of mentions (not mutually exclusive) is the number of times a code was applied where codes could be applied multiple times to a single case study.

intended for a single knowledge user group, it was most often for government organizations ($n = 20$), followed by local and/or Indigenous communities ($n = 5$), private industries ($n = 1$), and NGOs ($n = 1$).

3.2 | Knowledge exchange enabling conditions

We qualitatively examined the enabling conditions and implementation strategies of the 56 case studies to identify a total of 31 codes describing enabling conditions for KE (Table 2). The most frequently identified conditions enabling KE work included: collaboration ($n = 29$) with different multidisciplinary organizations; relationship building ($n = 29$), networking ($n = 28$); employing a boundary spanner ($n = 27$) to facilitate the exchange of knowledge between knowledge producers and users; building and establishing trust ($n = 24$) with project stakeholders; aligning project objectives ($n = 22$) with all

stakeholders involved, and; tailoring communications ($n = 22$) to make information relevant and accessible to the knowledge user. We noted that boundary spanners often took the role of a knowledge broker (i.e., an individual acting as an intermediary between knowledge producers and users). Informal communication ($n = 17$) with project stakeholders, evaluations ($n = 12$), and funding ($n = 11$) were also conditions that were frequently cited to help enable KE work. The 31 enabling condition codes were subsequently organized into one of the seven core capacities (organizational, individual, financial, material, practical, political, and social).

We identified 20 codes that describe the challenges to performing KE from the case studies reviewed (Table 3). Of these, the most frequently mentioned were limited organizational capacity to execute KE work ($n = 13$), mismatched project objectives and timelines between science and policy sectors ($n = 12$), lack of interpersonal skills for KE practitioners ($n = 10$), acquiring sufficient long-term



TABLE 4 A list of the outcomes (i.e., a measurable change due to information and advice from knowledge exchange [KE]) to performing KE that were inductively coded from the 56 case studies.

Code	Definition of code	Frequency of mentions
Development and adoption of new technology, boundary object, policy	A new technology, boundary object, or policy is adopted because of KE work.	28
Increased understanding	There is an increased level of understanding on a particular topic due to KE work and research.	17
Increased collaboration	Existing collaborative efforts are improved and/or new collaborations are developed.	13
Aligning interests	The interests and objectives of multiple disciplines and/or stakeholders are aligned.	11
Increased stakeholder engagement	There is an increased level of participation and engagement with all project stakeholders.	5
New social networks	New social connections are developed as a result of KE work and collaborations.	5
Increased organizational capacity	Increased number of staff, resources, and abilities to conduct effective KE work.	4
Expertise transfer	An exchange expertise occurs between or among KE practitioners, knowledge producers, and knowledge users.	2
Incorporate feedback	Feedback is actively incorporated to improve KE practices.	1

Note: Frequency of mentions (not mutually exclusive) is the number of times a code was applied where codes could be applied multiple times to a single case study.

funding ($n = 10$), few interpersonal relationships between project stakeholders ($n = 9$), and inadequate background knowledge for KE practitioners ($n = 9$). Additional challenges frequently cited include difficulty for KE practitioners to communicate complex ideas, information, and knowledge with knowledge users ($n = 8$), a lack of trust between project stakeholders ($n = 8$), and mismatched values between knowledge producers, users, and KE practitioners ($n = 8$).

3.3 | Outcomes and impact of KE work

It is important to note that the case studies used in this review focused on the implementation of KE, not the assessment of KE

outcomes or impacts. To distinguish between the outcome and impact codes, we define the *outcomes of KE* as the measurable change due to information and advice (LSE, 2019), while we define the *impact of KE* as the longer-term effect of an outcome (i.e., the effect information and advice can have on the ability to make an informed decision or empower broad life experiences) (LSE, 2019). While outcomes tend to be determined in advance, can be measured objectively, and are often evaluated by quantitative means, assessing impact can be more complex as it involves personal experiences and relationships which are often evaluated by qualitative means (LSE, 2019). As such, distinguishing between outcome and impact codes (i.e., the quantitative and qualitative effects of KE) were based on the perceived length of time required to achieve a single ‘outcome’ or ‘impact’.

We identified nine codes that address the outcomes of the KE case studies (Table 4). The most frequently cited outcomes of KE work were the development and adoption of a new technology, boundary object, or policy ($n = 28$), increased understanding of a topic by knowledge users ($n = 17$), increased collaboration among all project stakeholders and across disciplines ($n = 13$), and alignment of interests (i.e., alignment between science and policy objectives or with knowledge user concerns) ($n = 11$).

We identified 12 codes that describe the impact of KE work from the case studies (online Appendix C) and of these, change in knowledge user behavior or being more receptive to change due to an increased understanding of a topic ($n = 16$) and encouraging similar research to take place elsewhere ($n = 4$) were the most frequently cited impacts of KE work (Table 5).

4 | DISCUSSION

The 56 empirical case studies assessed in this scoping literature review allowed us to categorize enablers of KE across different contexts in environmental management, building upon Cvitanovic et al. (2018), Cvitanovic, Shellock, (2021). We synthesized challenges to effectively implement and engage in KE at an individual and organizational level. We also identified indicators for evaluating the outcomes and impacts of KE work which are needed to assess how effective KE is through short- and long-term evaluations. By doing so, this review attempts to bridge the theory-practice gap by providing a comprehensive analysis and list of the enablers, challenges, outcomes, and impacts of KE based on practical case studies—contributing to a wider understanding for practitioners of what is needed to put KE to practice in environmental management.

4.1 | Enablers to effective KE for practitioners

The identified enabling conditions for KE were most often related to the organizational, individual, and social capacity for KE, such as those related to trust, collaboration, interpersonal relationships, and communication practices to facilitate collaboration across disciplines and sectors. These are consistent with participatory KE approaches (such as

TABLE 5 A list of the impacts to performing knowledge exchange (KE) that were inductively coded from the 56 case studies.

Code	Definition of code	Frequency of mentions
Change in behavior	There is a change in individual behavior due to an increased understanding of a particular topic, individuals may be more receptive to change.	16
Encourage similar research elsewhere	Addressing the goals of the KE project allowed researchers to identify emerging issues and inspired additional research elsewhere.	4
Change in practice	There is a change in how KE is practiced or performed at an organizational and/or individual level.	3
Improved communication	Communication practices improved or new channels for communication have been developed.	3
Increased resiliency	The capacity for organizations or individuals to recover from setbacks has improved.	3
Shared language is developed	Common words and phrases with all project stakeholders are actively used to improve understanding and ensure accessibility.	3
Improved relationships	Interpersonal relationships with project stakeholders have been established or have improved such that KE practitioners can exchange knowledge across organizations and disciplines.	3
Shared value and mutual understanding are developed	All project stakeholders share common project objectives, hold KE work to a similar level of importance and usefulness, and understand each other's contributions and accessibility needs.	3
Increased sense of trust	An increased sense of trust is developed such that more project stakeholders feel like they are a part of the team, are able to communicate honestly, and trust each other to work towards a shared goal.	2
Boundary spanner enabled	A boundary spanner position is developed or employed by an organization to facilitate KE between multidisciplinary organizations.	2
Lowered cultural barriers	Fewer misunderstandings caused by cultural differences. This may be because project stakeholders have developed interpersonal relationships and have learned from multiple project stakeholders.	1
New economic opportunity	New economic opportunities arise as a result of KE work.	1

Note: Frequency of mentions (not mutually exclusive) is the number of times a code was applied where codes could be applied multiple times to a single case study.

co-production) that recognize KE as an iterative process reliant on multi-directional communication and relationships to improve mutual understanding (Chambers et al. 2022; Kirchoff et al., 2013; Nguyen et al., 2017; Young et al., 2014). Participatory forms of KE involve trust and relationship building to increase knowledge sharing and require honest participation by all actors (Cvitanovic, Mackay, et al. 2021). In addition, participatory forms of KE encourage knowledge uptake into policy and practice by establishing practices (e.g., incorporate boundary spanners) that facilitate collaborations and KE between knowledge producers and users for evidence-informed decisions and practices (Cash & Pratt, 2006; Cooke et al., 2020; Kirchoff et al., 2013; Levesque et al., 2017).

In this regard, we define boundary spanning as ‘work to enable exchange between the production and use of knowledge to support evidence-informed decision making in a specific context,’ and as such, boundary spanners as the ‘individuals or organizations that specifically and actively facilitate this process’ (following Bednarek et al., 2018). Following this definition, boundary spanners can take a variety of forms such as knowledge brokers (e.g. Cvitanovic et al., 2017) and other forms of individual ‘trusted mediators’ (Whyte & Crease, 2010), through to boundary organizations (Bednarek et al., 2015), among others. When implemented effectively, boundary spanners have been shown to support a diverse range of positive outcomes and impacts (e.g., the development of trust among academic and non-academic

actors, Whyte & Crease, 2010), as reviewed by Posner and Cvitanovic (2019), and illustrated in the following example. In the case study by Coleman and Stern (2018), they investigated the roles of individuals working for the US Forest Service (USFS) and discovered that collaborating with all project actors enhances forest management by encouraging the sharing of diverse information and ideas, diminishing conflict, and enhancing productive deliberation. Specifically, this study identified that such collaborations increased the development of trust and relationships between environmental groups and the USFS, and that boundary spanners played an important role in facilitating collaborative networks. The role of boundary spanners assisted the USFS in increasing the knowledge and tolerance of new knowledge for stakeholder groups to inform discussions and policies related to forest management by engaging in informal conversations with all project actors to build trust and align values and objectives. In addition, boundary spanners in this case advocated for all project actors to share their knowledge and expertise to ensure discussions were well rounded and fair.

Maintaining interpersonal relationships between knowledge producers and users, such as researchers and decision-makers, has been cited as an integral component to KE to bridge multiple sectors (Bradshaw & Borchers, 2000; Girling & Gibbs, 2019; Plaisance et al., 2021). Informal communication, such as face-to-face interactions, are of particular importance to KE practitioners who seek to



expand networking opportunities and build and maintain trusting relationships with knowledge users from various sectors and disciplines (Schwarz & Stensaker, 2020; Nguyen et al., 2021). In a case study produced by Ryan and Cerveny (2010), the ability for knowledge producers to communicate research findings to managers (knowledge users) at the US Forest Service through face-to-face interactions and hands-on technical demonstrations was critical for managers to interpret the highly complex knowledge accurately.

The importance of interpersonal interactions is not limited to the environmental field. For instance, Plaisance et al. (2021) empirically found that face-to-face engagement (or interpersonal interactions) with scientists, policymakers, and other stakeholders played a vital role in direct uptake of work from interdisciplinary philosophers of science to improve ways of influencing scientific practice, policy and public engagement with science. The authors found that these face-to-face interactions resulted in “upstream” impacts through conversation and interactions taking place before a study was completed and “downstream” impact (e.g., advising on policies, writing best practices, etc.) occurring after they published their work. Notably, these downstream impacts mostly resulted from face-to-face interactions (e.g., after giving a talk, or participating on a committee). These face-to-face interactions or “relational engagements” can come in many forms and range from opportunistic to strategic (see Ozanne et al. 2021 for relational engagement typology). Opportunities to engage in informal communication are thus important because oral and experiential forms of knowledge are often developed and communicated by engaging in hands-on practices or through in-person observations and interpersonal interactions (Nguyen et al., 2021; Plaisance et al., 2021).

As highlighted earlier, boundary spanners were regularly cited among the case studies to enable KE work (e.g., Berglund & Aradottir, 2015; Cadman & Soomai, 2020; Cohen & Mills, 2012; Coleman & Stern, 2018; Holzer et al., 2019), which is consistent with the broad literature suggesting that they play a key role in collaborating, facilitating, and exchanging context-specific knowledge with diverse knowledge users (Armitage et al., 2011; Bednarek et al., 2018; Karcher et al., 2021; Posner & Cvitanovic, 2019). It is necessary for boundary spanners to possess sufficient background knowledge and expertise of the knowledge they are exchanging (Michaels, 2009; Saarela & Söderman, 2015). With comprehensive knowledge and experiences in multiple disciplines, boundary spanners can identify and communicate the emerging scientific needs of decision-makers to mobilize evidence-informed decision-making (Cvitanovic et al., 2018; Rose et al., 2020). Our findings also highlight important individual attributes of KE practitioners consistent with Cvitanovic et al. (2018). Individuals working in the KE space should develop clear goals and objectives related to their KE work, possess strong leadership qualities, and be adaptable and capable of modifying work to meet the needs of various actors. For example, in a case study by Stange & Tatenhove, (2016), when researchers (knowledge producers) developed clear project goals and objectives, they were able to explicitly share how they would like project collaborators to engage in the research process. This enhanced project actors' understanding of how they can contribute with their knowledge and concerns.

4.2 | Challenges: How implementing more enablers can help overcome barriers

We identified a limited capacity (i.e., resources or staff) for organizations to perform KE work as the most common barrier (e.g., Carneiro & Da Silva Rosa, 2011; Knight & Vaske, 2015; Kaiser et al., 2019; Lemieux et al., 2018; Medema et al., 2016), which may result in challenges for organizations to obtain secure, long-term funding (Cvitanovic et al., 2018). Data analysis also found mismatched timelines and objectives between knowledge producers and users (e.g., Dunn & Brown, 2018; Hastings, 2011; Ryan & Cerveny, 2010), and a difficulty for knowledge producers to communicate complex knowledge with various end-users (e.g., Grygoruk & Rannow, 2017; Guido et al., 2016; Sheikheldin et al., 2010). This is consistent with the difficulties cited by researchers and decision-makers to translate or align their differing objectives across disciplines and sectors (Pennington., 2008).

Many of the challenges to implementing KE were related to the expertise and interpersonal skills of KE practitioners. For example, practitioners had difficulty maintaining trusting relationships with all project actors and sustaining regular communication to identify the evolving needs of knowledge users (e.g., Berglund & Aradottir, 2015; Laatsch & Ma, 2016). In the case study produced by Berglund & Aradottir (2015), they explored how officers at the Soil Conservation Service of Iceland (SCSI) can improve soil conservation decisions and practices through their interactions with project actors, specifically farmers and locals. One of the main challenges for SCSI officers was the ability to establish and maintain contact with farmers and other locals, which is needed to support and influence their soil conservation practices. Through semi-structured interviews with SCSI officers, this study identified that SCSI officers did not possess adequate interpersonal skills to remain impartial when communicating with farmers and locals. This study concludes that if SCSI officers possessed the skills to maintain regular contact with farmers and locals, they could maintain trusting relationships and better support and influence soil restoration work.

Our findings also highlight the challenges associated with power imbalances, language barriers, and cultural barriers (e.g., Crona & Parker, 2012; Hickey et al., 2013; Stewart et al., 2014). In the case study by Crona and Parker (2012), power imbalances between science and policy sectors led to misalignment of project objectives, decreased interactions between project actors, and fewer networking opportunities which can impact the exchange of knowledge across boundaries. Existing research has identified a range of factors that can empower actors to collaborate equally, such as equal access to information and the ability for all project actors to shape discussions (Levesque et al., 2017; Tuler & Webler, 2010; Whyte & Crease, 2010). Our findings suggest that boundary spanners play a critical role in overcoming these challenges because they act as intermediaries capable of facilitating KE across sectors and disciplines, and they possess excellent interpersonal skills that enable them to overcome communication differences (Naylor et al., 2012). Specifically, this review suggests that boundary spanners successfully facilitate multidisciplinary

collaborations when they set clear goals and objectives for all project actors, possess strong leadership qualities to organize KE work, are adaptable to new working conditions, and can modify their work for various audiences. These boundary spanner characteristics align with those identified by Cvitanovic et al. (2018), such that these individual attributes are important features of a flexible and adaptive organization engaging in effective KE work.

It is unsurprising that some key challenges are, like enabling conditions, related to interpersonal factors in addition to organizational culture and capacity. For instance, organizations that possess extensive *practical* core capacity (i.e., engage in social learning, peer-to-peer learning, and sharing expertise), may be better equipped to overcome communication and interpersonal barriers to KE. This is because organizations that promote social learning and share their expertise are more likely to be inclusive in their stakeholder engagement and develop collaborative solutions, which is consistent with our findings of the practical capacity enabling conditions (Koontz, 2014; Reed et al., 2010).

4.3 | Outcomes and impacts of KE work

The results highlight a number of outcomes and impacts of KE, where outcomes of KE are easily measurable often by quantitative indicators, and impacts require more time and resources to evaluate often by qualitative indicators. Oftentimes, the case studies described overall outcomes and impacts of KE that were not identified as a main goal of the KE work at the beginning of the case study suggesting practitioners should not limit themselves to only measuring intended goals. The most frequently cited impacts of KE work were change in behavior, increased resiliency (i.e., the ability to recover quickly from challenges or setbacks), increased feelings of trust, improved relationships, and reduced/removed cultural barriers that can inhibit KE (e.g., Crona & Parker, 2012; Feeney et al., 2010; Kaiser et al., 2019). The most frequently cited outcomes of KE work were the development and adoption of new technologies, boundary objects or policies, increased collaboration, and alignment of objectives or interests of multiple actors and stakeholder groups (e.g., Bautista et al., 2017; Chapman et al., 2017; Dunn & Brown, 2018; Holzer et al., 2019; Karcher et al., 2022). We noticed higher frequencies associated with outcome codes (see frequencies associated with outcomes: Table 4 and impacts: Table 5). This may be due to the easily quantifiable nature of outcomes, making them easier to identify as direct successes of KE work. As such, our results may not accurately depict the impacts of KE work due to how difficult social (or qualitative) forms of effective KE can be to evaluate (Bowen & Martens, 2005; Fazey et al., 2014).

One of the most widely used frameworks for analyzing research impacts describes three types of approaches: conceptual, instrumental, and symbolic (Amara et al., 2004). Research that has conceptual impact involves changing perceptions, raising awareness, or changing beliefs (Rudd, 2011). Instrumental impact occurs when research results in direct changes to policy and practice, often through the use

of boundary objects (Rudd, 2011). Finally, symbolic impact refers to using research results to legitimize and sustain existing policies and practices (Amara et al., 2004). In this review, *impacts of KE*, which often resulted in changes in behavior or perceptions, can be considered to have conceptual impact. *Outcomes of KE* can be considered to have instrumental impact, as these outcomes often resulted in direct changes to policy and practice through the development and adoption of technologies or boundary objects. It is possible for both *impacts* and *outcomes* of KE in this review to have symbolic impact to justify existing policies or practices.

Further, it often takes three to 9 years to notice any observable impacts in interdisciplinary science, policy, and environmental management work (Cvitanovic, Shellock, et al., 2021). As a result, many studies do not empirically assess the effectiveness of KE work (Westwood et al., 2021), highlighting the importance for practitioners to derive methods for evaluating the long-term impacts (i.e., qualitative indicators) of KE. To evaluate the full scope of how effective KE is, it is necessary to assess KE work through both quantitative and qualitative lenses. This review highlights an important KE theory-practice gap, such that KE is often performed via collaborations, relationships, and trust, but is often evaluated by quantitative means that cannot capture the impacts of interpersonal relationships (Pedersen et al., 2020).

The impacts of KE with the lowest mentions, such as increased sense of trust and improved relationships, coincide with challenges to KE that had the highest frequencies of mentions among the case studies, such as lack of interpersonal skills, few/poor interpersonal relationships, and lack of trust. Although it is difficult to determine with certainty, it is possible that these challenges may be associated with difficulties in evaluating the social impacts of KE through quantitative indicators. This emphasizes the need for evaluations of KE work (a *practical capacity* enabler) to assess the effectiveness of KE through both quantitative and qualitative lenses to discern the full scope and impact of KE work. Without a combination of quantitative and qualitative evaluations, KE practitioners may miss opportunities to strengthen and improve their interpersonal skill and relationships – skills that heavily influence the effectiveness of KE.

4.4 | Key recommendations: Lessons from assessing practical KE case studies

Overall, we provided a key list of enablers that KE practitioners may use as a resource to identify what to continue investing in and what areas need to be strengthened. It is evident through this review that interpersonal factors and relationships underpin many of the enabling conditions of KE (e.g., social relationships, face-to-face engagement, interpersonal trust), the challenges of KE (e.g., challenges in maintaining trust relationships, power imbalance, limited social capacity), and resulting KE impacts (e.g., change in behavior, increased resiliency, increased sense of trust, improved relationships, and lowered cultural barriers) and outcomes (e.g., increased collaborations and alignment of interests). Further, the inclusion of boundary spanners or knowledge



brokers (individuals and/or organizations) were key enabling factors across the case studies supporting these interpersonal relationships and interactions. This suggests that not everyone will, and can be, effective at practicing knowledge exchange and that there are certain individuals and/or organizations with key interpersonal characteristics that promote building and maintaining trusting relationships. As such, we recommend collaborating, hiring, training, learning from, and making space with and for these individuals (who may or may not be official boundary spanners) within networks to make better connections between science and policy or action. Oftentimes, these individuals are already found in organizations in an informal capacity and are champions of a topic (Cooke et al., 2021; Kapoor et al., 2023; Mumford & Harvey, 2014), albeit in roles that do not recognize or reward their boundary spanning efforts. As such, there is a need to more formally recognize the importance of boundary spanning roles at the organizational level through dedicated position profiles that are rewarded and developed appropriately (Kapoor et al., 2023). It may also be difficult to identify these individuals because they do not often occupy an official role or position, but what they have in common is a high level of influence on others because of certain personal characteristics as well as a passion and strong commitment to change (Mumford & Harvey, 2014). Further, organizations looking to use KE for impact should invest in strategies that support opportunities for development of interpersonal relationships such as researcher-practitioner-stakeholder forums and events that are iterative and allow for continuity in relationships. Lastly, the fact that enabling conditions under individual capacity was widespread shows that individuals in the context of KE can have control and influence of its impact and effectiveness.

It may be possible that challenges of KE related to a lack of resources and funding reflect the priorities given to KE relative to other activities such as primary research, but also the potential lack of evaluation of KE to demonstrate its actual impacts (Louder et al., 2021). We recommend that KE scholars and practitioners shift to measuring impacts and outcomes of KE to collectively elevate its importance in science policy and similar contexts. Louder et al. (2021) offers a useful set of 'rules of thumb' for improving such evaluations. Further, our review also highlighted that the enablers required to engage in effective KE are also the main challenges for practitioners. For example, possessing excellent interpersonal skills, acquiring long-term funding, aligning project objectives, maintaining regular communication with project actors, and the ability to communicate complex knowledge are simultaneously enablers to KE and what practitioners struggle to achieve. With additional research assessing both the quantitative and qualitative impacts of KE work, we may be able to better understand specific actions that can transform challenges into an enabler. This will require researchers to perform impact research over long time periods using empirical case studies and increase experimental or quasi-experimental approaches to better understand the tipping points between challenges and enablers.

Lastly, given the importance of interpersonal interactions and factors of our study, it is important for KE practitioners to capture the impact of interpersonal relationships and trust using both qualitative

and quantitative indicators. This is complex and challenging to do (Pedersen et al., 2020). To our knowledge, some more recent work exploring the evaluation of interpersonal factors that we recommend warrants further pursuit is the "productive interactions" concept introduced by Spaapen and Van Drooge (2011), and the typology of productive interactions by Muhonen et al. (2020). A productive interaction is where the science system encounters societal actors and can be presented as three kinds of productive interactions: direct (personal) interactions, indirect interactions (mediated through artifacts), and financial interactions (mediated through exchange relations). Spaapen and van Drooge (2011) discuss several possible indicators and suggest that quantifying or weighing these interpersonal interactions are unnecessary but can at least paint a picture of interactions among actors. Muhonen et al. (2020) builds on these ideas to develop a typology of "research impact pathways" that supports the evaluation of conditions supporting impact processes going from simply "counting" interactions between various actors to considering the pathways of these interactions. Further, through a comprehensive review of research impact literature in the social science and humanities, Pedersen et al. (2020) recommends avoiding catch-all indicators and universal metrics but that methods used need to be developed for given contexts and possibly combine a variety of assessment types. The complexity and open-endedness of research impacts are like KE impacts, and thus assessing and evaluating these impacts and outcomes will similarly require a combination of methods (see Pedersen et al., 2020 for comprehensive list of evaluation approaches).

4.5 | Strengths and limitations of the framework

We expanded upon Cvitanovic et al.'s (Cvitanovic & Hobday, 2018, 2021a) core capacity framework to detail specific enabling conditions for effective KE through an organizational, individual, financial, material, practical, political, and social lens. Although enablers, barriers, outcomes and impacts of KE have previously been identified by researchers, little to no research has synthesized empirical case studies to bridge the theory-practice gap and identify key recommendations for practitioners to operationalize KE effectively (but see Karcher et al., 2021). Here, we were able to logically organize and categorize the findings from case studies into the core capacity framework used in this review. Doing this bridges the theory-practice gap by confirming the enablers experienced by practitioners with those identified in the literature and strengthens the strong messages around interpersonal factors and trust as enablers of effective KE. The synthesis of enablers, challenges, outcomes, and impacts that this empirical review provided can be used as a resource and framework for practitioners to identify what enablers may be missing from their KE strategies and in what capacity the KE work can be strengthened.

This review provided useful information as to how enablers to KE can be conceptualized and organized based on empirical evidence while also highlighting the highly context-dependent nature of KE. As

such, there can be limitations to the applicability of this framework such that specific enabling conditions may fit into different core capacities based on the interpretations of the researchers. Further, much of this review considered the perspectives of KE practitioners at an individual and organizational level. This limits our understanding of what enables KE from a knowledge user's perspective or as a stakeholder organization collaborating on a project.

5 | LIMITATIONS OF ANALYSIS

We acknowledge several limitations in our analysis. This study focused on capturing items published in academic databases which tends to be biased towards academic sources. As such, we were likely unable to capture the full scope of empirical case studies by NGOs, Indigenous organizations, or private industries (Westwood et al. 2023). Our use of English as the study language may account for the majority of case studies taking place in Australia, Canada, USA, and the UK. We observed that most publications for this review were recent (after 2012) and related to Western countries (and thus representing contexts from the global minority). This may be due to a bias in search terms and language or could be a result of discussions and evaluations of KE recently occurring predominantly in Western countries (Ferreira et al., 2021; Westwood et al., 2021). Further, we omitted the term “climate change” in our search due to logistical constraints, and thus the study does not make use of lessons learned from climate research, however, we still believe the key findings are likely common across disciplines and fields.

Moreover, reporting of frequency of mentions for enablers, challenges, outcomes, and impacts may not be a true measure of importance, but rather a description of the factors that are easily observed and described. Absence or low frequency of mentions for an enabler, challenge, outcome, or impact does not imply they are not important, as practitioners may not have mentioned factors that they assume are obvious or irrelevant to the case study. Despite these limitations, this review provides a solid framework for practitioners to develop and expand upon the enablers, challenges, outcomes, and impacts to engaging in effective KE not only in environmental management, but broader fields.

6 | FUTURE RESEARCH

Additional research is required to understand how effective KE is evaluated through both quantitative and qualitative indicators. This would help us discern whether the challenges identified in this review are a result of true barriers to engaging in KE, or a result of limited evaluations assessing interpersonal relationships and the social aspects of KE. Future research in this area could help minimize the theory-practice gap identified in this review that KE is often performed via collaborations, relationships, and trust, but is often evaluated by quantitative means that cannot capture the impacts of interpersonal relationships.

Future research could benefit by evaluating empirical case studies that attempt to achieve a common outcome or impact. By assessing empirical case studies that have determined a specific impact they wish to achieve in advance and that is common across all cases studies, research can determine in greater detail the enablers or challenges associated with achieving the stated impacts. For example, future research may investigate empirical case studies in environmental and natural resource sectors and the enabling conditions required to implement KE specifically within the science-policy interface—where the pre-determined outcome is to implement or supplement regional or federal policies. In addition, by assessing the relationship between KE enablers and challenges with respect to a singular pre-determined impact, we may gain unique insight into what actions are required to transform a challenge into an enabler. This is especially relevant as this review identified that many of the enablers to KE were simultaneously identified as challenges to engaging in KE effectively.

Future research should also be broadened to include more empirical case studies that originate from outside western countries, such as those from the global south (and thus the global majority). This is an important area of research to potentially strengthen KE practices in the west and gain a deeper understanding of how KE practices differ across the globe.

Our results have also highlighted the critical importance of trust at the interface of environmental science and policy. Indeed, the importance of trust is well documented in the literature (Cvitanovic et al., 2023, 2024; Muir et al., 2023), and is considered as a critical precondition to the uptake and use of scientific knowledge in decision-making processes (Cvitanovic & Hobday, 2018). In this context, trust is defined as a psychological state in which an individual/entity (i.e., the trustor) accepts some level of vulnerability based on a positive expectation of another individual/entity (Rousseau et al., 1998). The willingness of a party to be vulnerable to another implies that there is something of importance to be lost (Mayer & Davis, 1995). Recent research also shows that trust is highly dynamic and fragile, and in extreme cases, ‘too much trust’ can lead to perverse outcomes (Lacey et al., 2018). As such, future work is needed to build on the results of this study to more deeply understand how different capacities can be harnessed to ensure positive trusting relationships.

7 | CONCLUSION

This study synthesizes and analyzes evidence of empirical case studies confirming the theoretical enablers to implementing and engaging in KE to bridge the theory-practice gap. Our findings notably highlight interpersonal factors and boundary spanners to be important. We provide categorized specific enablers of KE using the broad core capacities first outlined by Cvitanovic et al. (2018). This contributes to a wider understanding of the enablers to KE and provides practitioners with the ability to first identify areas for improvement by assessing which core capacity may require additional work, then concrete examples of how they can further enable and operationalize their KE work within each core capacity. The review highlights a theory-practice gap



with respect to evaluating the impact of KE work, such that KE is often evaluated by quantitative means that cannot capture the impacts of interpersonal relationships, collaborations, and trust. In addition, our findings outline the challenges to engaging in effective KE, many of which are the same as the identified enablers to KE and require qualitative indicators to assess their impact. Thus, there is a need for researchers to perform more long-term evaluations, using qualitative evaluations of empirical case studies to discern whether the challenges related to the social aspects of KE are a result of limited impact evaluations or a true barrier to KE work. We recommend practitioners incorporate long-term mixed-methods assessments to evaluate and report upon the quantitative and qualitative indicators of KE to help bridge our understanding of KE in practice over long time-scales. We encourage researchers and practitioners to build upon the proposed framework for enabling conditions categorized by core capacities using empirical case studies to garner a deeper understanding of how to effectively engage in KE, both within and outside of environmental and natural resource management.

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REFERENCES

- Amara, N., Ouimet, M., & Landry, R. (2004). New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies. *Science Communication*, 26(1), 75–106. <https://doi.org/10.1177/1075547004267491>
- Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice*, 8(1), 19–32. <https://doi.org/10.1080/1364557032000119616>
- Armitage, B. F., Dale, A., Kocho-Schellenberg, E., & Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change*, 21(3), 995–1004. <https://doi.org/10.1016/j.gloenvcha.2011.04.006>
- Bautista, S., Llovet, J., Ocampo-Melgar, A., Vilagrosa, A., Mayor, A. G., Murias, C., Vallejo, V. R., & Orr, B. J. (2017). Integrating knowledge exchange and the assessment of dryland management alternatives—A learning-centered participatory approach. *Journal of Environmental Management*, 195, 35–45. <https://doi.org/10.1016/j.jenvman.2016.11.050>
- Bednarek, A. T., Shouse, B., Hudson, C. G., & Goldberg, R. (2015). Science-policy intermediaries from a practitioner's perspective: The Lenfest Ocean program experience. *Science and Public Policy*, 43, 291–300.
- Bednarek, A. T., Wyborn, C., Cvitanovic, C., Meyer, R., Colvin, R. M., Addison, P. F. E., Close, S. L., Curran, K., Farooque, M., Goldman, E., Hart, D., Mannix, H., McGreavy, B., Parris, A., Posner, S., Robinson, C., Ryan, M., & Leith, P. (2018). Boundary spanning at the science-policy interface: The practitioners' perspectives. *Sustainability Science*, 13, 1175–1183. <https://doi.org/10.1007/s11625-018-0550-9>
- Beier, P., Hansen, L. J., Helbrecht, L., & Behar, D. (2017). A how-to guide for coproduction of actionable science. *Conservation Letters*, 10(3), 288–296. <https://doi.org/10.1111/conl.12300>
- Berglund, H. L., & Aradóttir, Á. L. (2015). Stakeholder interaction in participatory land restoration in Iceland: Environmental Officers' challenges and strategies. *Environmental Management (New York)*, 56(2), 519–531. <https://doi.org/10.1007/s00267-015-0506-0>
- Bornbaum, C. C., Kornas, K., Peirson, L., & Rosella, L. C. (2015). Exploring the function and effectiveness of knowledge brokers as facilitators of knowledge translation in health-related settings: A systematic review and thematic analysis. *Implementation Science*, 10(1), 1–12. <https://doi.org/10.1186/s13012-015-0351-9>
- Bowen, S., & Martens, P. (2005). Demystifying knowledge translation: Learning from the community. *Journal of Health Services Research & Policy*, 10(4), 203–211. <https://doi.org/10.1258/135581905774414213>
- Bradshaw, G. A., & Borchers, J. G. (2000). Uncertainty as information: Narrowing the science-policy gap. *Conservation Ecology*, 4(1), 7. <https://doi.org/10.5751/ES-00174-040107>
- Cadman, M. B. H., & Soomai, S. S. (2020). Sharing victories: Characteristics of collaborative strategies of environmental non-governmental organizations in Canadian marine conservation. *Marine Policy*, 115, 103862. <https://doi.org/10.1016/j.marpol.2020.103862>
- Carneiro, M. J., & Da Silva Rosa, T. (2011). The use of scientific knowledge in the decision making process of environmental public policies in Brazil. *Journal of Science Communication*, 10(1), 1–10. <https://doi.org/10.22323/2.10010203>
- Cash, B. J. C., & Patt, A. G. (2006). Countering the loading-dock approach to linking science and decision making: Comparative analysis of El Niño/southern oscillation (ENSO) forecasting systems. *Science, Technology & Human Values*, 31(4), 465–494. <https://doi.org/10.1177/0162243906287547>
- Chambers, J. M., Wyborn, C., Klenk, N. L., Ryan, M., Serban, A., Bennett, N. J., Brennan, R., Charli-Joseph, L., Fernández-Giménez, M. E., Galvin, K. A., Goldstein, B. E., Haller, T., Hill, R., Munera, C., Nel, J. L., Österblom, H., Reid, R. S., Riechers, M., Spierenburg, M., ... Rondeau, R. (2022). Co-productive agility and four collaborative pathways to sustainability transformations. *Global Environmental Change*, 72, 102422. <https://doi.org/10.1016/j.gloenvcha.2021.102422>
- Chapman, B. F., Fulton, E., Horwitz, P., Jones, T., Scherrer, P., & Syme, G. (2017). Knowledge that acts: Evaluating the outcomes of a knowledge brokering intervention in Western Australia's Ningaloo region. *Environmental Management*, 60(5), 896–907. <https://doi.org/10.1007/s00267-017-0917-1>
- Cohen, E. L. S., & Mills, M. (2012). Social networks supporting governance of coastal ecosystems in Solomon Islands: Social networks for ecosystem governance. *Conservation Letters*, 5(5), 376–386. <https://doi.org/10.1111/j.1755-263X.2012.00255.x>
- Coleman, K., & Stern, M. J. (2018). Boundary spanners as trust ambassadors in collaborative natural resource management. *Journal of Environmental Planning and Management*, 61(2), 291–308. <https://doi.org/10.1080/09640568.2017.1303462>
- Cook, C. N., Mascia, M. B., Schwartz, M. W., Possingham, H. P., & Fuller, R. A. (2013). Achieving conservation science that bridges the knowledge-action boundary. *Conservation Biology*, 27(4), 669–678. <https://doi.org/10.1111/cobi.12050>
- Cooke, S. J., Jeanson, A. L., Bishop, I., Bryan, B. A., Chen, C., Cvitanovic, C., Fen, Y., Forester, J., Fürst, C., Hu, J., la Rosa, D., Meurk, C., Nguyen, V. M., Paolisso, M., Qi, Y., Chun, F. K. S., Szetey, K., Wang, X., Wang, Y., ... Young, N. (2021). On the theory-practice gap in the environmental realm: Perspectives from and for diverse environmental professionals. *Socio-Ecological Practice Research*, 3, 243–255. <https://doi.org/10.1007/s42532-021-00089-0>
- Cooke, S. J., Rytwinski, T., Taylor, J. J., Nyboer, E. A., Nguyen, V. M., Bennett, J. R., Young, N., Aitken, S., Auld, G., Lane, J. F., Prior, K. A., Smokorowski, K. E., Smith, P. A., Jacob, A. L., Browne, D. R., Blais, J. M., Kerr, J. T., Ormeci, B., Alexander, S. M., ... Smol, J. P. (2020). On “success” in applied environmental research—What is it, how can it be achieved, and how does one know when it has been achieved? *Environmental Reviews*, 28(4), 357–372. <https://doi.org/10.1139/er-2020-0045>
- Crona, B. I., & Parker, J. N. (2012). Learning in support of governance: Theories, methods, and a framework to assess how bridging organizations

- contribute to adaptive resource governance. *Ecology and Society*, 17(1), 32. <https://doi.org/10.5751/ES-04534-170132>
- Cvitanovic, C., Cunningham, R., Dowd, A. M., Howden, S. M., & Van Putten, E. I. (2017). Using social network analysis to monitor and assess the effectiveness of knowledge brokers at connecting scientists and decision-makers: An Australian case study. *Environmental Policy and Governance*, 27(3), 256–269.
- Cvitanovic, C., & Hobday, A. J. (2018). Building optimism at the environmental science-policy-practice interface through the study of bright spots. *Nature Communications*, 9(1), 3466. <https://doi.org/10.1038/s41467-018-05977-w>
- Cvitanovic, C., Löf, M. F., Norström, A. V., & Reed, M. S. (2018). Building university-based boundary organisations that facilitate impacts on environmental policy and practice. *PLoS One*, 13(9), e0203752.
- Cvitanovic, C., Mackay, M., Shellock, R. J., van Putten, E. I., Karcher, D. B., & Dickey-Collas, M. (2021). Understanding and evidencing a broader range of ‘successes’ that can occur at the interface of marine science and policy. *Marine Policy*, 134, 104802.
- Cvitanovic, C., McDonald, J., & Hobday, A. J. (2016). From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. *Journal of Environmental Management*, 183, 864–874. <https://doi.org/10.1016/j.jenvman.2016.09.038>
- Cvitanovic, C., Shellock, R. J., Karcher, D. B., Tuohy, P., Mackay, M., van Putten, E. I., Ballesteros, M., & Dickey-Collas, M. (2024). Navigating the stormy seas of building ‘trust’ as a boundary organisation connecting marine science with policy and management. *Ocean and Coastal Management*, 248, 106952.
- Cvitanovic, C., Shellock, R. J., Mackay, M., Putten, E. I. V., & Karcher, D. B. (2021). Strategies for building and managing ‘trust’ to enable knowledge exchange at the interface of environmental science and policy. *Environmental Science and Policy*, 123, 179–189. <https://doi.org/10.1016/j.envsci.2021.05.020>
- Duggan, J., Cvitanovic, C., & van Putten, I. (2023). Measuring sense of place in social-ecological systems: A review of literature and future research needs. *Ecosystems and People*, 19(1), 2162968.
- Dunn, B. J., & Brown, R. (2018). Mediating the science-policy interface: Insights from the urban water sector in Melbourne, Australia. *Environmental Science & Policy*, 82, 143–150. <https://doi.org/10.1016/j.envsci.2018.02.001>
- Fazey, E. A. C., Reed, M. S., Stringer, L. C., Kruijsen, J., White, P. C. L., Nersham, A., Jin, L., Cortazzi, M., Phillipson, J., Blackstock, K., Entwistle, N., Sheate, W., Armstrong, F., Blackmore, C., Fazey, J., Ingram, J., Gregson, J., Lowe, P., & Trevitt, C. (2013). Knowledge exchange: A review and research agenda for environmental management. *Environmental Conservation*, 40(1), 19–36. <https://doi.org/10.1017/S037689291200029X>
- Fazey, I., Bunse, L., Msika, J., Pinke, M., Preedy, K., Evely, A. C., Lambert, E., Hastings, E., Morris, S., & Reed, M. S. (2014). Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research. *Global Environmental Change*, 25(1), 204–220. <https://doi.org/10.1016/j.gloenvcha.2013.12.012>
- Fazey, I., Schöpke, N., Caniglia, G., Patterson, J., Hultman, J., Van Mierlo, B., Säwe, F., Wiek, A., Wittmayer, J., Aldunce, P., & Al Waer, H. (2018). Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. *Energy Research & Social Science*, 40, 54–70.
- Feeney, R. G., La Valley, K. J., & Hall-Arber, M. (2010). Assessing stakeholder perspectives on the impacts of a decade of collaborative fisheries research in the Gulf of Maine and Georges Bank. *Marine and Coastal Fisheries*, 2(1), 205–216. <https://doi.org/10.1577/C09-038.1>
- Ferreira, C. C., Klütsch, C., Cornelya, F., & Nguyen, V. M. (2021). The knowledge-implementation gap in conservation science. In *Closing the knowledge-implementation gap in conservation science: Interdisciplinary evidence transfer across sectors and spatiotemporal scales* (pp. 4–16). Springer International Publishing AG.
- Girling, K., & Gibbs, K. (2019). Evidence in action: An analysis of information gathering and use by Canadian parliamentarians. In *Evidence for Democracy*. Canadian Climate Forum.
- Grygoruk, M., & Rannow, S. (2017). Mind the gap! Lessons from science-based stakeholder dialogue in climate-adapted management of wetlands. *Journal of Environmental Management*, 186(Pt 1), 108–119. <https://doi.org/10.1016/j.jenvman.2016.10.066>
- Guido, R. V., Greene, C., Gerlak, A., & Trotman, A. (2016). Connecting climate information producers and users: Boundary organization, knowledge networks, and information brokers at Caribbean climate outlook forums. *Weather, Climate, and Society*, 8(3), 285–298. <https://doi.org/10.1175/WCAS-D-15-0076.1>
- Guston, D. H. (2001). Boundary organizations in environmental policy and science: An introduction. *Science, Technology, & Human Values*, 26(4), 399–408. <https://doi.org/10.1177/016224390102600401>
- Hastings. (2011). International environmental NGOs and conservation science and policy: A case from Brazil. *Coastal Management*, 39(3), 317–335. <https://doi.org/10.1080/08920753.2011.566125>
- Hickey, G. M., Forest, P., Sandall, J. L., Lalor, B. M., & Keenan, R. J. (2013). Managing the environmental science-policy nexus in government: Perspectives from public servants in Canada and Australia. *Science and Public Policy*, 40(4), 529–543. <https://doi.org/10.1093/scipol/sct004>
- Holzer, J., Adamescu, C., Cazacu, C., Díaz-Delgado, R., Dick, J., Méndez, P., Santamaría, L., & Orenstein, D. (2019). Evaluating transdisciplinary science to open research-implementation spaces in European social-ecological systems. *Biological Conservation*, 238, 108228. <https://doi.org/10.1016/j.biocon.2019.108228>
- Ison, S., Cvitanovic, C., Pecl, G., Hobday, A. J., & van Putten, I. (2024). Participatory research in complex marine conservation settings: A review of recent trends and lessons for the future. *Ocean and Coastal Management*, 253, 107053.
- Kaiser, H. M., Maxwell, K. H., Eerkes-Medrano, L., Hilmi, N., Safa, A., Horbel, C., Juniper, S. K., Roughan, M., Theux Lowen, N., Short, K., & Paruru, D. (2019). The importance of connected ocean monitoring knowledge systems and communities. *Frontiers in Marine Science*, 6, 1–17. <https://doi.org/10.3389/fmars.2019.00309>
- Kapoor, T., Falconer, M., Hutchen, J., Westwood, A. R., Young, N., & Nguyen, V. M. (2023). Implementing and evaluating knowledge exchange: Insights from practitioners at the Canadian Forest Service. *Environmental Science & Policy*, 148, 103549.
- Karcher, D. B., Cvitanovic, C., Colvin, R. M., van Putten, I. E., & Reed, M. S. (2021). Is this what success looks like? Mismatches between the aims, claims, and evidence used to demonstrate impact from knowledge exchange processes at the interface of environmental science and policy. *Environmental Science & Policy*, 125, 202–218. <https://doi.org/10.1016/j.envsci.2021.08.012>
- Karcher, D. B., Cvitanovic, C., Shellock, R., Hobday, A. J., Stephenson, R. L., Dickey-Collas, M., & van Putten, I. E. (2022). More than money—The costs of knowledge exchange at the interface of science and policy. *Ocean and Coastal Management*, 225, 106194.
- Karcher, D. B., Cvitanovic, C., van Putten, I. E., Colvin, R. M., Armitage, D., Aswani, S., Ballesteros, M., Ban, N. C., Barragán-Paladines, M. J., Bednarek, A., & Bell, J. D. (2022). Lessons from bright-spots for advancing knowledge exchange at the interface of marine science and policy. *Journal of Environmental Management*, 314, 114994.
- Karcher, D. B., Tuohy, P., Cooke, S. J., & Cvitanovic, C. (2024). Knowledge exchange at the interface of marine science and policy: A review of progress and research needs. *Ocean and Coastal Management*, 253, 107137.
- Kirchhoff, C. J., Lemos, M. C., & Dessai, S. (2013). Actionable knowledge for environmental decision making: Broadening the usability of climate science. <https://doi.org/10.1146/annurev-environ-022112-112828>



- Knight, M. A. A., & Vaske, J. J. (2015). Information dissemination-diffusion and marine protected area approval in The Philippines. *Ocean and Coastal Management*, 113, 38–46. <https://doi.org/10.1016/j.ocecoaman.2015.05.016>
- Koontz, T. M. (2014). Social learning in collaborative watershed planning: The importance of process control and efficacy. *Journal of Environmental Planning and Management*, 57(10), 1572–1593. <https://doi.org/10.1080/09640568.2013.820658>
- Laatsch, J., & Ma, Z. (2016). Climate-change communication within public natural resource agencies: Lessons learned from the U.S. Forest Service. *Society & Natural Resources*, 29(10), 1169–1185. <https://doi.org/10.1080/08941920.2015.1107790>
- Lacey, J., Howden, M., Cvitanovic, C., & Colvin, R. M. (2018). Understanding and managing trust at the climate science-policy interface. *Nature Climate Change*, 8, 22–28.
- Lemieux, G. M. W., Bocking, S., & Beechey, T. J. (2018). Evidence-based decision-making in Canada's protected areas organizations: Implications for management effectiveness. *Facets*, 3(1), 392–414. <https://doi.org/10.1139/facets-2017-0107>
- Levesque, V. R., Calhoun, A. J. K., Bell, K. P., & Johnson, T. R. (2017). Turning contention into collaboration: Engaging power, trust, and learning in collaborative networks. *Society and Natural Resources*, 30(2), 245–260. <https://doi.org/10.1080/08941920.2016.1180726>
- Louder, E., Wyborn, C., Cvitanovic, C., & Bednarek, A. T. (2021). A synthesis of the frameworks available to guide evaluations of research impact at the interface of environmental science, policy and practice. *Environmental Science & Policy*, 116, 258–265.
- Lowey. (2016). Is social licence a licence to stall? A symposium on October 8, 2014 in Calgary, Alberta, organized by the School of Public Policy, University of Calgary. *Canadian Electronic Library*.
- LSE. (2019). A guide to knowledge exchange and impact. <https://info.lse.ac.uk/staff/services/knowledge-exchange-and-impact/Assets/Documents/PDF/18-0408-KEI-Brochure-V9-ONLINE.pdf>
- Matzek, V., Covino, J., Funk, J. L., & Saunders, M. (2014). Closing the knowing-doing gap in invasive plant management: Accessibility and interdisciplinarity of scientific research. *Conservation Letters*, 7(3), 208–215. <https://doi.org/10.1111/conl.12042>
- Mayer, R. C., & Davis, J. H. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709–734.
- Meadow, A. M., Ferguson, D. B., Guido, Z., Horangic, A., Owen, G., & Wall, T. (2015). Moving toward the deliberate coproduction of climate science knowledge. *Weather, Climate, and Society*, 7(2), 179–191. <https://doi.org/10.1175/WCAS-D-14-00050.1>
- Medema, F. A., Adamowski, J., Mayer, I., & Zhou, Q. (2016). Exploring the potential impact of serious games on social learning and stakeholder collaborations for transboundary watershed management of the St. Lawrence River Basin. *Water*, 8(5), 175. <https://doi.org/10.3390/w8050175>
- Michaels, S. (2009). Matching knowledge brokering strategies to environmental policy problems and settings. *Environmental Science and Policy*, 12(7), 994–1011. <https://doi.org/10.1016/j.envsci.2009.05.002>
- Muhonen, R., Bennenworth, P., & Olmos-Peñuela, J. (2020). From productive interactions to impact pathways: Understanding the key dimensions in developing SSH research societal impact. *Research Evaluation*, 29(1), 34–47.
- Muir, A. M., Bernhardt, J. R., Boucher, N. W., Cvitanovic, C., Dettmers, J. M., Gaden, M., Hinderer, J. L. M., Locke, B., Robinson, K. F., Siefkes, M. J., & Young, N. (2023). Confronting a post-pandemic new-normal—Threats and opportunities to trust-based relationships in natural resource science and management. *Journal of Environmental Management*, 330, 117140.
- Mumford, T., & Harvey, N. (2014). Champions as influencers of science uptake into Australian coastal zone policy. *Coastal Management*, 42, 495–511.
- Naylor, L. A., Coombes, M. A., Venn, O., Roast, S. D., & Thompson, R. C. (2012). Facilitating ecological enhancement of coastal infrastructure: The role of policy, people and planning. *Environmental Science and Policy*, 22, 36–46. <https://doi.org/10.1016/j.envsci.2012.05.002>
- Nguyen, V. M., Bell, C., Berseth, V., Cvitanovic, C., Darwent, R., Falconer, M., Hutchen, J., Kapoor, T., Klenk, N., & Young, N. (2021). Promises and pitfalls of digital knowledge exchange resulting from the COVID-19 pandemic. *Socio-Ecological Practice Research*, 3(4), 427–439. <https://doi.org/10.1007/s42532-021-00097-0>
- Nguyen, V. M., Young, N., & Cooke, S. J. (2017). A roadmap for knowledge exchange and mobilization research in conservation and natural resource management. *Conservation Biology*, 31(4), 789–798. <https://doi.org/10.1111/cobi.12857>
- Ozanne, J. L., Davis, B., & Ekpo, A. E. (2021). Research pathways for societal impact: A typology of relational engagements for consumer psychology research. *Journal of Consumer Psychology*, 32(1), 127–144. <https://doi.org/10.1002/jcpy.1269>
- Pedersen, D. B., Grønvd, J. F., & Hvidtfeldt, R. (2020). Methods for mapping the impact of social sciences and humanities—A literature review. *Research Evaluation*, 29(1), 4–21. <https://doi.org/10.1093/reseval/rvz033>
- Pennington, D. D. (2008). Cross-disciplinary collaboration and learning. *Ecology and Society*, 13(2), 8. <https://doi.org/10.5751/ES-02520-130208>
- Plaisance, K. S., Michaud, J., & McLevey, J. (2021). Pathways of influence: Understanding the impact of philosophy of science in scientific domains. *Synthese*, 199(1), 4865–4896.
- Posner, S. M., & Cvitanovic, C. (2019). Evaluating the impacts of boundary-spanning activities at the interface of environmental science and policy: A review of progress and future research needs. *Environmental Science and Policy*, 92, 141–151.
- Reed, E. A. C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., & Stringer, L. (2010). What is social learning? *Ecology and Society*, 15(4), 542. <https://doi.org/10.5751/ES-03564-1504r01>
- Reed, M. S., Stringer, L. C., Fazey, I., Evelyn, A. C., & Kruijssen, J. H. J. (2014). Five principles for the practice of knowledge exchange in environmental management. *Journal of Environmental Management*, 146, 337–345. <https://doi.org/10.1016/j.jenvman.2014.07.021>
- Reed, M. S., Vella, S., Challies, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R. K., Oughton, E. A., Sidoli del Ceno, J., & van Delden, H. (2018). A theory of participation: What makes stakeholder and public engagement in environmental management work? *Restoration Ecology*, 26, S7–S17. <https://doi.org/10.1111/rec.12541>
- Rogga, S. (2021). *Transcending the loading dock paradigm—Rethinking science-practice transfer and implementation in sustainable land management*. Springer International Publishing. https://doi.org/10.1007/978-3-030-50841-8_13
- Rose, D. C., Mukherjee, N., Simmons, B. I., Tew, E. R., Robertson, R. J., Vadrot, A. B. M., Doubleday, R., & Sutherland, W. J. (2020). Policy windows for the environment: Tips for improving the uptake of scientific knowledge. *Environmental Science and Policy*, 113, 47–54. <https://doi.org/10.1016/j.envsci.2017.07.013>
- Rose, D. C., Sutherland, W. J., Amano, T., González-Varo, J. P., Robertson, R. J., Simmons, B. I., Wauchope, H. S., Kovacs, E., Durán, A. P., Vadrot, A. B. M., Wu, W., Dias, M. P., Di Fonzo, M. M. I., Ivory, S., Norris, L., Nunes, M. H., Nyumba, T. O., Steiner, N., Vickery, J., & Mukherjee, N. (2018). The major barriers to evidence-informed conservation policy and possible solutions. *Conservation Letters*, 11(5), 1–12. <https://doi.org/10.1111/conl.12564>
- Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Review*, 23(3), 393–404.

- Roux, D. J., Kingsford, R. T., Cook, C. N., Carruthers, J., Dickson, K., & Hockings, M. (2019). The case for embedding researchers in conservation agencies. *Conservation Biology*, 33(6), 1266–1274. <https://doi.org/10.1111/cobi.13324>
- Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., & Rebeck, K. (2001). A systems thinking framework for knowledge management. *Decision Support Systems*, 31(1), 5–16. [https://doi.org/10.1016/S0167-9236\(00\)00116-0](https://doi.org/10.1016/S0167-9236(00)00116-0)
- Rudd, M. A. (2011). How research-prioritization exercises affect conservation policy. *Conservation Biology*, 25(5), 860–866. <https://doi.org/10.1111/j.1523-1739.2011.01712.x>
- Ryan, C. M., & Cervený, L. K. (2010). Science exchange in an era of diminished capacity: Recreation Management in the U.S. Forest Service. *The American Review of Public Administration*, 40(5), 593–616. <https://doi.org/10.1177/0275074009354121>
- Saarela, S. R., & Söderman, T. (2015). The challenge of knowledge exchange in national policy impact assessment—A case of Finnish climate policy. *Environmental Science & Policy*, 54, 340–348. <https://doi.org/10.1016/j.envsci.2015.07.029>
- Saldana. (2016). *The coding manual for qualitative researchers* (Third ed.). SAGE.
- Schneider, F., Tribaldos, T., Adler, C., Biggs, R. O., de Bremond, A., Buser, T., Krug, C., Loutre, M. F., Moore, S., Norström, A. V. & Paulavets, K. (2021). Co-production of knowledge and sustainability transformations: A strategic compass for global research networks. *Current Opinion in Environmental Sustainability*, 49, 127–142.
- Schwarz, G. M., & Stensaker, I. (2020). Researching a pandemic: Letting COVID-19 drive our research. *The Journal of Applied Behavioral Science*, 56(3), 261–265. <https://doi.org/10.1177/0021886320937820>
- Sheikheldin, G., Krantzberg, G., & Schaefer, K. (2010). Science-seeking behaviour of conservation authorities in Ontario. *Environmental Management*, 45(5), 912–921. <https://doi.org/10.1007/s00267-010-9463-9>
- Spaapen, J., & Van Drooge, L. (2011). Introducing ‘productive interactions’ in social impact assessment. *Research Evaluation*, 20(3), 211–218.
- Stange, L. V., & Tatenhove, V. (2016). Boundary spaces, objects and activities in mixed-actor knowledge production: Making fishery management plans in collaboration. *Maritime Studies*, 15(1), 1–19. <https://doi.org/10.1186/s40152-016-0053-1>
- Stern, M. J., & Baird, T. D. (2015). Trust ecology and the resilience of natural resource management institutions. *Ecology and Society*, 20(2), 14. <https://doi.org/10.5751/ES-07248-200214>
- Stewart, A., Edwards, D., & Lawrence, A. (2014). Improving the science-policy-practice interface: Decision support system uptake and use in the forestry sector in Great Britain. *Scandinavian Journal of Forest Research*, 29(1), 144–153. <https://doi.org/10.1080/02827581.2013.849358>
- Tuler, S., & Webler, T. (2010). How preferences for public participation are linked to perceptions of the context, preferences for outcomes, and individual characteristics. *Environmental Management*, 46(2), 254–267. <https://doi.org/10.1007/s00267-010-9515-1>
- Van den Hoonaard, D. K. (2011). *Qualitative research in action: A Canadian primer* (2nd ed.). Oxford University Press.
- Walsh, J. C., Dicks, L. V., Raymond, C. M., & Sutherland, W. J. (2019). A typology of barriers and enablers of scientific evidence use in conservation practice. *Journal of Environmental Management*, 250, 1–9. <https://doi.org/10.1016/j.jenvman.2019.109481>
- Westwood, A. R., Hutchen, J., Kapoor, T., Klenk, K., Saturno, J., Wang, J., Falconer, M., & Nguyen, V. M. (2021). A systematic mapping protocol for understanding knowledge exchange in forest science. *Ecological Solutions and Evidence*, 2(3), 1–8. <https://doi.org/10.1002/2688-8319.12096>
- Westwood, A. R., Hutchen, J., Kapoor, T., Klenk, K., Saturno, J., Antwi, E. K., Egunyu, F., Cortini, F., Robertson, M., Le Noble, S., Wang, J., Falconer, M., & Nguyen, V. M. (2023). A systematic map of knowledge exchange across the science-policy interface for forest science: How can we improve consistency and effectiveness? *Ecological Solutions and Evidence*, 4(1), e12214. <https://doi.org/10.1002/2688-8319.12214>
- Whyte, K. P., & Crease, R. P. (2010). Trust, expertise, and the philosophy of science. *Synthese*, 177(3), 411–425.
- Young, J. C., Waylen, K. A., Sarkki, S., Albon, S., Bainbridge, I., Balian, E., Davidson, J., Edwards, D., Fairley, R., Margerison, C., McCracken, D., Owen, R., Quine, C. P., Stewart-Roper, C., Thompson, D., Tinch, R., van den Hove, S., & Watt, A. (2014). Improving the science-policy dialogue to meet the challenges of biodiversity conservation: Having conversations rather than talking at one-another. *Biodiversity and Conservation*, 23(2), 387–404. <https://doi.org/10.1007/s10531-013-0607-0>

SUPPORTING INFORMATION

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