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Conservation practitioners' and researchers' needs for bridging the knowledge–action gap

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In the field of biodiversity conservation, there is a growing need for research to translate to real-world impacts. Currently there exists a gap between research outcomes and on the ground action, commonly referred to as the knowledge-action gap. Previous research has focused on identifying the causes of the gap, but less research has focused on how to bridge it. We conducted an online survey with conservation researchers and practitioners to identify barriers in the science-to application pipeline and to understand how potential solutions would need to account for their information needs and workflows. Through a qualitative analysis of the open-ended survey responses, we found that information about tools and approaches to address conservation challenges is needed, but decision makers also need information to help them account for context specific barriers and opportunities. Solution-specific information alone, however, is often insufficient for practitioners, who also require the resource capacity and capable personnel to work with that information. Word of mouth and scholarly databases are the most common ways of learning about new tools and techniques, but lack of time, funding and personnel are barriers to implementing them. In addition, respondents identified a need for increased engagement with the conservation social sciences. We argue that a user-centered design approach should underpin any proposed solution to the gap and suggest that an online tool could be one effective solution.

KEYWORDS

knowledge use, implementation gap, research utilization, research impact, decision support tools

1 Introduction

We live in a time when effective conservation is crucial. Rapid, human-caused environmental change has resulted in unprecedented rates of biodiversity loss (Ceballos et al., 2015; IPBES, 2019). Yet a number of studies over the last two decades have shown that the management implications of conservation science are not easily integrated into conservation practice (Pullin et al., 2004; Sutherland et al., 2004; Kadykalo et al., 2021; Nguyen et al., 2021). In other words, evidence does not always underpin management decisions, creating what has been termed a knowledge–action gap – a mismatch between what we know from conservation science and the actions that are employed in the practice of conservation. There is now wide acknowledgement in the field that this gap hinders efforts to manage, mitigate, and reverse the crisis of biodiversity loss.

The reasons for the gap have been well documented and an important one is accessibility (Sutherland et al., 2004; Pullin and Knight, 2005; Cook et al., 2010; Cvitanovic et al., 2014). Nearly half of the conservation community has inadequate access to scientific literature (Larios et al., 2020). Evidence is often dispersed in journal articles, many of which are behind paywalls, in agency reports, or goes unpublished by organizations (Cvitanovic et al., 2014). In addition, evidence is often presented in the format of a scientific article and managers have reported a lack of time and capacity to find, access, read, and incorporate evidence when it is presented in this format (Pullin et al., 2004; Walsh et al., 2019). But even when evidence is accessible, it may not be relevant (Laurance et al., 2012; Matzek et al., 2014), its relevance may not be clear for practitioners (Fazey et al., 2005; Cvitanovic et al., 2014), or it may not be usable in different decision-making contexts (Nguyen et al., 2019).

Other reasons for the gap are rooted in the individual user of evidence and the organizational culture in which they are embedded (Nguyen et al., 2019; Walsh et al., 2019). Behavior change research has demonstrated that beyond the evidence itself, potential users of evidence must have the capacity, motivation, and opportunity to use it (Michie et al., 2011; Langer et al., 2016), and work specific to how conservation evidence is used has demonstrated the salience of these contextual factors (Nguyen et al., 2017, 2019; Walsh et al., 2019). Thus, how scientific information is produced, presented, and disseminated, who it is being used by, their tacit knowledge, and the organizational and wider cultural context in which they are embedded are all complexities that have made finding solutions in the field of conservation thus far inadequate (Hulme, 2014).

The reasons for a lack of evidence-informed conservation action are more complex and multifaceted than what is conveyed by the linear "gap" and "bridge" metaphors that are often used to describe it. More complex conceptualizations of the gap offer a two-way model of exchange between users and producers of knowledge (Roux et al., 2006; Toomey et al., 2017), or take a view of knowledge as a dynamic system operating at various scales (Nguyen et al., 2017). These conceptualizations suggest that users have important perspectives that need to be taken into account in the process of knowledge production, translation, and dissemination (Toomey et al., 2017). In other words, simply making evidence more accessible is not enough (Hulme, 2014; Kadykalo et al., 2021); efforts to "bridge the gap" will need to attend to the dynamic interplay between users and producers of scientific information, the ways in which evidence is used in practice, and the various scales of the system.

Recent work has moved beyond understanding what information on-the-ground conservationists use or do not use and why (Cook et al., 2010, 2012) and towards understanding these complexities. These studies have deepened our understanding of the needs and perspectives of conservationists, as well as how information flows between them (Gossa et al., 2015; Young et al., 2016; Fabian et al., 2019; Nguyen et al., 2019). However, much of this work focuses on specific management areas or regions. This study seeks to broaden our understanding of conservation workflows across issue areas and geographies, so as to inform solutions created to address the knowledge–action gap. But in seeking to address this gap, it is important to first define what constitutes "evidence." While literature on the gap shares a common understanding that evidence should inform conservation, definitions of evidence vary (Sutherland et al., 2004; Cook et al., 2010; Adams and Sandbrook, 2013), and many exclude traditional, local, or indigenous knowledge. This could mean the exclusion of traditional ecological knowledge, which is derived from evidence observed over generations (Berkes et al., 2000), or knowledge held by a manager who has worked in an area for an extended period. Sutherland et al. (2004) note that a failure to consult the evidence can lead to interventions that are ineffective or even harmful. While we agree that this is problematic, it is also important to recognize the contributions of different ways of knowing. Indeed, Indigenous knowledge is being increasingly incorporated into conservation practice, particularly on Indigenous governed lands (Ens et al., 2021). While these differences in definition constitute larger epistemological and ontological debates over what counts as evidence, and how evidence derived from different research paradigms should come together to inform conservation practice (Reid et al., 2021), we are increasingly aware of ways to work more effectively with multiple types of evidence (e.g., Tengö et al., 2014; Reid et al., 2021). And while evidence, broadly defined, has been found to be highly valued by practitioners, the reality is that the knowledge required for conservation action extends beyond scientific evidence because decisions must account for the broader social and political context and available resources (Cook et al., 2012; Kadykalo et al., 2021). We follow Adams and Sandbrook's (2013) call for an evidence-informed approach to conservation that is grounded in "pluralistic view of evidence".

We present the findings of surveys that we have conducted in order to understand, across geographies and issue areas, what information needs are and the current modes of satisfying those needs, to identify gaps, and how each of these may differ from the perspective of knowledge producers and users. We focus on the questions that help to identify the information and resources they need in order to begin a conservation project, where and how they search for new tools and techniques, what barriers they face in learning about and implementing new tools and techniques, and which areas of conservation it would be useful to have more knowledge of. We approach the division between producers and

users of knowledge with the understanding that many conservationists both produce and use knowledge at different times, depending on their given role in a project. We use the findings to provide recommendations for creating knowledge–action gap solutions that are in line with existing workflows and address the needs and barriers of conservation professionals.

2 Materials and methods

2.1 Data collection

To collect data on the information needs and current information gathering practices of people who work in conservation, we created an anonymous online survey using Qualtrics. A Human Subjects Review Board approved the study protocol (PHSC-2020–10-12–14577-jpswad), which included an informed consent section prior to beginning the survey. In the summer of 2021, we distributed it to twenty conservation networks through social media, professional listservs, and organizations (see Supplementary Materials for complete list). The survey was available in English, Spanish, and Portuguese.

The survey contained both closed and open-ended questions (see Supplementary Materials for the full survey). In the first section of the survey, all respondents received a common set of demographic questions. In the second section, the survey provided four distinct, but similar sets of questions that were tailored to the following types of conservation work: 1) management or support of on-the-ground conservation implementation; 2) regulation, enforcement, permitting, or policymaking; 3) education, outreach, or engagement in the community or classroom; and 4) conducting conservation science or research. Respondents answered the set of questions associated with their current type of conservation work. Because conservationists can participate in multiple types of work, the survey did not limit respondents to one role, meaning that respondents could answer the question set for multiple roles.

2.2 Data analysis

The open-ended questions, which are our focus here, capture qualitative reflections and provide an opportunity to view the information gathering practices and needs of the conservation community through a "wide angle lens" by capturing a variety of perspectives and experiences in their own words (Braun et al., 2021). These responses were imported into NVivo software for thematic analysis, performed through coding. NVivo allows for the documenting and organizing of codes, as well as a measure of their frequency. The purpose of coding in qualitative analysis is to identify themes and patterns from which the analyst can draw conclusions. One member of our team (ANS), first took a structural approach to coding, creating codes that refer to each open-ended survey question relevant to the analysis. This approach creates an index of questions and responses in the form of codes, allowing for easy sorting of the data within the qualitative software (Namey et al., 2008). This is a common approach for larger qualitative data sets, particularly open-ended survey questions, and allows for determination of the frequency of individual codes, aiding in comparisons (Namey et al., 2008; Saldaña, 2021). Frequency refers to the number of respondents who mention a given code in the responses to one survey question. For increased transparency and communicability (Auerbach and Silverstein, 2003), we provide a code frequency table with the description of each code (see Supplementary Materials).

After the structural coding, ANS inductively coded the responses to each question. This data-driven approach to thematic analysis, whereby the data themselves are used to generate the codes, requires an iterative approach resulting in multiple rounds of coding (Namey et al., 2008). Responses were first coded based on the patterns and categories that appear in an initial reading. Once this initial set of codes was identified, a second round of coding was performed to check and re-apply codes, as well as to identify others that were missed in the first round.

The codes identified in these initial rounds were then organized based on the larger themes that they spoke to. We report the codes and themes that emerged in the responses to each question and discuss their frequency relative to each other.

Coding is an unavoidably subjective form of analysis as it is the coder's responsibility to interpret the raw data (Auerbach and Silverstein, 2003). Given her experience with qualitative research, ANS was the sole coder but took steps to ensure the "justifiability of interpretations" (Auerbach and Silverstein, 2003, p. 76), such as regularly discussing interpretations with the author team to clarify and validate emergent themes and to ensure their communicability, conducting multiple rounds of coding, and writing analytic memos to document the thinking underlying the coding process, which includes the identification of patterns, themes, issues, categories, and areas to return to during subsequent rounds of coding (Saldaña, 2021).

3 Results

We received 288 responses. Of those, 132 were complete and thus included for analysis. Some 58% (77 respondents) reported their primary role as management or support of implementation (henceforth "Implementation"), 59% (78) as conservation science and research (henceforth "Research"), 45% (60) as outreach, education or engagement, and 16% (22) as regulation and enforcement. In order to sharpen the focus and most effectively address our main research question (Miles and Huberman, 1994), we focus here on only the question sets related to two of the roles: Implementation and Research. We exclude the responses for the Regulation and Enforcement and Conservation Education question sets. This analytic decision was made due to, on the one hand, the low number of responses to the Regulation and Enforcement question set, and on the other, to the very specific needs of conservation educators (e.g., curricula and lesson plans) that differed significantly from Implementation and Research respondents. Respondents were able to choose more than one primary role and answer a question set for each role. We report the results of analysis only of Implementation and Research responses, which comprise 116 of the complete surveys. Of

those, 39 respondents reported their primary role as both Implementation and Research and answered the question sets for both roles, 39 reported their primary role as Implementation, and 38 reported their primary role as Research. Despite distributing the survey to an international audience via social media, email, and network listservs, our results were skewed to respondents who primarily work in the United States (43% of respondents, with the remaining 57% split between 29 other countries. See Supplementary Materials). Though it was available in three languages, the majority of complete responses (88%) were to the English version of the survey, 3% to the Spanish version, and 8% to the Portuguese version. We could not record a response rate because we do not know how many individuals received the survey. While this method does not provide statistical representativeness, it does provide insights from a rich dataset and diverse sample of conservationists working in many countries. One limitation of this online survey is that it reflects the opinions of those conservationists who have internet access, are literate, and have an understanding of English, Spanish, or Portuguese.

Of the 116 survey respondents whose primary role is either Implementation, Research, or both, 17% (20) work at a government agency, 36% (42) at an NGO or non-profit, 38% (44) at a university, 1% (1) at a transnational agency, and 8% (9) at a type of organization not listed (e.g., consultancy).

3.1 Information and knowledge needs

We asked Implementation respondents the most common things that they need to know when performing conservation management or implementation in their job. Research respondents did not receive this question. We identified two broad areas in their responses: contextual information and capabilities. Below, we provide an overview of the themes and relative frequency of the themes found in these two areas. See Figure 1A for a chart documenting the frequency of themes found in both areas, as described below.

3.1.1 Contextual information

According to survey respondents, the contextual information required when managing or implementing conservation includes context specific data, applicable approaches and tools, an understanding of the socio-cultural landscape, relevant laws and policies, costs and budget, and monitoring and evaluation information. According to the responses, context specific data refers to information such as streamflow data, property boundaries, and species distribution. Applicable tools and approaches refer to the landscape of potentially applicable tools and approaches, including examples of tools in use, information as to how to implement them, how to measure their effectiveness, and any tradeoffs to using them. Socio-cultural landscape refers to understanding who a conservation action will impact, their resource governance systems, and past and current land ownership and use. Relevant laws and policies refer to protected area or forest management policies, legal boundaries, permitting, and local, state, and federal laws. Cost and budget refer to project costs and funding options. Monitoring and evaluation refer to measuring and evaluating the effectiveness of conservation interventions.

Context-specific data was cited most frequently in responses but was closely followed by applicable approaches and tools. Socio-cultural landscape and relevant laws and policies were also commonly cited contextual information needs. Cost and budget and monitoring and evaluation themes were less commonly mentioned (see Supplementary Material for the coding frequency chart).

3.1.2 Capabilities

According to survey respondents, the capabilities required to implement or manage conservation interventions include project management, stakeholder engagement, and applied knowledge and technical skills. Project management refers to capabilities in the areas of strategy development, soft skills, team management, time management, and defining objectives.

According to the responses, capabilities related to stakeholder engagement include understanding the needs of different groups and building relationships with them, particularly with local and Indigenous communities. Other responses included needing to know how to motivate volunteers and get buy-in from stakeholders. In these responses, "stakeholder" refers to a broad range of individuals or groups that may be involved in or impacted by a conservation project (the public, those to be impacted, government agencies, etc.).

Applied knowledge and technical skills include a range of skills from various fields including data science, genomics, field safety, predator control methods, recapture methods, fire management and survey tools, corridor ecology, semi-structured interviewing, coral reef management, and coding skills. Such a wide range can be expected based on the different types of conservation actors that the survey reached.

Stakeholder engagement and project management were the most commonly mentioned, followed by applied knowledge and technical skills.

3.2 Resource needs

We asked both groups what resources they need and look for when starting a new project. "Resources" was interpreted widely by Research and Implementation respondents, resulting in three resource types: information, relationships and networks, and organizational needs. See Figure 1B for an illustration of the frequency of themes found in these three categories of resources, as described below.

3.2.1 Information

For both groups, the information required to begin a new project included literature and research, an understanding of the cultural landscape, spatial and ecological data, plan and objectives, and possible tools and solutions. Literature and research refer to scientific literature, though a small number of responses refer to

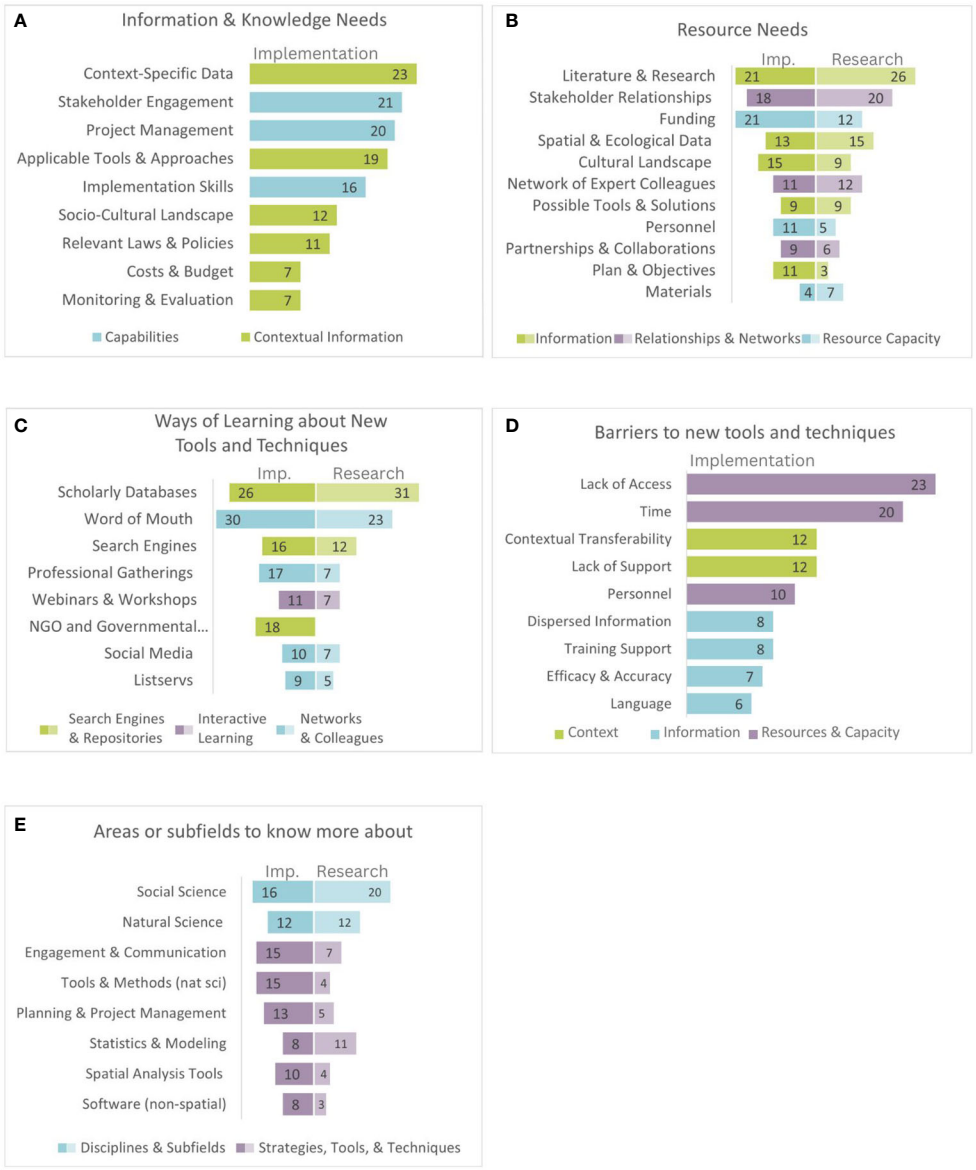

FIGURE 1
(A) Frequency of codes in response to the question "what are the most common things that you need to know when performing conservation management or implementation in your job?" (Research respondents did not receive this question). **(B)** Frequency of codes in response to the question "when you start a new project, what resources do you need and look for?" **(C)** Frequency of codes in response to the question "how do you learn about new tools and techniques that would help you?" **(D)** Frequency of codes by category in response to the question "What are common barriers you face in learning about or implementing new conservation tools?" (Research respondents did not receive this question). **(E)** Frequency of codes in response to the questions "what conservation disciplines or conservation tools would be most useful to learn about?" (Implementation) and "what areas or subfields of research do you wish you knew more about, that would help you in your conservation science?" (Research).

gray literature, news, and other forms of media. Cultural landscape refers to information about past and current land ownership and use, livelihoods, and the culture, values, beliefs, needs, and hopes of stakeholder communities. Spatial and ecological data refers to a wide array of site-specific data needs (e.g., natural areas inventory, spatial data). Plan and objectives include having a plan, objectives, and indicators of success. Possible tools and solutions refer to information about the landscape of possible interventions together with examples to give context.

For both groups, access to literature and research stands out as the most frequently mentioned. Cultural landscape and spatial and ecological data also stand out as important for Implementation, while spatial and ecological data stands out as important for Research respondents.

3.2.2 Relationships and networks

For both groups, stakeholder relationships, a network of expert colleagues, and partnerships and collaborators are necessary for starting new conservation projects.

Stakeholder relationships refer to relationships with landowners, land managers, government, local authorities, relevant agencies, communities, and the public. A network of expert colleagues refer to experts who can offer consultation or guidance on an issue of concern. Partnerships and collaborators refer to individuals or organizations who will help to realize a project.

References to each theme were similar in both groups, with stakeholder relationships as the most frequently mentioned, followed by a network of expert colleagues, and finally, partnerships and collaborators.

3.2.3 Resource capacity

Both groups identified funding, personnel, and materials as resources required for starting a new conservation project. Funding refers to financial support to carry projects out. Personnel refers to personnel with the necessary competencies, time, and bandwidth to carry out a project. Materials include the physical means to carry out a project, such as transport, technology, field stations, physical access to a site, safety equipment, and field equipment.

Funding stands out as the most frequently mentioned by both groups in this area, but was mentioned more frequently by Implementation respondents. Personnel was also frequently mentioned by Implementation respondents. The other capacity-related resource needs were less frequently mentioned.

3.3 Ways of learning about new tools and techniques

To understand current modes of satisfying information needs, we asked respondents how they learn about new tools and techniques. In their responses, we identified three ways: networks and colleagues, online search engines and repositories, and interactive learning. See Figure 1C for an illustration of the frequency of themes found in these three categories of ways of learning, as described below.

3.3.1 Networks and colleagues

Respondents identified four ways that they learn about new tools and techniques through their networks and colleagues: word of mouth, professional gatherings, social media, and listservs. Word of mouth responses simply refer to that: learning through regular conversation with colleagues. Professional networks refer to professional societies and their conferences, as well as conservation-specific online networks that serve as a site for the exchange of ideas. Social media responses referred mostly to Twitter, but included Facebook, Telegram, and WhatsApp. Listservs and newsletters refer to updates from NGOs, professional societies, and industry.

Within this category, word of mouth is by far the most common way of learning about new tools and techniques for both groups. Professional gatherings stood out as important for Implementation respondents as well, followed by social media. The other ways of learning were mentioned less frequently by both groups.

3.3.2 Search engines and repositories

Both groups identified scholarly databases and search engines as important ways of learning about new tools and techniques, while Implementation respondents identified a third: governmental and NGO sources.

Scholarly databases refer to journals, Web of Science or Google Scholar. Search engines refer more generally to a "web search" or Google. Government and NGO resources refer to resources provided by organizations in their libraries and repositories (e.g., Conservation Measures Partnership, International Union for the Conservation of Nature, U.S. Fish and Wildlife Service).

Scholarly databases are the most commonly mentioned by both groups. For Implementation respondents, government and NGO resources are also commonly mentioned, but did not appear at all in Research responses. Search engines were mentioned less frequently than other ways but are still of importance to both groups.

3.3.3 Interactive learning

Webinars and workshops, both online and in person, are a more interactive way that both groups learn about new tools and techniques and are the only interactive way of learning identified. This way of learning was mentioned with less frequency.

3.4 Barriers to learning about and implementing new tools

We asked Implementation respondents about barriers to learning about and implementing new tools. We identified three broad types of barriers in their responses: resources and capacity, information, and context. See Figure 1D for an illustration of the frequency of themes found in these three categories of barriers, as described below.

3.4.1 Resources and capacity

In the responses, we identified three types of resource and capacity barriers: lack of access, time, and personnel. Lack of access refers to a lack of access to new tools due to the cost of journal access, the cost of courses to learn about new tools, and the cost of new tools. Time refers to a lack of time more generally, but also to the need to act quickly against emerging threats to biodiversity. Personnel refers to a lack of staff with the proper training or bandwidth to learn about new tools.

Lack of access was the most frequently mentioned barrier, followed closely by time. The personnel theme was less frequently mentioned.

3.4.2 Context

We identified two contextual barriers: contextual transferability and lack of support. Contextual transferability refers to the difficulty of understanding if a tool is applicable to a different context. Lack of support refers to a lack of support for new tools from donors, volunteers, collaborators, partners, and the public or resistance to trying new tools within an organization, including from co-workers or higher-ups.

The contextual barriers were mentioned with equal frequency.

3.4.3 Information

We identified four informational barriers to learning about and implementing new tools: dispersed information, lack of training support, lack of efficacy or validating information, and language. Dispersed information refers to the existence of an overwhelming number of tools, a lack of awareness of what is out there, and the spread of information about tools over many websites. Lack of training support refers to a lack of support necessary to adopt new tools. Efficacy and accuracy refer to lack of information about a tool's efficacy (e.g., validation studies, effectiveness in one's context), particularly in comparison to other tools, and understanding its strengths and limitations. Language refers to a lack of information about new tools in languages other than English.

These informational barriers were mentioned a similar number of times, but with less frequency than capacity and resource or contextual barriers.

3.5 Areas or subfields of research that would be useful to know more about

Both groups were asked a similar question about what areas or tools they would find useful to know more about. For both groups, we identified two main types of responses: Disciplines and Subfields, and Strategies, Tools, and Techniques. See Figure 1E for an illustration of the frequency of themes found in these two categories of responses, as described below.

3.5.1 Disciplines and subfields

We identified human dimensions and social science as one area of interest, and natural science as another. Human dimensions and social science refer to specific social science disciplines or subfields such as psychology, environmental justice, and political ecology. Natural science refers to disciplines and subfields spanning a range of areas such as ecology, hydrology, animal behavior, and genomics.

Both groups more frequently cited human dimensions and social science disciplines and subfields as areas of research that would be useful to know more about.

3.5.2 Strategies, tools, and techniques

We identified six areas of strategies, tools, and techniques: stakeholder engagement and communication, natural science tools and methods, planning and project management, statistics and modeling, spatial analysis tools, and software (non-spatial). Stakeholder engagement and communication refers to areas like community engagement and outreach, communicating to a lay audience, and how to moderate between stakeholder groups with conflicting values. Natural science tools and methods refer to specific tools and approaches for an array of conservation challenges such as species abundance surveys, bird monitoring, and animal tracking. Planning and project management refers to basic skills such as meeting moderation, and more complex ones, such as results chains and developing performance metrics. Statistics and modeling refer to an array of methods such as Bayesian statistics and population modeling. Spatial methods refer to GIS and remote sensing. Software refers to learning specific programs for tasks like project management, database management, and integrating different types of data.

For Implementation respondents, stakeholder engagement and communication, along with natural science tools, were the most frequently mentioned areas, followed closely by planning and project management. Spatial analysis tools were mentioned with some frequency followed by the less frequently mentioned statistics and modeling, and software (non-spatial). Research respondents most frequently mentioned statistics and modeling, followed by stakeholder engagement and communication. Other areas in this category were mentioned fewer than five times.

4 Discussion

4.1 Knowledge and information needs

The survey responses demonstrate the wide variety of knowledge and information needs required for conservation decision-making and action, including an understanding of the context and socio-cultural landscape, available tools, and the capacity to gather and use that information through stakeholder engagement, project management and other applications. Evidence is an important piece, but alone is insufficient. These findings are in line with others that find that the information required for conservation decision-making extends beyond the evidence-based information found in the literature (Cook et al., 2012; Nguyen et al., 2019; Kadykalo et al., 2021). It follows that efforts to bridge the knowledge action gap should consider the complexity of conservation decision-making, and where possible, present information in a way that speaks to contextual considerations. This could mean making clear any laws, policies, or ethical considerations that should be taken into account (e.g., privacy laws and ethics related to using drones to collect data) or presenting the strengths and limitations of an intervention that give a practitioner insight into its contextual transferability.

However, knowledge needs go beyond information about a context and relevant tools to include the capacity to gather, manage, and employ that information. It is not only important to know, but also to *know how to* (manage teams, manage projects, engage stakeholders, understand the cultural context). This reflects the increasing complexity of the field as it has become more interdisciplinary, creating the need to develop capacity to work beyond or in conjunction with fields outside of conservation science. It also suggests that the knowledge–action gap may link to capacity gaps in areas like project management (Barlow et al., 2016), soft and interpersonal skills (Elliott et al., 2018), and working across disciplines (Habel et al., 2013).

4.2 Resource needs

Literature and research was the most mentioned resource need for both groups of respondents, indicating the importance of

accessibility for both research and practice. This suggests that this type of information, and the evidence it contains, is valued by both groups. While we were gauging needs rather than accessibility, Larios et al. (2020) found that while much of the conservation community requires access to scientific literature very frequently or frequently, nearly half (49%) find it not easy or not at all easy to access. That study found that geographic region was an important factor related to access. Similarly, Gossa et al. (2015) found scientific literature to be more difficult to access for those working in developing countries (Gossa et al., 2015). The movement toward open access seeks to address these issues (Fuller et al., 2014); however, our findings suggest that the information deficit characterized by inaccessible evidence is just one dimension of a more multifaceted knowledge–action gap. Other resources of similar importance include stakeholder relationships and funding, particularly for Implementation respondents.

4.3 Ways of learning about new tools and techniques

Scholarly databases were the most frequently mentioned way of learning about new tools for Research respondents, and the second most frequently mentioned by Implementation respondents. This again suggests that scholarly literature is of value to both groups, and we have already discussed the need for and lack of access to scholarly journals.

Word of mouth was the most frequently mentioned way of learning about new tools and techniques for Implementation respondents, and the second most frequently mentioned by Research respondents. This reflects the social aspect of knowledge systems, wherein the movement from knowledge to action is mediated by social networks (Nguyen et al., 2017). That word-of-mouth networks play such an important role in helping conservationists learn about new tools suggests that solutions created to bridge the knowledge action gap can leverage social networks to mobilize new knowledge. Both accessibility and social sharing can provide ways to bridge the divide; however, how they can be used together for enhanced impact is a question for future study.

4.4 Barriers to learning about and implementing new tools

Lack of access and time were identified as the most common barriers to learning about and implementing new tools. The movement toward open access has been put forth as one way to address issues of accessibility (Fuller et al., 2014), as has open science (Cornell et al., 2013; Roche et al., 2022), but improving access to primary literature and research outputs does not address the time constraints related to finding, reading, digesting, and applying the information in primary literature. Providing information about new tools that is not only open access but also presents information organized in a way that reduces the time required to discover and learn about them could address both of these critical barriers.

A lack of information about the contextual transferability of tools (the information that helps a user to know if it would be applicable to their context), also creates a barrier to their use. This suggests that if tools are provided with practical information that helps a user to better understand their contextual transferability such as pitfalls, challenges, and things to consider before devoting time to learning about a new tool, this barrier could be directly addressed. The lack of access to information is of obvious importance, but a lack of useful and usable information is another (Nguyen et al., 2019).

Another similarly important barrier is lack of support for new tools from colleagues and stakeholders. Walsh et al. (2019) similarly showed that characteristics of the knowledge users at the level of individual and organization (e.g., values, beliefs, organizational culture), can act as a barrier to the use of evidence in conservation practice. This is an important dimension of the gap, but one that will be difficult for any potential solution to directly address.

4.5 Areas to learn more about

The areas and fields that respondents felt would be useful to know more about spanned the natural and social sciences but for both groups the most frequently mentioned was social science disciplines and subfields. Implementation responses suggested interest in a greater variety of areas than Research responses, but stakeholder engagement and communication stood out as a salient and specific area of interest. There is now widespread recognition that social science is crucial to progress in the field (Mascia et al., 2003) and evidence of its positive impact on conservation outcomes (Serota et al., 2023), but its integration into practice remains a challenge (Sievanen et al., 2012). We recognize the significant ideological, institutional, capacity, and knowledge barriers that stymie the integration of the social sciences into conservation research and practice (Bennett et al., 2017), but advocate for the support of opportunities for exploration and learning in these areas.

But a lack of integration doesn't stop with the divide between the social and natural sciences. There also exist gaps between subfields in conservation (Habel et al., 2013). One example is conservation behavior, whose findings are also underutilized in conservation practice due to a lack of communication (Greggor et al., 2021). Many respondents listed natural science subfields and more specific tools and techniques as areas of interest, such as animal behavior and population genetics, demonstrating a desire for conservation researchers and practitioners to reach beyond their areas of expertise. Support for exploration and learning from the many fields that inform conservation research and practice would support a more interdisciplinary and integrative approach to conservation.

5 Conclusion

Our findings as well as the literature seem to suggest not one but many interdependent gaps that impede the transition from knowledge to action. These include resource gaps, capacity gaps, disciplinary gaps, and a knowledge and information gap, among others (see Figure 2 for a summary of findings). Without addressing these complexities, solutions to the knowledge–action gap will do little to bridge the divide.

In fields like medicine there already exist mechanisms for bridging this divide, but efforts to this end are only nascent in conservation and will require concerted effort to have an impact (Fazey et al., 2004; Segan et al., 2011; Kadykalo et al., 2021). This provides an opportunity for solutions in the field of conservation to be designed with end users in mind, and that effort could be well worth it. For example, Walsh et al. (2015) found that when practitioners were presented with summarized evidence on interventions for reducing the predation of birds, almost half changed their opinions of interventions and 90% would be willing to change at least one intervention they used. Their findings suggest that the format in which information is presented can impact its intended uptake by practitioners, though intention and action cannot be equated, and this does not account for the contextual constraints that may prevent change. Future studies should focus on the role of evidence in the decision-making process and how this might differ across practitioner communities, and how potential solutions can be designed with these conservation workflows in mind.

More than thirty-five years ago, Michael Soule wrote that much of conservation is decision-making based on limited information (Soule, 1985). Despite the advances that have been made since that time, the challenges of finding, accessing, and utilizing conservation tools usually means that his assertion still stands. While it is unlikely that evidence will replace anecdote, expert opinion, and past experience in context specific decision-making, it could be more readily used in combination with and supported by evidence that is easy to find and access. Our findings have begun to shed light on how to face these challenges to improve the effectiveness of conservation work by bridging the knowledge action gap. Given the complexity of the multi-faceted nature of the knowledge–action gap, bridging it will likely require many different types of solutions including open access (Fuller et al., 2014), open science (Roche et al., 2022), bridging the

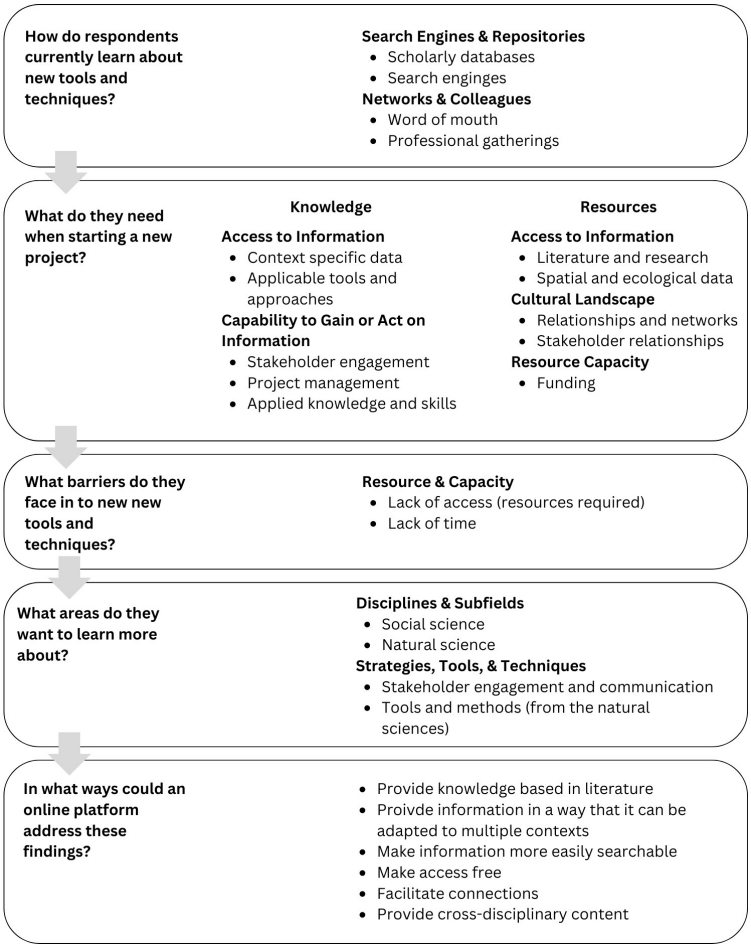

FIGURE 2
Summary of findings and guidance they provide for how needs, barriers, and common ways of satisfying information needs can be effectively addressed through an online platform to bridge the knowledge action gap.

researcher–practitioner divide (Sunderland et al., 2009; Gardner, 2012), altering the researcher–practitioner relationship altogether (Smith et al., 2009), and increasing inter- and transdisciplinary work and exchanges (Cornell et al., 2013; Matzek et al., 2014). While of critical importance, many of these require profound cultural shifts in the ways that conservation is researched and practiced. One potential near term solution is the development of an online platform that is free to use and provides open access materials. By taking a user-centered design approach (Rose et al., 2017) that focuses on the existing workflows and needs of practitioners, this potential solution can be designed in a way that directly addresses how to make evidence easier to find, access, and use for the end users. We provide recommendations to that end based on our findings below.

Recommendations for efforts to close the knowledge–action gap.

- Provide cross disciplinary content, and especially connect to the social sciences
- Information should be actionable (i.e., not simply presented in article format)
- Information presentation should allow a user to quickly assess its applicability to their context (e.g., pitfalls and challenges, pros and cons to using a tool or an approach)
- Facilitating user connections to topic area experts is valuable and would fit current workflows
- Provide access to insights from those who have implemented tools in the field
- Existing networks of colleagues could be expanded through a community-based platform

Data availability statement

The datasets presented in this article are not readily available because data was collected from human subjects via surveys that included open-ended questions. The responses to those questions contain information that could make survey respondents identifiable. Requests to access the datasets should be directed to ansabo@wm.edu.

Ethics statement

The studies involving humans were approved by William & Mary Human Subject (PHSC) Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

AS: Formal analysis, Visualization, Writing – original draft, Writing – review & editing. OB: Conceptualization, Methodology, Writing – review & editing. DB: Conceptualization, Methodology, Writing – review & editing. AG: Conceptualization, Methodology, Writing – review & editing. JS: Conceptualization, Methodology, Writing – review & editing.

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Conflict of interest

DB is the Field Chief Editor for Frontiers in Conservation Science.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be constructed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2024.1415127/full#supplementary-material

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