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PERSPECTIVE

Supporting frontline workers in the biodiversity crisis by empowering and enabling practitioners to embrace conservation evidence

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Abstract

Biodiversity conservation involves a broad spectrum of activities, from research to reveal mechanisms of population decline, to policy that mobilizes this information to guide practice, to hands-on action. Scientists rarely implement conservation actions alone. Instead, their work supports conservation practitioners—a broad group of decision-makers, managers, and stewards who are the essential frontline workers of biodiversity conservation. Here we discuss three necessary actions scientists can take to better support conservation practitioners in making decisions that benefit biodiversity and people. These are: (1) Build the evidence base by working with and across diverse knowledge systems; (2) Synthesize evidence to provide accessible and reliable guidance and decision-support tools for practitioners; and (3) Create and facilitate a culture of evidence use that transcends individuals and institutions to empower and enable practitioners to make evidence-informed decisions. Underpinning each of these actions are a series of principles that provide tangible guidance. We present these ideas from our position as scientists with an interest in doing conservation-relevant work, some of whom wear scientist-practitioner hats. We suggest that without progress on all three actions, durable solutions are unlikely and biodiversity loss will continue. Our intended audience is primarily scientists seeking to better support the many conservation practitioners tasked with reversing biodiversity declines around the globe.

Keywords Biodiversity · Conservation decisions · Culture · Evidence · Practitioners

1 Introduction

Conservation practitioners engage in actions and decision-making processes intended to reverse the biodiversity crisis and ensure that biological resources and ecosystems are managed sustainably to benefit biodiversity and people. Here we use the term "conservation practitioner" (herein, practitioner) to encompass decision-makers, managers, and stewards who occupy a wide range of paid and unpaid roles. These include working with and for various levels of government (i.e., municipal, state/provincial, federal, multinational, and Indigenous governments), working with NGOs, community groups (including Indigenous rightsholders), local stakeholders such as some resource users (e.g., hunters, fishers, trappers, foragers), farmers, ranchers, landowners, and industry[1]. In many ways, such practitioners are the frontline workers of the biodiversity crisis. Like frontline workers in health care (Mishra et al. 2015; Blau et al. 2021, p.168), practitioners face decisions with real consequences for people and ecosystems, often involving complex

[1] Just because one is affiliated with a certain group does not mean that they are necessarily acting as a conservation practitioner. For example, not all industry members work in good faith towards biodiversity conservation, and similarly, not all resource users are conservation-minded or engage in stewardship actions.

Extended author information available on the last page of the article trade-offs, resource constraints, incomplete information, and short lead times.

Whether in academia, government, or allied organizations, knowledge producers in the science and research space (i.e., herein called "conservation scientists" or "scientists") play an important role. Yet their work represents only one part of a much broader system of people working together to reverse biodiversity loss (Evans 2021). Collaboration between scientists and practitioners has advanced through co-production, embedded scientist-practitioner roles, and growing efforts to align research with conservation needs. Even so, gaps persist. For instance, academic research often lacks the local context or cultural grounding that practitioners need to inform real-world decisions (Knight et al. 2008; Laurance et al. 2012). Additionally, scientists often serve as educators of future practitioners, yet do not always equip their students with the skills needed for conservation decision-making (Downey et al. 2021, p.7).

Ultimately, practitioners are responsible for applying evidence[2] to action and should be celebrated in the fight to reverse biodiversity declines (Jeanson et al. 2020), with scientists being a part of the supporting cast (Howarth et al. 2025, p.2). Indeed, for every conservation scientist, there are perhaps tens if not hundreds of practitioners. Yet it is not uncommon for conservation scientists to be assigned senior leadership roles in organizations. Moreover, scientists are often recruited to serve on committees that allocate conservation funding or provide science advice for practitioners (formally or informally) such that scientists also have influence on institutions that employ practitioners and are responsible for conservation decisions. Collectively, this raises an important question: what can conservation scientists do to best support practitioners (Morris et al. 2021)?

Not surprisingly, much has been written on how conservation scientists can support practitioners, and on the benefits of engaging in co-production (Caro et al. 2023), engaging with knowledge brokers (Karcher et al. 2025) and boundary organizations (Posner and Cvitanovic 2019), and understanding the enablers and barriers to evidence use (Walsh et al. 2019). Here we extend and integrate those ideas more holistically across the entirety of the space in which conservation practitioners act and engage. We argue that there is value in reorienting the thinking of conservation scientists to focus on supporting, empowering, and enabling practitioners to make the best[3] possible decisions and engage in the most effective actions to benefit both biodiversity and people[4].

As a group of conservation scientists based in Canada and Australia, we identified three necessary actions to achieve this goal: (1) Build the evidence base by working with and across diverse knowledge systems such as, but not limited to, Western scientific knowledge and experiential knowledge; (2) Synthesize evidence to provide accessible and reliable guidance and decision-support tools for practitioners; and (3) Create a culture of evidence use that transcends individuals and institutions to empower and enable practitioners to make evidence-informed[5] decisions that draw upon diverse knowledge systems. Given the inherent overlap (or blurriness) among elements of the three actions, we have organized them in a manner that seemed most logical to our team. Underpinning each of these actions are a series of principles that provide tangible guidance to the reader, which we expand upon under each action (see Fig. 1). We also reflect on what we, as conservation scientists working with practitioners, have learned from our experience about how to optimize the relevance of our work for frontline workers.

This paper is written for conservation scientists by conservation scientists. Some of us also wear hats as scientist-practitioners and have various leadership or supporting roles with institutions that employ practitioners, and all of us collaborate closely with diverse practitioners. Our viewpoint mostly comes from and focuses on countries with well-established democratic governance systems, scientific research and environmental management capacity, and wealth. Within Canada and Australia (where our team of authors is based), these contexts are also shaped by ongoing settler-colonial systems and histories. The majority of team members are settlers in our respective countries, and one co-author is an Indigenous scholar.

[2] The word "evidence" is an oft-used work but difficult to define. Here we embrace the definition presented by Nyboer et al. (2025) based on interviews of environmental managers and decision-makers in Canada. That definition is as follows: "(Good) evidence for environmental policy is reliable, diverse information collected systematically through established methodologies (including Western social and natural science, Indigenous science, and place-based knowledge accumulated intergenerationally by close and continuous observation) that is credible and yields practical advice or relevant conclusions while being transparent about uncertainties".

[3] We acknowledge that the word "best" is normative. In the context of this paper "best" means considering trade-offs and making informed decisions based on the best available evidence and considering the perspectives of diverse voices, actors, and knowledge systems.

[4] We acknowledge that in the short-term securing benefits for both biodiversity and people is challenging and a benefit to one can yield a disbenefit to the other. This emphasizes the importance of embracing a long-term perspective.

[5] We have intentionally embraced the notion of evidence-informed decision-making rather than evidence-based to recognize that there are many factors considered when making decisions. Moreover, we acknowledge that there are tensions related to evidence-informed decision-making such as disagreements over what counts as valid evidence, trade-offs between rigor and timeliness, or power asymmetries among actors. Those issues cannot be solved here but are important context and if ignored can contribute to unintended consequences that negatively impact people and biodiversity/the environment.

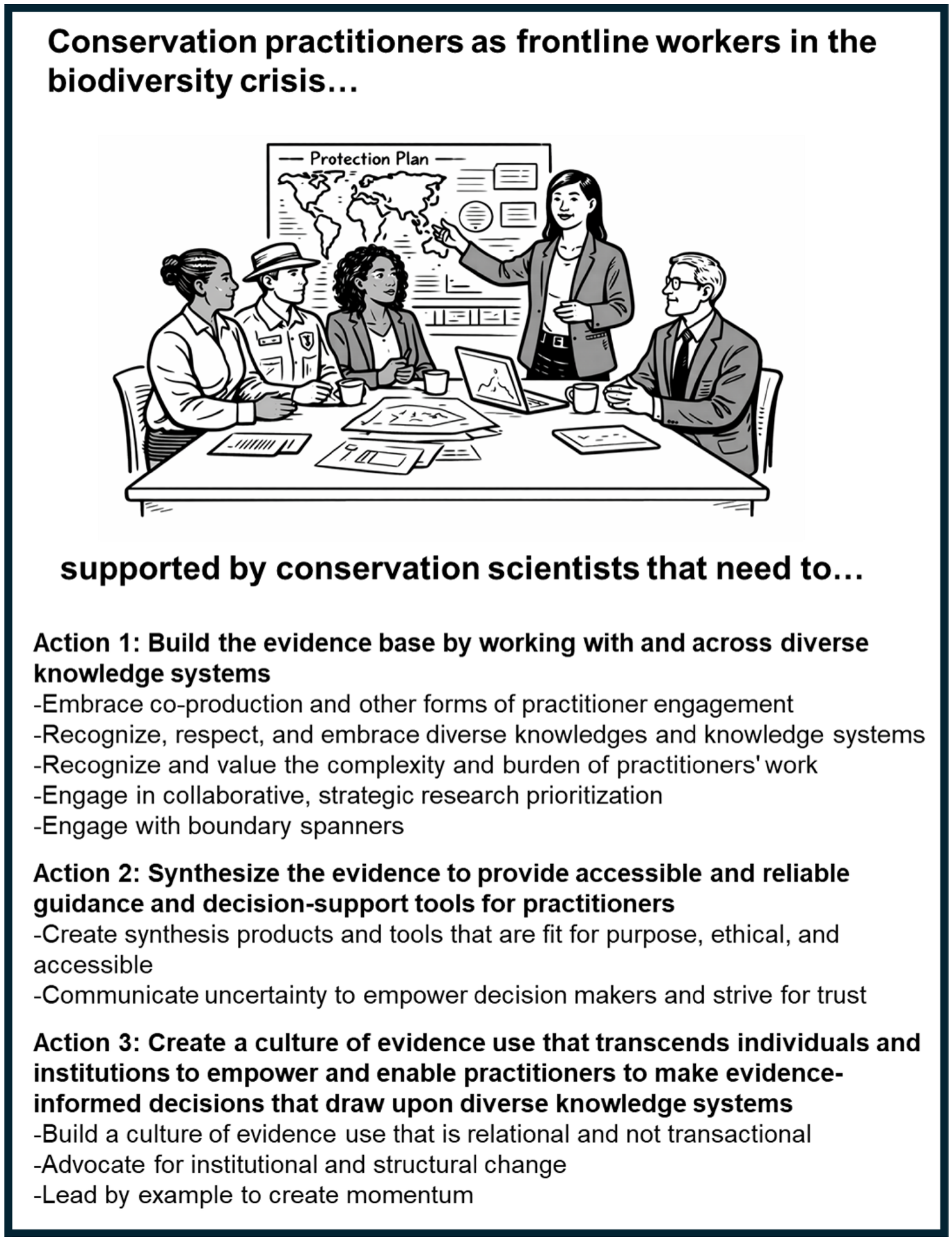

Fig. 1 Summary figure of how conservation scientists can support frontline workers in the biodiversity crisis by empowering and enabling practitioners to embrace conservation evidence

2 Action 1: Build the evidence base by working with and across diverse knowledge systems

Without an adequate evidence base, it is difficult to make decisions that mitigate risk and benefit biodiversity and people (Sutherland et al. 2004). However, capacity and resources for building an evidence base are always limited, and evidence from multiple sources of expertise may be required to support decision-making. For example, the root causes and solutions of some conservation problems may lie more in the domain of the economist, legal scholar, and behavioural scientist than in the domain of the natural scientist. Interdisciplinary conservation science can better support conservation practitioners.

Conservation scientists can improve the quality and usefulness of their work by following scientific best practices (e.g., replication, addressing sources of bias, appropriate controls/reference systems/scales) that enable robust conclusions (Bilotta et al. 2014a, b; Cooke et al. 2017). Scientists can also proactively ensure that their research decisions are tailored to meet conservation needs. Priority research needs may range from figuring out the causal drivers of environmental problems, to testing which solutions work and which do not, to collecting routine monitoring data or basic information to determine the conservation status of a given population. Traditional scientific education often emphasizes scientific best practices, so we focus here on strategies for ensuring that research efforts meet the evidence needs of practitioners and includes knowledge generated through western scientific endeavors, experiential knowledge, Indigenous knowledge, and other ways of knowing.

2.1 Embrace co-production and other forms of practitioner engagement

The biodiversity crisis is a "wicked problem" (Game et al. 2014), involving complex and interdependent issues that require conservation solutions developed with input from a wide range of rightsholders and stakeholders. Although the diversity of actors in this space (e.g., scientists, practitioners, and educators) provides opportunities for cross-sectoral communication, the structure to support deeper forms of collaboration is often lacking. Collaborations or partnerships that tend to be reactive, which are driven by one-off needs or funding opportunities, may lack resilience and lead to practitioner fatigue.

Hallmarks of reactive projects include poor planning, weak partner relationships, and a lack of long-term commitment. These may not only lead to project failures, but also to workplace distress and instability for practitioners (e.g., insufficient funding/support/capacity to continue with a project or work; Catalano et al. 2019; Pienkowski et al. 2023). Additionally, reactive approaches in cross-sectoral engagement may lead to inefficient use of resources, and shallow impact that is unlikely to solve the root causes of conservation issues (Buxton et al. 2021a, p.2). Reactive approaches are also often tokenistic, lacking the essential underpinnings for trust and respect to be built and for meaningful relationships to be sustained over time.

By comparison, proactive engagement and "deep" knowledge co-production are intentional, forward-looking processes of building relationships, identifying shared goals, and collaboratively shaping actions before problems or funding dictates them (Dubois et al. 2020; Muhl et al. 2023). This approach moves beyond a performative or transactional relationship to build long-term engagement, shared ownership of goals and methods, mutual learning and respect for different forms of knowledge (Indigenous science, local expertise, Western science), and the joint implementation of solutions (Ardichvili 2013; Tengö et al. 2014; Norström et al. 2020). Collaborative and equitable engagement results in the sharing of power, experiences, and expertise, allowing for better understanding of challenges and the potential levers of change (Berkes 2009). As such, outcomes may include local agency, stronger policy relevance, and better local uptake of proposed solutions (Nguyen et al. 2019; Rodríguez Valencia 2020; Cooke et al. 2021).

However, co-production should not be seen as a single approach. Many modes of co-production exist, each with its own strengths and weaknesses (e.g., researching solutions, navigating differences; see Chambers et al. 2021 and Bandola-Gill et al. 2023). Thus, it is important to reflect on which mode of co-production would best support frontline practitioners in their given context, and allow the process sufficient agility to ensure sustained success over time (Chambers et al. 2022).

2.2 Recognize, respect, and embrace diverse knowledges and knowledge systems

Conservation efforts often rely exclusively on Western scientific approaches, overlooking experiential and Indigenous knowledge systems (Fazey et al. 2006; Kimmerer 2013; Kadykalo et al. 2021a). Western science relies on variable-specific, short-term studies to create generalized conclusions, which can limit our understanding of ecologically complex systems and cause us to overlook cultural significance that is also important for conservation (Kimmerer 2013). Embracing diverse knowledge systems broadens the available information and approaches to inform conservation solutions, and enables more culturally grounded and locally relevant conservation decisions. Embracing diverse knowledges and knowledge systems is relevant to both the individual scientist and to organizational culture (see Action 3), but we have placed this under Action 1 because scientists are charged with generating, collating, and synthesizing evidence (see Action 2).

Indigenous knowledge is rooted in generations of observation, recognizing animals and plants as the oldest teachers and viewing humans as part of a complex ecological system (Kimmerer 2013). Interweaving Indigenous knowledge with Western science can foster collaborations, support sovereignty, and lead to more effective conservation and environmental management practices (Brondízio et al. 2021). There is growing support worldwide for mobilizing Indigenous knowledge, with an emphasis on ethical engagement and non-extractive practices. For example, Indigenous hunters in Canada contributed intergenerational knowledge on caribou (*Rangifer tarandus*) movements and body condition, which strengthened monitoring programs and fostered collective learning (Kendrick and Manseau 2008). Additionally, in Tanzania, grazing management practices by Indigenous and local pastoralists provided insights on how livestock needs can be balanced with the health of plant communities (Selemani 2020). By engaging with Indigenous ways of knowing, rooted in experience, community, and relationships, western-trained scientists can improve conservation practices through more inclusive and informed decision-making. This process requires respect for relevant Indigenous data governance principles, such as the First Nations' OCAP® principles (Ownership, Control, Access, and Possession) and Inuit Qaujimajatuqangit (IQ). Protocols for relational accountability, and free, prior, and informed consent are equally essential. Upholding these standards is essential for ensuring transparency, trust, and reciprocity in cross-knowledge system collaborations.

Practitioners and resource users (naturalists, fishers, hunters, etc.) often possess important knowledge based on local experience, which may be qualitative or anecdotal. This experiential knowledge can catalyze scientific research, for example, through social media posts that guide scientists to wildlife occurrences (Bergman et al. 2022; Chowdhury et al. 2023). Additionally, experiential knowledge can provide important information on ecosystems (e.g., community composition) and people (e.g., perceptions on the conservation issue at hand) that may not be feasible to quantify with Western science (Fazey et al. 2006). On a deeper level, it can provide the basis for knowledge co-production between local experts and conservation scientists who can help with tools such as advanced surveying and statistical techniques. For example, in an environmental DNA study conducted in Norfolk, England, scientists and practitioners co-produced research objectives based on community needs. The practitioners included experts in freshwater monitoring and citizen science, as well as local anglers and naturalists, and their experiential knowledge was used to help select sites for sampling (Clarke et al. 2023). Ultimately, by recognizing, respecting, and embracing diverse knowledges, conservation scientists can contribute to building robust and relevant knowledge for use by practitioners.

2.3 Recognize and value the complexity and burden of practitioners' work

Practitioners are under immense pressure to make "good" decisions on complex issues in the face of competing interests and uncertainty, which comes with significant professional and personal burden and stress. Working with and supporting practitioners therefore requires an appreciation for those realities. Moreover, practitioners bring their own values, experiences, and motivations to their work, and operate within institutional norms and constraints that may differ from those experienced in academia. Recognizing both individual and institutional contexts is a critical first step in building relationships founded upon mutual respect and trust. Building collaborative relationships with practitioners relies on respect and on recognizing their goals, needs, constraints, and efforts.

Fruitful collaborations require scientists to be willing to listen, learn, and adapt to shifting priorities. Involving practitioners from the outset of research programs and proactively offering support reinforces the reciprocal nature of science-practice collaborations and enhances knowledge exchange (Cvitanovic et al. 2015). In these collaborations, scientists should be as open-minded as possible and willing to adapt if new insights emerge, even if this slows the production of outputs such as peer-reviewed papers that are valued in research institutes. This includes acknowledging that the "best" decision can be influenced by feasibility, institutional constraints, and/or social contexts, and supporting practitioners even when those considerations cause their decisions to deviate from evidence. In some cases, the best support that scientists can provide to practitioner colleagues is simply serving as an honest broker when describing the strengths and weaknesses of a given evidence base. Moreover, showing appreciation through celebrating achievements, expressing gratitude, and acknowledging the ongoing efforts of practitioners is essential, and can be formalized through co-authorships or other meaningful recognition. Such practices help foster long-term partnerships and strengthen the production of conservation knowledge (Hoesen and Lemieux 2025). Like 2.2, this is salient to both individual scientists and their institutions/organizations, but the scientists are more likely to interact directly with practitioners.

2.4 Engage in collaborative, strategic research prioritization

In an era of limited resources and funding for conservation, available resources should be allocated as efficiently as possible. Notwithstanding the importance of reproducibility (see Baker 2016), knowledge generators should be careful to avoid "evidence saturation" where there already exists sufficient evidence for practitioners to make informed decisions. Prioritizing research involves not only understanding the current challenges faced by practitioners, but also establishing the evidence base for future challenges, for example, through forward-looking horizon scans (e.g., Sutherland et al. 2024). Often such prioritization is led by scientists embedded within organizational structures and processes in partnership with practitioners. Nonetheless, individual scientists play a key role given that much foresight work is led by scientists.

One framework that can be used to categorize and prioritize uncertainties regarding conservation decisions is the "Rumsfeld Matrix". The Rumsfeld Matrix categorizes knowledge into four categories: (1) known-knowns, (2) known-unknowns, (3) unknown-knowns, and (4) unknown-unknowns. The first category, known-knowns, refers to a consensus on a topic that has been extensively researched (i.e., we know that we know it). There is sufficient information about known-knowns to support practitioner decisions, and additional resources should be allocated elsewhere. Persistent biases in research funding towards charismatic species, for example, mean that significant resources still go towards documenting known-knowns (Buxton et al. 2021b). Notably, whether or not existing evidence is sufficient for the decisions at hand is context-dependent, so we recommend that these decisions be made by both practitioners and conservation scientists, in consultation with one another. Where feasible, evidence synthesis methods such as systematic reviews can be used to identify and summarize available, relevant knowledge (see Action 2 section; Briner and Denyer 2012; Cooke et al. 2023).

Known-unknowns are things that practitioners need to know to make decisions, but for which knowledge is limited. This lack of evidence limits the ability of practitioners to make evidence-informed decisions, and further research should be prioritized. Another key source of known-unknowns is related to issues of scale and transferability. In some cases, sufficient information exists from other geographies, spatial scales, or ecological systems to support the decision that practitioners are faced with. Translating large-scale biodiversity information down to a local scale in a way that meets the goals and needs of practitioners remains challenging and sometimes contentious (Sequeira et al. 2018; Chaplin-Kramer et al. 2022). Scientists can meet these challenges through careful experimental design, where scalability and transferability are considered a priori (e.g., Bennett et al. 2017). In some cases, this requires research to address known deficiencies related to threat assessments. For example, "data deficient" is a common assessment outcome in species status assessments published by the International Union for the Conservation of Nature (IUCNstatus assessments), but Data Deficient species are unlikely to receive conservation resources. Practitioners would benefit from having those knowledge gaps filled, to clarify whether conservation action is needed (Roberts et al. 2016). To prioritize "known-unknowns" for targeted research, it may be productive to first quantify the bias and how much is unknown. It is also possible to reframe "unknowns" as risk management. There could also be merit in linking the "unknowns" directly to things like food security, climate resilience, and compliance with biodiversity treaties, It could also be useful to build coalitions outside academia (e.g., agricultural producers, NGOs, and industry stakeholders dependent on ecosystem services) so that biodiversity knowledge gaps are framed as things relevant to those actors and entities. Doing so could help to direct more resources to addressing "unknowns".

When conservation scientists and practitioners collaboratively identify known-unknowns, the exchange of information may reveal that some known-unknowns were actually unknown-knowns. Unknown-knowns refer to something that we thought we did not know, but for which evidence already exists (e.g., Cvitanovic et al. 2021a). In many cases, this evidence may have been missed due to inaccessibility, inappropriate formats, or other potential failures in science communication (Sunderland et al. 2009).

Finally, unknown-unknowns refer to factors that we are not yet aware of, but that could represent the conservation challenges and opportunities of the future. Horizon scans are effective at identifying these emerging challenges before their effects are widely recorded (Sutherland et al. 2024). These forward-looking efforts can take various methodological forms, but all seek to "minimize surprises by foreseeing these threats and opportunities, enabling policy-makers and scientists to respond quickly to developing problems" (Wintle et al. 2020). Alongside horizon scans, basic research can play a key role in identifying future potential challenges and turning them into actionable known-unknowns.

2.5 Engage with boundary spanners

Another increasingly used approach to facilitate working with and across diverse knowledge systems is the use of boundary spanners. Boundary spanning is defined as "work to enable exchange between the production and use of knowledge to support evidence-informed decision making in a specific context". Boundary spanners are the "individuals or organizations that specifically and actively facilitate this process" (Bednarek et al. 2018), and can take a range of forms (see Kadykalo et al. 2021b). For example, they can operate as individual knowledge brokers embedded within a research agency, focused on building relationships and social networks to facilitate knowledge exchange (e.g., Cvitanovic et al. 2017). They can also be dedicated boundary organisations that work as a collective to improve knowledge exchange and enable knowledge use (e.g., Cvitanovic et al. 2018). A growing body of evidence speaks to the benefits boundary spanners can confer in conservation (Posner and Cvitanovic 2019; Cvitanovic et al. 2025; Karcher et al. 2025). Boundary spanners should be engaged in the knowledge generation phase as a starting point, and two things are required to maximize their utility and the associated benefits on a more meaningful scale, and thus strengthen knowledge exchange and evidence-informed policy making in the long-term. The first is the establishment of a community of practice to promote social learning (i.e., the process of acquiring new knowledge by observing, imitating, and interacting with others) within the boundary spanners' community, and increase their visibility. The second is increased funding specifically for boundary spanning roles (Cvitanovic et al. 2025). To be clear, boundary spanners are also salient to the second action we discuss (synthesizing evidence), because they can ensure that practitioners are provided with evidence and tools that serve them, and that those data products are accessible.

3 Action 2: Synthesize the evidence to provide accessible and reliable guidance and decision-support tools for practitioners

Creating accessible syntheses by adapting research findings into different forms (including into decision support tools) is essential to mobilize knowledge generated by scientists (Buxton et al. 2021a). Although the focus of this paper is on supporting practitioners, it is worth noting that also sharing knowledge with diverse publics can indirectly support practitioners by improving scientific literacy around topics for which practitioners interact with the public. Effectively synthesizing evidence and mobilizing knowledge can be challenging given that conservation scientists and practitioners are often concerned with different scales, and have different incentives driving their work (Bertuol-Garcia et al. 2018). Effective knowledge mobilization involves relationship-building, trust, and transparency between scientists and practitioners—elements that take a great deal of time and capacity (Golhasany and Harvey 2023). Academic scientists' host organizations (e.g., universities) can play a role in supporting knowledge mobilization, knowledge brokers and boundary-spanning organizations by providing a third space in which scientists and practitioners can meet and engage in knowledge exchange. Such spaces are crucial for knowledge mobilization and the kind of synthesis necessary to provide accessible, reliable guidance for practitioners, and reflexive research approaches (Clark et al. 2019). Good evidence is a seed for good synthesis—academic institutes, practitioners, and boundary-spanning organizations can play a crucial role in transforming that seed into effective knowledge mobilization.

3.1 Create synthesis products and tools that are fit for purpose, ethical, and accessible

At the core of evidence synthesis are a robust suite of tools (e.g., systematic reviews) that serve to collate, assess, and synthesize evidence to answer specific questions (e.g., does intervention X contribute to population recovery of taxon Y), while acknowledging and minimizing bias to the extent possible (Cook et al. 2017). These tools emerged first in the health care space and are increasingly being embraced in environmental decision-making (Keene and Pullin 2011; Pullin 2012). A survey of environmental decision-makers in Canada revealed that when systematic reviews were available on a relevant topic, they were preferentially embraced (and trusted) over other synthesis methods (Thomas-Walters et al. 2021). Involving practitioners in the process is key to ensure that the correct questions are being addressed in evidence syntheses, and that they are tailored to specific legislative or procedural requirements relevant to a given decision-making context (Land et al. 2017). Whichever evidence synthesis method is embraced, developing tailored and accessible research communications that are transparent about limitations and bias is key to supporting practitioners (Pullin et al. 2020). Proactively creating concise research communications paired with open and accessible supplementary information can reduce the uptake time for translating science into action (Roche et al. 2022). For example, creating policy-relevant "one-pagers" where emphasis is placed on actionable knowledge (Izumi et al. 2010), rather than focusing on gaps in research, can reduce the time it takes to apply research findings to decision-making (Buxton et al. 2021a).

In addition to evidence synthesis methods, bespoke decision-support tools have been developed (some of which are summarized in Bower et al. 2018). Tools that have sufficient flexibility that they can be customized by practitioners to work with their specific context or data types are particularly helpful (Hemming et al. 2022). As such, developing general tools along with guidelines for customizing more specific tools serves a broader suite of users than making one-off, context-specific tools that cannot be adapted to other uses (Wong-Parodi et al. 2020). Practitioners can potentially be overwhelmed by the growing number of methods and tools, especially given limited time and resources to explore and apply them (Smith et al. 2023). New methods may be unfamiliar or insufficiently established for practitioners to rely on them. Scientists can address this by explaining methods accessibly, co-developing tools, providing training, being transparent about assumptions and limitations, and using comparative evaluations to clarify their relative usefulness (Roche et al. 2022). Tool selection guidelines that highlight broad classes of tools or specific approaches can help navigate this complexity (Bower et al. 2018; Schwartz et al. 2018). Interactive tools, such as ArcGIS Story Maps or other web-based communication and data exploration platforms, can further increase uptake by allowing users to explore scenarios dynamically. This flexibility is especially useful when multiple, potentially competing, conservation options are under consideration.

Finally, open science and ethical, transparent communication are foundational to fostering trust in research, avoiding duplication of effort, and ensuring that data remain available for use (Allen and Mehler 2019), but open science has its own pitfalls. It is vital that open science practices are applied alongside principles of data sovereignty and respect for diverse knowledge systems such as FAIR (Findable, Accessible, Interoperable, Reusable), CARE (Collective Benefit, Authority to Control, Responsibility, Ethics), and rights-centered principles for open science (Wilkinson et al. 2016; Carroll et al. 2021). Open science practices and reporting standards (e.g., ROSES, Reporting standards for Systematic Evidence Syntheses; Haddaway et al. 2018) should be implemented with a clear focus on the rights of knowledge holders. Central to all knowledge mobilization efforts is the need to develop communication plans proactively with communities and practitioners, ideally before the research begins. Doing so can improve the relevance, impact, and inclusivity of research (Cooke et al. 2020).

3.2 Communicate uncertainty to empower decision makers and strive for trust

Practitioners who make or advocate for evidence-informed decisions must often explain and defend those decisions to people with a wide range of interests, perspectives, levels of scientific literacy, and trust in science. In contentious contexts, these people may include lobbyists who argue that science is too uncertain to inform action—a tactic observed across many issues such as climate change, COVID-19, and caribou conservation (Michaels 2020; Carrasco-Farré 2024; Boan et al. 2018; Bissonnette and Teitelbaum 2020). Given that there are risks associated with both understating and overstating certainty, transparent communication of scientific assumptions, limitations, and uncertainties is essential and challenging (Gustafson and Rice 2020; Whitehead et al. 2023; Abraham and Hlaing 2025; Zhao et al. 2024). Not all evidence is equal; some has more uncertainty and/or bias, so assessing and weighing the quality of evidence is important. In evidence synthesis this process often takes the form of critical appraisal (Stanhope and Weinstein 2023), but it can also involve a weight-of-evidence approach (Christie et al. 2023).

Trust is built not merely through accuracy, but also through transparency and responsiveness in the process (Turner et al. 2016; Cvitanovic et al. 2021b; Kadykalo et al. 2024). Scientists must recognize that their "standard" methods for clearly communicating uncertainties and limitations to their peers may not be sufficient for other audiences, and that their Western scientific training may not have equipped them to engage effectively across different knowledge systems or with publics who are skeptical of scientific authority (Abraham and Hlaing 2025). Similarly, scientists should remain aware that their specific, academic expertise does not render them more knowledgeable than their practitioner colleagues. For best practices on working across knowledge systems, please refer to Sect. 2.2.

Most conservation decisions are made based on expert knowledge and judgement (often termed science advice) rather than empirical evidence, often due to constraints on time, resources, or data (Kadykalo et al. 2021b; Sutherland 2022a). To ensure that science advice is as transparent as possible, conservation scientists can benefit from practicing a structured, systematic approach to rank-ordering expertise (Sutherland and Burgman 2015). Such approaches allow practitioners and policymakers to understand whose knowledge is informing a decision and why. Clearly communicating uncertainties remains critical for maintaining trust and enabling informed trade-offs. Ethical considerations must also guide how we synthesize and present expert knowledge. Evidence synthesis is also not a neutral act—it involves value judgments about what counts as evidence and whose knowledge is prioritized (Suri 2020). Accordingly, conservation science should strive for transparency, inclusivity, and reflexivity in how expert input is gathered, interpreted, and communicated. Embracing structured expert elicitation is not a second-best alternative to empirical evidence; it must be acknowledged as a necessary tool for conservation, especially when time-sensitive decisions must be made (Martin et al. 2012).

Finally, an increasingly important component to evidence synthesis is the role conservation scientists can play in helping practitioners identify and discount false or inaccurate claims (e.g., "manufactured uncertainty"; Boan et al. 2018). For instance, lobby or special interest groups might present false claims to practitioners to sway policy decisions. This can cast doubt on evidence-informed approaches advocated by conservation scientists, often in high-profile and complex contexts and utilizing tactics designed to degrade trust in robust science (Boan et al. 2018; Bissonnette and Teitelbaum 2020). Conservation scientists can assist in guiding practitioners and the public away from manufactured uncertainty by using robust evidence to publicly refute false and inaccurate claims, and by objectively discussing the risks of policy scenarios that involve inaction or actions based on false or inaccurate rhetoric from biased sources (Boan et al. 2018).

4 Action 3: Create a culture of evidence use that transcends individuals and institutions to empower and enable practitioners to make evidence-informed decisions that draw upon diverse knowledge systems

Creating a culture of evidence use in conservation means enabling and supporting practitioners to make decisions that involve uncertainty, and that might disappoint or be challenged by stakeholders, rightsholders, and interested political and private actors. We must create institutional cultures that legitimize the responsible use of evidence, even when outcomes are uncertain, and encourage practitioners to act decisively in the face of complexity and uncertainty (Frick et al. 2022). To do this, practitioners need environments that reward learning and adaptation rather than penalize failure. This includes recognition that taking evidence-informed risks is not recklessness, but an essential part of innovation and responsive conservation management (Frick et al. 2022; Mahajan et al. 2023). Academic institutions and funders must also revise incentive structures that often discourage the co-production of knowledge or the application of evidence to messy, real-world problems (Bednarek et al. 2018). On the surface these issues may appear to be the responsibility of the institutions, but universities are comprised of scientists who have a voice (to some extent) in shaping institutional practices and norms. When practitioners are confident that scientists will stand behind them in the aftermath of difficult, evidence-based decisions (i.e., be willing to speak publicly about the evidence), and not just consult during planning phases, then evidence becomes not only more useful but also more usable. In this section, we outline strategies to build a culture of evidence use in decision-making by supporting collaborations, reforming incentives, improving tools and training, and, most importantly, supporting practitioners to take evidence-informed risks in their decision-making. We encourage readers to also explore the checklists for creating a culture of evidence use presented in Frick et al. (2022).

4.1 Build a culture of evidence use that is relational and not transactional

Trust is a critical ingredient for empowering practitioners to make evidence-informed decisions (Marshall et al. 2017; Cvitanovic and Hobday 2018; Karcher et al. 2024). While the importance of trust is well-established, there has historically been less information about specific approaches to building, managing and maintaining successful trusting relationships between scientists and decision-makers (Boschetti et al. 2016). This is particularly important given the highly dynamic and fragile nature of trust, whereby even “too much trust” (i.e., an excessive level of trust leading to blind faith, favoritism, or a lack of diverse ideas) can adversely impact the use of knowledge in decision-making (Stevens et al. 2015; Lacey et al. 2018). Cvitanovic et al. (2021a, 2024) identified empirically-derived strategies for building successful and trusting relationships to enable knowledge sharing and use, highlighting the need for transparency, not advocating for a specific outcome, having a clear process for developing and providing knowledge, maintaining regular contact, and demonstrating independence. Importantly, their results emphasize the need to move beyond transactional relationships (i.e., those whereby scientists are seen as knowledge providers and practitioners are seen as knowledge users) toward long-term relationships founded upon shared interests and visions for what conservation success can look like.

Shared interests, visions, and understanding are central features of the culture required to support evidence use. Enabling and empowering practitioners to make informed decisions requires that these conditions be actively fostered (Ostrom et al. 1999; Pretty 2003). Collective approaches to knowledge production (e.g., learning networks, extended peer communities, co-production) can help build these conditions by promoting trust, reciprocity, and shared understanding among actors with diverse perspectives (Funtowicz and Ravetz 1993; Balint et al. 2011; Innes and Booher 2016; Cooke et al. 2021). This is very different from conventional expert-driven approaches, which can be isolating in nature and thus unintentionally create consequences such as disempowerment, lack of trust, and divergent values—the inverse of the benefits outlined above (Allen and Gould 1986; Rose 2018; Cardou and Vellend 2023). Some important steps toward such relational approaches have been taken in conservation, but progress toward a culture of evidence use may be greatly accelerated by pursuing them more actively. Currently, this pursuit is hampered by many institutional and structural barriers (e.g., disciplinary boundaries, incentives to publish) that disincentivize knowledge co-production, boundary work, relationship-building, and other activities integral to a relational culture of evidence use.

4.2 Advocate for institutional and structural change

Structural and institutional changes in conservation science are needed, and they will require new ways of thinking. Expectations for scientists often still prioritize novelty, rapid building of evidence, and academic publications (Tewksbury and Wagner 2014). However, the urgency of conservation demands that scientists actively engage in sharing knowledge and building relationships with stakeholders, rightsholders, and the public to make science readily relevant and actionable for policy and practice (Cooke et al. 2022). This requires significant time and additional competencies that are not always recognized or rewarded (Singh et al. 2019). In fact, this work of “engagement” may carry significant risks for scientists, as it can delay achievement of traditional metrics (e.g., novelty of research, grant writing, publications, international recognition). As such, fundamental changes to institutional structures, incentives, and metrics are required to reflect a greater emphasis on relational and actionable knowledge (Gerber et al. 2020;

Uriarte et al. 2007). For this to happen, institutions need to incentivize and reward these aspects of doing science. For example, new and alternative metrics for tenure and promotion that highlight non-academic impacts could be considered (Moher et al. 2018; Grant 2021). Scientists can help to make this happen by adjusting their norms as key actors in this ecosystem which is already happening in some institutions (see Rice et al. 2021). Tools such as Overton (www.overton.io), SAGE policy profiles (policyprofiles.sagepub.com), and qualitative assessments (e.g., letter from practitioners) could be leveraged to assess practitioner-related activities, relationship-building work, and policy impacts.

At a fundamental level, the gap between evidence producers and evidence users could be narrowed so they are operating in an environment where working together is the norm. Institutions that make environmental decisions may also publicly declare that they are embracing an evidence-informed approach that could even extend to legislative requirements. Institutions may also commit to building internal capacity and structures that facilitate these activities (everything from physical spaces that enable collaboration to science advice and decision-making processes that are rooted in evidence-informed practices). It is also possible to popularize a "return-on-investment" approach to conservation so that evidence use is an essential requirement to support predictions about species and ecosystem responses to different stressors. Without institutional and structural supports, efforts to establish a culture of evidence use will be continually constrained. Scientists play a key role in advocating for those changes and helping to enact them through individual and coordinated efforts.

Relatedly, a lack of educational and financial support can hinder progress toward conservation goals. For example, Burt et al. (2022) interviewed practitioners involved in island conservation in the Western Indian Ocean and identified limited capacity (i.e., ability to act and the necessary skills to do so) and lack of resources as key barriers. Addressing these challenges requires targeted support, such as exchange programs that build scientific capacity or provide direct funding. Practitioners should be invited to participate as true collaborators in conservation research, and when individual skills are lacking, training should be offered to strengthen their capacities. Institutional recognition of knowledge exchange—such as rewarding collaborative efforts—can also help foster a culture that values and promotes collaboration (Cvitanovic et al. 2015). However, for these actions to be effective, adequate financial support is essential. Training events, workshops, and field excursions are often costly, and practitioners may otherwise need to cover these expenses with their own limited project budgets (Fabian et al. 2019).

4.3 Lead by example to create momentum

Support from organizational leadership in environmental decision-making institutions is essential for building and sustaining a culture of effective evidence use in conservation, but this cannot occur without encouragement and support from scientists. Leaders in decision-making organizations can exemplify this by emphasizing that practitioner needs are a priority for resource allocation. For example, the creation of an online portal where practitioners upload conservation challenges, and scientists access them to produce relevant knowledge, would demonstrate a commitment to addressing practitioner needs.

Organizational leaders also shape the incentive structures that determine what kinds of research are valued (e.g., tenure and promotion committees, grant review panels), yet committees that directly assess such matters are often populated by scientists. At present, important activities such as knowledge co-production and capacity building are overlooked in traditional metrics of academic success (e.g., citation counts; Flinders et al. 2016; Oliver et al. 2019) although thankfully, that is changing (https://www.hepi.ac.uk/2025/06/10/redefining-academic-success-why-career-progression-must-look-beyond-research/). Reimagining evaluation criteria to value practitioner engagement and applied problem-solving would encourage more scientists to align their efforts with practitioner needs. If organizational leadership and scientists both lead by example in appreciating and meeting practitioner needs, rewarding applied problem-solving efforts, and actively adapting their approaches based on practitioner feedback, momentum towards a sustainable culture of evidence use in conservation will continue to grow.

5 Conclusions

Evidence-informed decision-making is simple in theory, but incredibly difficult in practice (Bowers and Testa 2019; Cooke et al. 2023). The three essential elements we have outlined in this paper (Fig. 1) provide a clear pathway to success, but this path is not easy. There are many practical challenges to achieving each individual action and in bringing them together to support practitioners in a meaningful way. The fact that this "clear" pathway requires the action of many – from knowledge generators, to evidence synthesizers, to evidence users; and including individuals and institutional structures and processes – emphasizes that there are many barriers to overcome. Nevertheless, scientists play a pivotal role and we are hopeful that they will take on this challenge.

We acknowledge that the world is complex (Morowitz 2002) and that what we present here is, by necessity, overly simplified (see Sutherland 2022b for more on what is needed to transform conservation). However, the core ideas are broadly transferable and can serve as a foundation for change. We also acknowledge that the perspectives shared here reflect our positionality. We are citizens of wealthy nations with democratic governance structures (shaped by settler-colonial systems that are still being evolving in the path towards reconciliation with Indigenous peoples and governments) and strong scientific capacity. We believe that the geographical validity of the proposed actions are broadly salient in high-income countries, with somewhat less direct transferability to low and middle income countries. Considering how our list of actions may (or may not) be relevant and transferrable to middle-low-income countries will require involvement of people from those countries who can speak to how (or whether) our ideas interface with each of their institutional and cultural systems.

Our perspective is that conservation scientists play a supporting role in the actual conservation of biodiversity (see Howarth et al. 2025), and have the potential to help practitioners and decision-makers embrace and implement evidence-informed practices. The barriers and enablers to this process will vary depending on context (institutions, actors, issues, socio-economic factors, culture, etc.), but we submit that they can all be overcome. Scientists play key roles as advocates within organizations and can support institutions leaders in enacting change. The examples we provide here are not exhaustive, but collectively help move us towards a better future for people and nature.

It is clear that we need to reorient how we produce, relate to, and use knowledge in the conservation space. Change, innovation, and enhanced relationships will generate the momentum we need to develop a more effective evidence-informed decision-making ecosystem for conservation practice. If the conservation science community can reorient itself to truly take up the charge of being supporters and champions of the frontline practitioners, we anticipate the potential for rapid and meaningful change. The key is to recognize that change requires action by all actors (Lubell 2002). For example, if the science community generates more relevant and actionable evidence, but it is either not synthesized or organizational structures constrain its use, failure is inevitable. It is time to rethink evidence-informed decision-making itself as being an ecosystem (sensu Sutherland 2022b), necessitating a systems-level approach. The ideas shared here are intended to help the evidence-informed decision-making ecosystem evolve in a way that its benefits are realized, and that supports and empowers frontline conservation workers so they can do what they need to do for the benefit of people and nature.

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Data availability This is a perspective paper so no data are available.

Declarations

Conflict of interest The authors declare that they do not have any competing interests. Steven Cooke and Chris Cvitanovic are members of the Editorial Board of Socio-Ecological Practice Research, Vivian Nguyen a former board member, and we declare that none of them were involved with any aspect of the editorial process for this paper.

Ethics statement We acknowledge that all ethical standards were followed when developing the ideas presented here.

Statement on the use of generative AI We proudly declare that AI was not used in the writing of the manuscript. However, it was used to generate the image of conservation practitioners in Fig. 1 (using Chat GPT).

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