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A practical conservation tool to combine diverse types of evidence for transparent evidence-based decision-making

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Abstract

Making the reasoning and evidence behind conservation management decisions clear and transparent is a key challenge for the conservation community. Similarly, combining evidence from diverse sources (e.g., scientific and local knowledge) into decision-making is also difficult. Our group of conservation researchers and practitioners has co-produced an intuitive tool and template (Evidence-to-Decision [E2D] tool: www.evidence2decisiontool.com) to guide practitioners through a structured process to transparently document and report the evidence and reasoning behind decisions. The tool has three major steps: (1). Define the Decision Context; (2). Gather Evidence; and (3). Make an Evidence-Based Decision. In each step, practitioners enter information (e.g., from the scientific literature, practitioner knowledge and experience, and costs) to inform their decision-making and document their reasoning. The tool packages this information into a customized downloadable report (or is documented if using the offline template), which we hope can stimulate the exchange of information on decisions within and between organizations. By enabling practitioners to revisit how and why past decisions were made, and integrate diverse forms of evidence, we believe our open-access tool's template can help increase the transparency and quality of decision-making in conservation.

KEYWORDS

conservation management, cost-effectiveness, decision support tools, decision-making, evidence-based, practitioner knowledge, transparency, values

1 | INTRODUCTION

Embedding the use of evidence in practice and policy to inform conservation and natural resource management decisions is increasingly recognized as best practice to achieve desired outcomes and protect species, genetic diversity, and habitats (Addison et al., 2016; Rose et al., 2019; Gillson et al., 2019; Kadykalo, Cooke, & Young, 2021; Sutherland et al., 2013; O'Brien et al., 2021). By learning from past successes and failures, we can understand how to do more of what works, and less of what does not work, reducing wasted resources previously spent on actions that are known to be ineffective, inefficient, or harmful (Sutherland et al., 2013, 2020; Sutherland, Atkinson, et al., 2021; Sutherland, Downey, et al., 2021). While avoiding wasted effort has always been important, it is perhaps even more relevant now when efficient, large-scale action is required to reverse current trends of unprecedented biodiversity loss (Díaz et al., 2019; Leclère et al., 2020).

A conservation practitioner planning to make a reasoned and informed decision using evidence needs to consider a variety of relevant information sources (Kadykalo, Buxton, et al., 2021; Kadykalo, Cooke et al., 2021; Schwartz et al., 2018). Evidence in this decision-making context can be broadly defined as: "Relevant information used to inform a decision" (drawing from Salafsky et al., 2019). Currently, there appear to be two main approaches to using evidence to inform conservation management decisions (Sutherland et al., 2017): (1.) focusing on using "local knowledge" derived from indigenous and local communities, practitioners, and stakeholders, without considering evidence drawn from wider contexts; and (2.) focusing on using scientific evidence (derived from peer-reviewed primary and secondary research in journals and syntheses, and increasingly from non-peer-reviewed reports and documents) to find generality in the effectiveness of conservation actions and provide wider, generic recommendations on best practice.

We believe that to truly inform evidence-based practice and policy in conservation, we need to combine these approaches to ensure relevant and reliable evidence from different sources of evidence are used to their full potential (Adams & Sandbrook, 2013; Sutherland et al., 2017). For example, in an ideal world, relevant evidence from the scientific literature on the effectiveness of conservation actions would be available across many different local contexts. However, there is often little to no available evidence from the scientific literature on the effectiveness of many conservation actions, and where evidence is available, actions have often only been tested on a small subset of species and locations and the evidence may be of poor quality (Christie, Abecasis, et al., 2020; Christie, Amano, et al., 2020a, 2021; Junker et al., 2020). The relevant information that can be taken from the generic recommendations of evidence collated at a global level (i.e., from syntheses of peer-reviewed research, such as systematic reviews and meta-analyses) is often perceived to be small, particularly by practitioners (Gutzat & Dormann, 2020; O'Connell & White, 2017; Walsh et al., 2015, 2019). This is often justified by the concern or perception that the effectiveness of conservation actions may vary considerably between different local contexts (e.g., habitats and species; Cook, Mascia, et al., 2013; Cook, Possingham, et al, 2013; Gutzat & Dormann, 2020; Levins, 1966; Shapin, 1998).

To determine, in practice, the likelihood that a conservation action will achieve its desired outcomes in a given local context requires complementing scientific studies and syntheses drawn from different contexts with evidence from more localized or contextualized sources that is relevant to the local context of interest (Adams & Sandbrook, 2013; Cook et al., 2017; Sutherland et al., 2017). These sources may include: (i.) the non-peer-reviewed literature (also called the "grey literature", which is sometimes partially included in scientific syntheses); (ii.) decision-makers' own monitoring data, written experience (e.g., notebooks or logs), and research; and (iii.) undocumented (or tacit) knowledge (e.g., Indigenous People and Local Community [IPLC] knowledge and experience; Table 1). Just as for peer-reviewed scientific evidence, the reliability and relevance of the evidence each type of source provides must be carefully assessed (Kadykalo, Buxton, et al., 2021; Kadykalo, Cooke et al., 2021). Note that when we use the terms "peer-reviewed" and "non-peer-reviewed", we refer to the formal process of peer-review in scientific journals, rather than organizational peer-review that is sometimes undertaken outside of scientific journals — we use these in preference to the term "grey literature" as this has negative, derogatory connotations (Table 1).

In addition to evidence on the likely local effectiveness of a conservation action (i.e., whether it produces desired outcomes on its target), the wider costs and risks (including cost-effectiveness), feasibility, and acceptability to key stakeholders are also key factors to consider in decision-making (Kadykalo, Cooke, et al., 2021). For example, let us consider the conservation conflict involving the problem of controlling the numbers of geese to reduce crop damage. Sport hunting (i.e., allowing private individuals to reduce the numbers of geese using permits) and the government lifting a ban on licensed culling of geese may be considered reasonable options (Mason et al., 2018). The costs associated with culling geese may be higher than allowing increased sport hunting (i.e., sport hunting would bring in revenue at the same time;

TABLE 1 Differences between different forms of evidence for the purposes of this tool

Type	Subtypes	Description	Example
Forms of evidence to assess local effectiveness			
Scientific literature	Peer-reviewed primary research	Documented, peer-reviewed, and published scientific research paper.	Scientific paper testing an action published.
	Evidence syntheses and summaries	Analyses of primary research that attempt to provide evidence-based recommendations by drawing on findings from multiple papers. Some of these may be formally peer-reviewed and some may not — as with primary research, the quality and "evidence-based" nature of these syntheses varies.	Systematic reviews, meta-analyses, websites showing summaries of primary research (e.g., Conservation Evidence). Guidance documents provided by DEFRA and RSPB.
	Non-peer-reviewed ("grey") literature	External non-peer-reviewed primary research, reports, data, or books (i.e., not published in a formally peer-reviewed scientific journal).	Preprints, private reports, analyses, published reports, and data that are not peer-reviewed. See Applied Ecology Resources for a searchable database (https://www.britishecologicalsociety.org/applied-ecology-resources/search/). PANORAMA also provides a source of descriptive case studies (https://panorama.solutions).
Decision-makers' own data, written experience, and monitoring		Any internal primary research, reports, monitoring, notes, or data that is unpublished or private.	Monitoring data from a nature reserve on the effects of a conservation action, or logbooks or notes from implementing actions.
Undocumented knowledge		Undocumented or "tacit" knowledge that is simply known but difficult to attribute to a source or mechanism (e.g., from experience).	Intuition, experience, wisdom, stories, indigenous or local knowledge passed down through generations.
Additional decision-making factors			
Costs	Financial and resource-based costs	Data or evidence from the scientific literature, or undocumented knowledge on the time, money, and resources required to implement an action.	Budget report.
	Non-financial costs and risks	Data or evidence from the scientific literature, or undocumented knowledge on the possible positive and negative effects of the action on non-target species, habitats, and stakeholders.	Primary research study on costs of an action. Opinions of stakeholders. Changes in value of natural capital.
Values		Information describing the feelings, identity, or opinions held by stakeholders.	Elicited values from stakeholders such as that preserving traditions is important to the local community group.
Acceptability		Information on how well the effects of an action align with the values held by stakeholders.	It is judged to be unacceptable to implement an action that would limit access of local people to an area used for a local tradition.
Feasibility		Information, partly drawn from costs and acceptability, on whether the action can be implemented given the available resources, time, and conditions	It is judged an action is not feasible based on the logistical difficulties in moving heavy equipment to the required location.

Note: When we use the term "peer-reviewed," we refer to the formal process of peer-review in scientific journals, rather than organizational peer-review that is undertaken by some government bodies and non-governmental organizations.

Mason et al., 2018). The feasibility of these two actions will also differ; culling geese might allow more direct control on how many individuals are removed from the population versus sport hunting. Finally, the acceptability of these actions to various stakeholders will differ (e.g., sport hunters and local businesses would approve of additional hunting opportunities, while it may be politically challenging to lift a ban on culling). It is therefore very important that when combining diverse sources of information to make conservation and natural resource management decisions, there is transparency and clarity over what evidence has been used, as well as the thinking and reasoning used by the decision-maker (Schwartz et al., 2019).

There are a range of Decision Support Frameworks and processes to help conservationists make decisions using evidence (Bower et al., 2018; Schwartz et al., 2018; Wright et al., 2020), including: strategic foresight (e.g., horizon scanning and scenario planning; Sutherland, Downey, et al., 2021); Structured Decision-Making (e.g., involving consequences tables and expert elicitation; Gregory, Failing, et al., 2012; Gregory, Long, et al., 2012), Conservation Standards (e.g., results chains; CMP, 2020), theory of change (Rice et al., 2020), and argument maps (Keith et al., 2017); Bayesian Belief Networks (Newton et al., 2007), multi-criteria decision analysis (Adem Esmail & Geneletti, 2018; Knight et al., 2019), systematic conservation planning (Margules & Pressey, 2000; Watson et al., 2011), and cost-effectiveness or cost–benefit analysis (Cook et al., 2017). These frameworks can help collate diverse sources of information to improve decision-making, and often provide a stepwise, structured process for aiding those decisions, which may be particularly useful and warranted when decisions involve major investments of time and money, or where the negative consequences of failing to make the most optimal decision are high. However, one major issue for practitioners in using these frameworks is that they may only be able to allocate hours or days to making many of their decisions (Sutherland, Downey, et al., 2021), and thus perceive these tools as being too time-consuming to use. Other problems include the fact that some of these frameworks may not be widely known or understood by conservation practitioners, and may be perceived as too complex to use (particularly if they lack an intuitive user interface or reusable template). If more practitioners are to use evidence-based decision-making tools to inform their work, there is a need for more co-designed, user-centered tools (Rose et al., 2017; Sturm & Tscholl, 2019) that are more accessible, widely disseminated, and easier to use (Schwartz et al., 2018).

Transparency is another key issue that merits more attention in conservation management decision-making. For example, whilst the frameworks mentioned earlier promote transparency in the structure and operation of the decision-making process, we believe that the conservation community would benefit from a tool that explicitly guides practitioners through transparently reporting the evidence and reasoning used to make decisions within a step-by-step process that integrates evidence from diverse sources. However, to the best of our knowledge, a freely available, co-designed, and interactive tool that achieves this has yet to be developed and we believe could play a key role in fostering more "evidence bridges" between practitioners and researchers (Kadykalo, Buxton, et al., 2021).

Here we adapt and apply the well-established Evidence-to-Decision (E2D) framework used by the UK's National Institute for Health and Care Excellence (NICE; Alonso-Coello et al., 2016) to create a versatile, co-designed decision support tool: the Evidence-to-Decision (E2D) tool. The goal of the E2D tool is to make the evidence and reasoning behind conservation management decisions more systematic and transparent to both internal and external stakeholders. The aim of this article is to describe the tool and explain its potential value to practitioners, providing a generic template for wider use and application in conservation practice.

2 | METHODS

2.1 | Overview of tool and intended users

The E2D tool (Figure 1) draws upon the aspects of the E2D framework described in clinical medicine (Alonso-Coello et al., 2016), as well as the Conservation Standards (CMP, 2020) and structured decision-making (Gregory, Long, et al., 2012; Hamilton et al., 2021) frameworks from conservation. The tool guides users through three major steps to transparently document the evidence and reasoning used to make their decision (1. Define the Decision Context, 2. Gather Evidence, and 3. Make an Evidence-based Decision; Figure 1). We refer to terms defined by the Conservation Standards (CMP, 2020) where possible.

The intended users of the tool are conservation practitioners who conduct interventions or actions to improve biodiversity in any field, sector (e.g., public or private), or location. Practitioners that contributed to the development and user testing of this tool typically worked in environmental Non-Governmental Organizations (NGOs), nature conservation-related governmental bodies, charities, or commercial agriculture companies. Their organizational position mostly ranged from lower to mid-

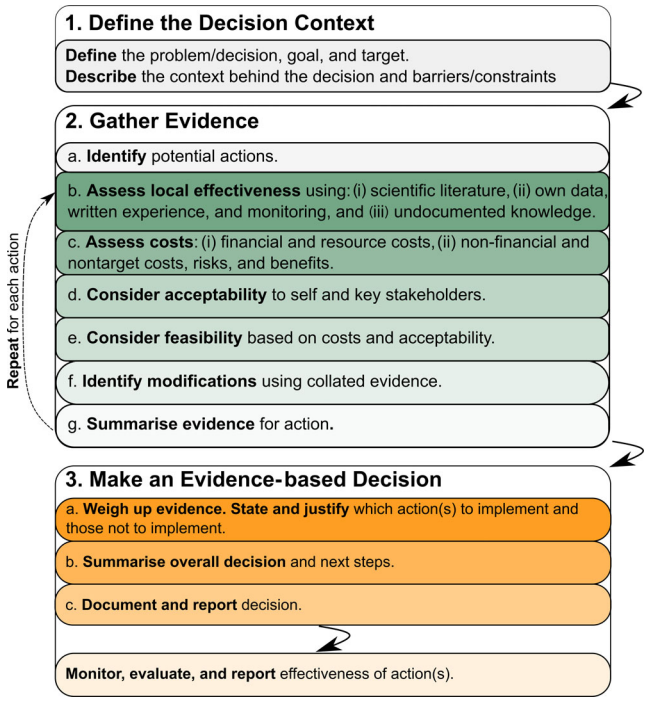

FIGURE 1 The structure and implementation of the Evidence-to-Decision (E2D) tool. Numbers, letters, and roman numerals refer to the steps described in the Results. Figure S1 gives a worked example and excerpts from this are provided in the Results for each step and section. Note that Step 2 (b–g) is repeated for each action and that the size of each section is not meant to be a guide — this will vary for each decision being considered and the evidence available

level team leaders, area managers, and reserve managers, but also included some higher-level officers and managers in some relatively small NGOs. The tool was most suited to use by a single person, or in a team where a single person entered information into the tool with input from colleagues and stakeholders. The offline version of the tool can be used as a generic template to structure a transparent evidence-based decision-making process (see www.evidence2decisiontool.com and the Supporting Information).

2.2 | Co-design process

The tool was created by a discussion of needs for a decision support tool with practitioners at various conservation organizations (Bat Conservation International, Berkshire Buckinghamshire and Oxfordshire Wildlife Trust, Froglife, Gloucestershire Wildlife Trust, Ingleby Farms, Kent Wildlife Trust, NatureScot, The Medway Valley Countryside Partnership, and The Woodland Trust). A team of practitioners and researchers worked collaboratively to co-develop and co-design the tool to iteratively improve its user-centered structure and functionality (Rose et al., 2017; Sturm & Tscholl, 2019).

We started by creating a prototype structure for the tool with some steps that are typically involved in making a decision as suggested by practitioners and drawing from the literature on Decision Support Frameworks (e.g., Bower et al., 2018; Schwartz et al., 2018). Practitioners on the author team and in the different organizations provided feedback on this structure and suggested additional steps, modifications to the order of these steps, and the types of important evidence that should be included (e.g., local and indigenous knowledge, costs, and feasibility). We produced and user-tested prototypes of the tool (using an online R Shiny [Chang et al., 2020] application) iteratively with different practitioners using real-life case studies to see how the tool could be used and improved (including scenarios with Master's students (see Acknowledgements), typically from diverse practitioner-focused backgrounds, with at least three years professional experience in conservation). Many of the changes that were made involved adding further guidance on how to assess scientific evidence and undocumented knowledge for biases, adding a dynamic summary table and text in the final step to aid weighing up the evidence, and explicitly integrating uncertainty into the tool through a scoring system and color-coding of the summary table.

3 | RESULTS

3.1 | Structure and process of the E2D tool

In the following sections, we outline the different parts of the tool and explain how these work — guidance on how to use the tool is provided in a downloadable guide on the tool website (www.evidence2decisiontool.com — where an offline template is also available) and in the Supporting Information. Questions are described in each section to act as prompts for the user to answer to guide their decision-making.

We illustrate the use of the tool and types of information a conservation practitioner using a simple hypothetical example where we are interested in reducing amphibian mortality along a road that runs through a nature reserve or protected area (see also Figure S1).

1. Define the Decision Context
   What is the problem and desired outcomes? What is the relevant ecological, physical, and social context underlying the decision?
   The tool prompts users to define and describe the decision context. Users are asked to give a brief

description of the problem or direct threat, identify the desired focal target (i.e., species, group, or habitat), and state the ultimate goal of the conservation intervention or action (i.e., desired outcomes; CMP, 2020). Users are encouraged to report important contextual knowledge, such as ecological (habitat types, species present), physical (e.g., location), and socioeconomic and cultural information (e.g., background on relevant stakeholders — people or groups with interests or concerns related to the context being considered; Franks et al., 2018). The tool asks users to identify constraints that may influence their decision such as regulatory structures/legislation, budget available, and personal/organizational values.

Example: We are interested in reducing mortality of amphibians crossing a road in one of our reserves. This issue is particularly problematic for the Natterjack toad (*Epidalea calamita*) in a nature reserve near Toadhampton, Toadshire, UK (Figure S1).

2. Gather Evidence

What does the available evidence suggest about the likely effectiveness, costs, acceptability, and feasibility of different potential actions?

This second step comprises several subsections, where the tool prompts users to consider different forms of evidence (Table 1) to assess the suitability of potential actions to achieve the focal targets and goals defined in the previous step. In section 2.A., users are asked to first identify a wide range of potential actions, and then in subsections 2.B–2.G. they can assess whether the implementation of each action is supported by the available evidence. These subsections include the consideration of the desirable and undesirable effects on the focal target, and the costs, acceptability, and feasibility of each action. By considering the evidence, users can also identify whether certain modifications to each action are required. By the end of this step, users will have summarized and assessed the available evidence, providing the basis on which to make an evidence-based decision in the third and final step. For steps 2.B–2.F, users will provide simple summary scores for different sections (including the uncertainty associated with the evidence), which will be tabulated in the third and final step to help them make their decision.

It is important to note that if the user cannot access or find sufficient evidence to include in any of the subsequent sections, then the user should note this and make this added uncertainty in the evidence clear so this can be considered later when making a decision.

2.A Identify potential actions

Which actions could be taken to address the problem?

Before considering the evidence for and against each action, users are asked to identify the potential actions they could take to address the focal targets and ultimate goal defined previously. This helps to ensure that users consider a wide range of potential actions and do not discount or miss out potentially useful actions that they may not have immediately considered (e.g., using techniques such as the "vanishing options test", Red Teaming, Nominal Group Technique (Tanner et al., 2020; Table S4), Solution Scanning (Sutherland et al., 2014), and searching online databases such as Conservation Evidence (www.conservationevidence.com; Sutherland et al., 2019). We suggest that actions are defined broadly at first as later in the tool there will be time to consider if beneficial modifications can be made (2.F) based upon the evidence that has been considered (2.B–2.E). However, if users already have a prior understanding of possible modifications, these can be listed here separately as alternative actions and each considered separately (in this case, section 2.F may still be useful if there are minor, detailed modifications that the evidence suggests may be useful).

Example: We identified three potential management actions: 1. Install culverts or tunnels as road crossings; 2. Install barrier fencing along roads; and 3. Use humans to assist amphibians across roads (Figure S1).

2.B Assess desirable and undesirable effects on the focal target and uncertainty

What do different types of evidence tell us about the desirable and undesirable effects of each action on the focal target? How certain are we of the credibility of this evidence?

Once potential actions have been identified, users are asked to summarize the available evidence on the effects of each action on the focal target and the uncertainty associated with that evidence. The tool prompts users to consider four forms of evidence from different sources: (a.) peer-reviewed primary research; (b.) evidence syntheses and summaries; (c.) the non-peer-reviewed literature (a., b., and c. are collectively termed the "scientific literature"); and (d.) undocumented knowledge (see Table 1 for more detailed definitions and details of additional decision-making factors). Combining these diverse sources of evidence helps users to assess the relevance of evidence from the scientific literature (its local validity), avoids conflicts between different stakeholder needs, and importantly can give local and indigenous communities a sense of ownership over a project or conservation management decision (O'Brien et al., 2021).

TABLE 2 A list of useful resources and guides that provide evidence and advice on evidence use in decision-making

Resource name and reference	Description
A decision-making bias typology https://www.mckinsey.com/~/media/mckinsey/business%20functions/strategy%20and%20corporate%20finance/our%20insights/the%20case%20for%20behavioral%20strategy/most_frequent_biases_in_business.ashx	An infographic summary of different decision-making biases prepared by Dan Lovallo and Olivier Sibony.
Alliance for Conservation Evidence and Sustainability (ACES) website https://www.allianceconservationevidence.org/	A partnership of NGOs and academic institutions committed to transforming how we generate and use evidence to support effective community-based conservation. Their website contains lots of resources and evidence to help decision-makers in community-based conservation.
Applied Ecology Resources https://www.britishecologicalsociety.org/applied-ecology-resources/	A globally accessible open platform to share and discover information on the management of biodiversity and environment to support evidence-based decision making.
CEE Database of Evidence Reviews (CEEDER) https://environmentalevidence.org/ceeder/	An open access evidence service to help evidence consumers find reliable evidence reviews and syntheses to inform their decision making.
CEE Evidence Syntheses https://environmentalevidence.org/completed-reviews/	A digital library containing all systematic reviews and systematic maps that have been approved by CEE.
CEE Plain Language Summaries https://environmentalevidence.org/policy-briefs/	A list of easy-to-read summaries of recent CEE systematic reviews and maps.
Collaboration for Environmental Evidence (CEE) https://environmentalevidence.org/	An open community of stakeholders working toward a sustainable global environment and the conservation of biodiversity. CEE seeks to promote and deliver evidence syntheses on issues of greatest concern to environmental policy and practice as a public service. They primarily conduct systematic reviews and systematic maps.
Conservation Evidence website www.conservationevidence.com	A free, searchable evidence database designed to support decisions about how to maintain and restore global biodiversity. The project summarizes evidence from the scientific literature (studies) about the effects of conservation actions such as methods of habitat or species management and produces synopses of evidence that review the effectiveness of all actions you could implement to conserve a given species group or habitat or to tackle a particular conservation issue. Expert panels assess the effectiveness (or not) of actions, based on the summarized evidence. They also publish new evidence in their online *Conservation Evidence* Journal.
Conservation Measures Partnership Resource Library https://conservationstandards.org/resources/	Website library of resources for a community of conservation-oriented NGOs, government agencies, funders, and private businesses that work collectively to guide conservation around the world. They are stewards of the Conservation Standards, and seek better ways to design, manage, and measure the impacts of conservation action.
Nature-based Solutions Evidence Platform https://www.naturebasedsolutionsevidence.info/	An evidence platform providing an interactive way to filter and search for evidence on nature-based solutions.
Panorama https://panorama.solutions/en	Website for a partnership promoting examples of inspiring, replicable solutions across a range of conservation and development topics, to enable cross-sectoral learning and upscaling of successes.

(Continues)

TABLE 2 (Continued)

Resource name and reference	Description
Tanner, L., Mahajan, S.L., Becker, H., DeMello, N., Komuhangi, C., Mills, M., Masuada, Y., Wilkie, D., & Glew, L. (2020). Making better decisions: How to use evidence in a complex world. The Research People and the Alliance for Conservation Evidence and Sustainability. https://www.allianceconservationevidence.org/s/Making_better_decisions_ACES.pdf	A guide to making better decisions in conservation management.
Tanner, L., Mahajan, S.L., Becker, H., DeMello, N., Komuhangi, C., Mills, M., Masuada, Y., Wilkie, D., & Glew, L. (2020). Knowledge brief: Decision-making biases. The Research People and the Alliance for Conservation Evidence and Sustainability. https://www.allianceconservationevidence.org/s/ACES-Briefing-Biases.pdf	A briefing on how to avoid decision-making biases.
"That's a claim! Key Concepts for thinking critically about environmental claims" website https://thatsaclaim.org/environmental/	A website presenting a visual framework for thinking critically about claims, evidence, and choices and whether they are trustworthy or not.
Conservation Practice Benefit–Cost Templates by the US Department of Agriculture Natural Resources Conservation Service (USDA NRCS) https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/data/?cid=nrcseprd1298864	Templates containing basic qualitative benefit–cost information identified for all 175 NRCS Conservation Practices in the form of one-page documents. These are considered the first step toward an economic or financial analysis and designed so the user can easily review and discuss the benefits and costs of each conservation practice.

Note: This is not designed to be a complete comprehensive list of all resources available, but a starting guide as to what major resources are readily available.

We provide a brief overview of the potential resources that users could access to retrieve and use evidence in Table 2 (which is also present in the tool guide — see Supporting Information). Please note that this is not intended to be a comprehensive list. However, it does cover many of the major and readily accessible resources for evidence in conservation and natural resource management, as well as best practice advice on how to use evidence in decision-making.

We also recognize that using and searching these different sources of evidence may be challenging, even if plain language summaries of evidence are available, due to time and resource constraints. The tool can still be used even if practitioners decide not to, for example, undertake an extensive search of the scientific literature — we discuss this later in Section 4.1. In brief, we suggest investing an appropriate amount of time in gathering evidence relative to the risks involved in making the decision (i.e., using the Strategic Evidence Assessment Framework; Sutherland, Downey, et al., 2021). The value of the tool is that, regardless of the level of time and resources invested in the process, users can document the evidence and reasoning they have used to reach a decision — this will enable scrutiny of the depth and breadth of evidence used from different sources.

Once these sources of evidence have been considered, users can then score the likely local effectiveness of the action and their certainty in their assessment. Users are given several choices, including: Harmful (the action is likely to have undesirable effects on the focal target); Ineffective (the action is unlikely to have desirable effects); Weakly effective (the action is likely to have weak desirable effects); Moderately effective (the action is likely to have moderate desirable effects); Highly effective (the action is likely to have strong desirable effects); Trade-off between benefits and harms (the action is likely to have both desirable and undesirable effects); Unsure (not confident enough to give an effectiveness score, for example, if there is no evidence available). The user will also give certainty scores to rate their confidence and certainty in their effectiveness score, which include the following categories of certainty: Very low (i.e., very low weight of evidence or no evidence available), Low, Moderate, High, and Unsure (not confident enough to rate certainty).

2.B.i Scientific literature

How locally effective is this action likely to be based on evidence from the scientific literature? What is the overall certainty (reliability) of this evidence?

Users are asked to assess the available evidence on the effects of each action from peer-reviewed primary research, evidence syntheses and summaries, and the non-peer-reviewed literature (see Table 1 for definitions). The tool asks users to consider: (i.) the quality of methodological design (internal validity; i.e., how reliable is this evidence?); and (ii.) the relevance of evidence to the question of interest (external validity; would the findings of this evidence apply/generalize to the local setting of interest?).

Critical appraisal of evidence is encouraged — while users are not expected to go back to the original sources of evidence syntheses and summaries, they are asked to think critically about how reliable a given study, synthesis, or summary may be with help from the tool's guidance document (including an evidence hierarchy and common biases to cautious of — see Table S1 and Figure S2 adapted from Cooke et al., 2017 and Mupepele et al., 2016).

Example: *Sources*: Conservation Evidence. Applied Ecology Resources. *Assessment*: On Conservation Evidence, as of 10/10/2021, 32 studies investigated the effectiveness of installing culverts or tunnels as road crossings for amphibians. Most studies (including three replicated studies) in Canada, Germany, Italy, Hungary, and the USA found that installing culverts or tunnels significantly decreased amphibian road deaths; in one study this was the case only when barrier fencing was also installed. Two reports from DEFRA also suggested trials of tunnels showed that they decreased road deaths. These studies and reports were deemed to offer weak-moderate evidence (Figure S2). *Summary*: This action was assessed as being a trade-off between beneficial and harmful on Conservation Evidence by a panel of subject experts. There seems to be variable use of culverts and tunnels by differences species, and in some cases, depending on the design of culverts and tunnels, amphibians can become trapped and die. The evidence base is not that strong and there is uncertainty over whether culverts and tunnels do more harm than good. *Assessment of Effectiveness*: Trade-off between benefits and harms. *Certainty*: Moderate (Figure S1).

2.B.ii Decision-makers' own data, written experience, and monitoring

How locally effective is this action likely to be based on your own monitoring data or notes? What is the overall certainty (reliability) of this evidence?

As for the previous section, here users are asked to assess the reliability and relevance of any evidence they can provide from their own data, monitoring, or written experience (e.g., logbooks or notebooks) on the likely effectiveness of each action. This is separate to the non-peer-reviewed literature as this evidence is usually internal (i.e., collected by the decision-maker or their organization) rather than external, and is documented or recorded in the form of physical data or written observations — hence the distinction from undocumented knowledge (see Table 1).

Example: Our report about a test trial of a tunnel under the old road didn't record any Natterjack toads. *Assessment of Effectiveness*: Ineffective. *Certainty*: Moderate (Figure S1).

2.B.iii Undocumented knowledge

How locally effective is this action likely to be based on you and your stakeholders' knowledge? What is the overall certainty (reliability) of this knowledge?

Wheeler and Root-Bernstein (2020) suggest there is "not one unified definition for indigenous and local knowledge beyond it being the knowledge of indigenous and local people which often pertains to social-ecological systems." We use the term "undocumented knowledge" for the purposes of evidence-based decision-making to specify information that is not published or written down, which typically includes a knowledge holder's intuition, experience, wisdom, and values (also known as "tacit" knowledge; Tanner et al., 2020). For example, undocumented knowledge may include evidence that cannot be tied to a specific source or justified by a mechanism or explanation, but is simply "known" by the knowledge holder. This may include forms of Indigenous and Local Knowledge (ILK; Kadykalo, Cooke et al., 2021; Reyes-García & Benyei, 2019; Wheeler & Root-Bernstein, 2020), such as indigenous storytelling (Fernández-Llamazares & Cabeza, 2018). Undocumented knowledge will play a particularly important role when there is little or no evidence available from the scientific literature and where there is concern that the effectiveness of the conservation action may not transfer well to the decision-maker's local context (Christie, Amano, et al., 2021; Gutzat & Dormann, 2020). Users must be careful and considerate to respect the rights and beliefs of indigenous and local communities, as well as other practitioners and local experts, when drawing upon this evidence to use to make decisions, and should try to involve these stakeholders in their decision-making process where possible.

In this section, users are asked to consider evidence from undocumented knowledge on the

likelihood that each action would be effective in the user's local context and critically consider the uncertainty associated with such knowledge. In particular, users are advised to consider how the knowledge holder's experience, expertise, and skillset may affect uncertainty in the evidence they provide — important biases to be aware of are described in the guidance document for the tool and Table S2 adapted from Tanner et al., 2020).

Example: On a neighboring reserve where tunnels were installed, the warden tells me they have not seen any toads use them, and toads continued to cross in large numbers above the road. This is also my understanding from my experience on other reserves I have worked on. *Assessment of Effectiveness*: Ineffective. *Certainty*: Moderate (Figure S1).

2.C Assess costs, risks, and wider benefits

What information and evidence on the costs of this action are available and what does it tell us about its possible financial and wider non-financial risks and consequences?

Now that information has been gathered on the effectiveness of the action, users are asked to consider the likely cost-effectiveness of actions, and the wider effects that each action may have on non-target species, habitats, and stakeholders.

2.C.i Assess financial and resource-based cost-effectiveness

How much does the action cost financially and what are its resource requirements? What is the overall certainty (reliability) of these costs?

Resource requirements and financial costs can be broadly defined as the resources and finances required to implement a conservation action and form the core of assessing the cost-effectiveness of actions (e.g., Murdoch et al., 2007; Cook et al., 2017; Pienkowski et al., 2021). Users are asked to state the direct costs of implementation, which may include labor, time, consumables, overheads, and equipment/capital costs (see Iacona et al., 2018 for a framework for recording direct implementation costs). If relevant, possible opportunity costs (e.g., loss of income), costs of future management and monitoring, and financial benefits are also important to include (e.g., avoided costs such as removing an invasive species and so not having to pay recurrent costs, or financial gains such as ecotourism value and Non-Timber Forest Products from implementing an action). Costs should be recorded alongside useful information (metadata) required to interpret cost data including date, currency, location, discount rates and time horizons if used. Iacona et al. (2018) provide a process for reporting relevant metadata alongside costs.

Users are prompted by the tool to enter cost information from the scientific literature, guidance, and accounts, as well as from practitioners' experience and undocumented knowledge. Often there may be limited published data on the costs of interventions (e.g., White et al, in review; Pienkowski et al., 2021) and in this situation users may need to rely on practitioner experience and other sources of evidence (e.g., IPLC knowledge) to estimate costs. Frameworks for thinking about types of cost and important input data may help with estimation (Iacona et al., 2018). Users are encouraged to state the uncertainty associated with cost estimates (particularly if these are based on old data, taken from a different local context, or are anecdotal) and standardize costs on the same scale (e.g., cost per unit area or effort). Users are asked to score the cost-effectiveness of each action (from very poor to high) and their certainty in this score (as for previous sections).

Example: This action is likely to cost a lot in materials (quotes range from £250 to 350 per 500 mm) and construction labor given our small budget (total capital costs range from £300-900/m for a 10 m tunnel with diameters from 300 to 900 mm, including labor, according to Kirklees Council in "Cost estimation for culverts—summary of evidence report—SC080039/R4" dated 2014). *Assessment of Cost-effectiveness*: Low. *Certainty*: Moderate (Figure S1).

2.C.ii Assess the non-financial costs, risks, and benefits for non-target species, habitats, and stakeholders

What are the wider non-financial costs, risks, and benefits of implementing this action?

Users are prompted to consider any potential undesirable and desirable effects of the action on species, habitats, and stakeholders that are not the focus of the action. For example, negative sociocultural or political outcomes from using pesticides, excluding access, or removing invasive species like reputational costs, loss of access, livelihood, or health costs. There may also be positive social or cultural benefits that the conservation action may provide to local communities or stakeholders that align with the strategic aims of the practitioner or organization (if these were not the focal target of the action — e.g., farmers acting as stewards of their land; O'Brien et al., 2021), or if the action helps promote public engagement and/or citizen science projects — we suggest the US

United States Department of Agriculture Conservation Practice Benefit–Cost Templates (see Table 2) may be useful to consider here (Hein et al., 2020). Costs, risks, and benefits on non-target species and habitats are also important to consider, such as whether types of grazing benefit the focal target (e.g., butterflies) but negatively impact other species (e.g., spiders).

Users will also be able to score the relative balance between these non-financial costs, risks, and benefits on non-targets from the following: costs/risks far greater, costs/risks slightly greater, trade-off between costs/risks and benefits, benefits slightly greater, benefits far greater, and unsure. As for previous sections, they will also be able to score their certainty from very low to high, with an option to select unsure.

Example: Tunnels and culverts could cause mortality in other species of amphibians and animals, but could also save many other species from suffering road mortality. If we use volunteers to help this will cost a lot of volunteer time and effort. *Assessment of wider non-target costs, risks, and benefits*: Trade-off. *Certainty*: Moderate (Figure S1).

2.D Assess acceptability

Are the effects of implementing this action acceptable to all the key stakeholders? Are there sociocultural barriers to implementing this action?

We define acceptability as whether each action aligns to the values held by the practitioner and the key stakeholders (who were identified in Step 1: Define the decision context). Stakeholders will hold many human values (i.e., concepts or beliefs about desirable end states or behaviors that guide their choices and evaluation of outcomes; Schwartz & Bilsky, 1987) — see eight main types of values in Table S3. It is outside the scope of this tool to elicit these values directly from key stakeholders, so we suggest that the user and their organization gathers this information using suitable methods already used by organizations (e.g., formal consultations, focus groups etc. depending on the time available to invest in this process) and summarize the key findings here.

We encourage users to provide background on the important concepts, beliefs, and motivations that stakeholders hold and how these relate to the decision context, and then consider how the potential effects of this action on targets (2.B.) and non-targets (2.C.ii.) align with these values. As for previous sections, users will be able to score their assessment of acceptability (from very low to high) and their certainty in this choice.

Example: Constructing culverts that cause a lot of mortality may lead to negative perceptions of the organization and reserve. Volunteers may not be willing to undertake such an action if they know this is possible. *Assessment of acceptability*: Low. *Certainty*: Moderate (Figure S1).

2.E Assess feasibility

Can this action be successfully accomplished and properly implemented?

Users are asked to assess the feasibility of actions by considering both the costs (2.C) and acceptability (2.D) of the action to the user and key stakeholders. They are prompted to think about not only financial feasibility, but also social and operational feasibility; as in previous sections, users will then score their assessment of feasibility and their confidence in this choice. When assessing the feasibility of each action (and their certainty in this selection), users will be able to choose from the same options as in previous sections (very low to high).

Example: This action is likely to use a considerable amount of our current resources and is unlikely to be achievable within our given budget. *Assessment of feasibility*: Low. *Certainty*: High (Figure S1).

2.F Consider modifications

How can the action be modified based on the previous evidence gathered?

After considering the previous evidence gathered, users are now asked to identify and consider modifications to improve each action's effectiveness, cost-effectiveness, feasibility, and acceptability. Certain scientific studies may have trialed different methods of implementation, or the undocumented knowledge reported by the user may point to a better design or way of undertaking the action. For example, a structural action may also be too expensive to implement using certain materials, but using cheaper alternatives (e.g., suggested by undocumented knowledge) could increase its cost-effectiveness and feasibility. In section 2.A, we suggested that actions could be defined broadly so that in this section beneficial modifications can be considered based upon the evidence gathered in previous sections. However, if users already detailed possible modifications as different potential actions in section 2.A, we suggest that this section could still be used to determine if any additional detailed modifications may be beneficial (i.e., depending on the level of detail specified in section 2.A). Users will be able to score their assessment of the degree to which these modifications could improve this action, as well as their confidence in this choice in the same way as for previous sections.

Example: We could modify the designs of culverts and tunnels to limit mortality — some variation in designs and associated mortality are reported in the scientific literature, which we could investigate further. *Potential for modifications to improve action*: Moderate. *Certainty*: Moderate (Figure S1).

2.G Summarize the likely local effectiveness of action and uncertainty

How likely is this action to be locally effective based on all the evidence gathered? What is the overall level of uncertainty associated with these conclusions?

In this final stage of gathering evidence, the tool helps users summarize the likely local effectiveness of each action (whether modified or not), and the important cost, acceptability, and feasibility considerations. Users are prompted to reflect on the level of uncertainty associated with the evidence for and against the implementation of each action and whether it is sufficient evidence on which to base a decision. At this summarization stage (and in Step 3: Making an Evidence-Based Decision), the tool guide also flags important biases to avoid that often affect organizational decision-making (such biases also affect undocumented knowledge; see Table S2), as well as approaches to counter these biases (see Table S4; adapted from Tanner et al., 2020).

Example: The local effectiveness of installing culverts or tunnels as road crossings to reduce mortality of Natterjack toads on roads is probably low. There was mixed scientific evidence on their effectiveness and concerning findings that they could cause mortality of amphibians and other wildlife, whilst our own report and gathered undocumented knowledge on this action suggest Natterjacks rarely use tunnels to pass under roads. The feasibility of the action is also low due to the financial and resource costs of building these structures. We could also suffer reputational damage if our actions backfire and result in mortality of amphibians and wildlife — making this action relatively unacceptable. We could modify the design of culverts to limit mortality, but the evidence is patchy and weak, and this ultimately seems like a risky choice.

3. Make an Evidence-based Decision

3.A Weigh up the evidence for and against different actions

Which action(s) are the best ones to implement to achieve the focal targets and goals defined at the beginning? Which action(s) should not be implemented? Justify these choices.

In this final step of the tool, the tool prompts users to carefully consider how each action tackles the original decision or problem being considered (in Step 1. Define the Decision Context). This involves weighing up how locally effective, cost-effective, acceptable, and feasible each action and whether its implementation is justified. There are many possible ways to do this, which are discussed below. A summary table is provided which collects the scores provided by users in previous steps (2.B–2.F) and displays them for each action side-by-side to aid comparisons — cells are colored to allow users to visually assess uncertainty in their decision-making (see guidance below).

The tool encourages practitioners to note if actions are: (1.) retaining biodiversity and avoiding impacts, (2.) minimizing impacts, (3.) restoring or remediating impacts, or (4.) compensating for impact or renewing biodiversity (corresponding to the Mitigation and Conservation Hierarchy; Arlidge et al., 2018; Milner-Gulland et al., 2021), and prioritize actions that avoid and minimize threats over restoration and compensatory measures (see Booth et al., 2019). A link to the diagram of this hierarchy is presented within the tool and tool guide.

A summary table is provided that automatically displays the scores (in the online tool) given by users in previous steps (2.B–2.G for each action) to allow a simple comparison across different decision-making factors (in some ways, reflecting a consequence table used in Structured Decision-Making; Schwartz et al. 2018). In addition, users are encouraged to first consider whether there is sufficient certainty in the evidence gathered to make a decision and the risks involved — the summary table helps assess uncertainty through color-coding cells to represent certainty in the evidence gathered previously. For example, if insufficient evidence has been found earlier from the scientific literature or undocumented knowledge (e.g., fields left blank or with very limited information) then this added uncertainty can be taken into consideration here. We therefore encourage users to consider whether undertaking no action may be the optimal strategy, particularly if there is great uncertainty and/or great risk from undertaking any action.

If users believe there is sufficient evidence to support implementing some of the actions, we advise that they could start to determine the optimal actions to use by eliminating actions that are unlikely to be cost-effective (e.g., if they exceed budget limits), particularly where the evidence suggests other actions are either relatively less expensive (and equally effective) or more effective (and equally expensive). Actions that are clearly unacceptable to the practitioner or key stakeholders, or are not feasible to implement could also be rejected relatively early on. Guidance and examples on possible trade-offs between different decision-making

factors are provided in the guidance document.

Example: We have decided to "install barrier fencing along roads". This is because, if implemented properly, the evidence gathered suggests that this action is likely to be locally effective. The costs should lower, and permissions should be received faster, than installing culverts or tunnels. If we target the fencing at strategic positions, and make it high enough so Natterjack toads do not climb over it, we can funnel them to natural watercourses by the road. We will *not* "use humans to assist amphibians across roads" as this has been shown not to prevent population declines elsewhere and might divert volunteers away from more important activities. We also *won't* "install culverts or tunnels as road crossings" because this could lead to mortality of amphibians and other wildlife within the culverts and tunnels, as well as costing a significant amount of money (beyond our budget) and take too much time to get permission to build (Figure S1).

3.B Justify overall decision and next steps

What is the overall decision, what are the next steps, and why?

Once actions have been selected or rejected for implementation, the final step of the tool asks users to summarize and justify their decision. Users are prompted to set out the rationale and evidence behind their decision and to detail the next steps they will take. When deciding on the next steps, we recommend users consider drawing up a strategy to implement the actions they have selected. If there is too much uncertainty to make their decision, we also recommend investing in the use of a more detailed Decision Support Framework or tool to gather and assess the evidence more thoroughly (see Section 4 for suggestions). Users may also wish to consider further research to test possible modifications to a particular action, better understand the risks of implementing an action, or consult more widely with stakeholders on ways to implement different actions to ensure they are cost-effective, acceptable, and feasible.

We recommend that implemented actions are then rigorously evaluated and reported to the wider community as part of the continual generation of evidence, regardless of the outcomes (i.e., positive, negative, or neutral). Many journals facilitate practitioners in publishing reports of tests of conservation actions (e.g., see the *Conservation Evidence* journal, *Ecological Solutions and Evidence, Conservation Science and Practice, and material stored in the British Ecological Society's Applied Ecology Resources*; Cadotte et al., 2020; Sutherland et al., 2020).

Example: We will now investigate the correct height, material, and length of fencing needed and identify key strategic points along the road to place the fencing. We will also request permission to install the fencing and trial it during the next migration season. We aim to report the results of this trial to the wider community by writing up the findings, comparing it to previous years' mortality, and publish this online through an accessible scientific journal or grey literature repository (e.g., *Applied Ecology Resources, Conservation Evidence Journal, Conservation Science and Practice*; Figure S1).

3.C Document and report decision

Using the online tool, users can download a report that details the information they gathered and filled in throughout the entire process. We also provide an offline template version of the tool so that users can also create a documented report of their decision-making process (see Supporting Information). Documenting the evidence, logic, and reasoning behind the decision enables greater transparency in decision making and we suggest that these reports could be stored in "decision libraries." These could be used to disseminate and share information on how past decisions were made to internal and external practitioners, stakeholders, and organizations, enabling practitioners to revisit and reassess decisions based on new evidence or for new projects. This lends itself to the iterative concept of Adaptive Management and links this process in a complementary way to Evidence-Based Conservation (Dubois et al., 2020; Gillson et al., 2019). An example report can be retrieved from navigating to tab "3. Make an Evidence-Based Decision" in the online tool (www.evidence2decisiontool.com).

Example: A report documenting this decision and the process behind it will be created using the online E2D tool and kept so we can revisit the decision in the future.

3.2 | Data sharing and security considerations

We have designed the online tool so that the data inputs and outputs users contribute or generate are not publicly available. The only time that data or text entered into the tool is stored is when the user bookmarks their work; when this occurs, the state of the tool is saved on a private shiny server maintained by Conservation Evidence, accessed via SSH for administration and uses HTTPS (i.e., uses an SSL certificate). This design was made to help keep any private or sensitive data entered by users away from the public domain (given that data

security, particularly that of personal data, is both a legal and a moral duty) and this means that open, transparent, and public scrutiny of decisions made using the tool requires the user and their organization to publish the downloaded reports. We believe, however, that this design will ultimately encourage greater uptake amongst practitioners and organizations that need to comply with data sharing and security legislation and rules when making decisions on sensitive issues, whilst enabling internal scrutiny of decision-making at the very least. Clearly, we would encourage that reports be made public and open access for external scrutiny as soon as possible, potentially with redacted areas if data sharing and security continues is a concern. The open sharing and publication of reports generated by the tool could be used as one desirable (but not essential) step toward accreditation or recognition for evidence use through schemes such as "Evidence Champions" led by the Conservation Evidence project.

4 | DISCUSSION

4.1 | Exploration of strengths, limitations, and proposed use

The E2D tool we have presented here has three key strengths. First, the tool enables users to make the rationale and process behind making decisions explicit and documentable; the online version of the tool allows users to fill in and produce a downloadable report that documents the users' decision-making process. We envisage that this tool could be used by organizations to make "decision libraries" detailing how and when evidence-based decisions were reached, which can be documented and disseminated across the organization, to stakeholders, and other organizations. This would allow others to see the logic and reasoning behind decisions made now and in the past. This is important because future staff or stakeholders can use these reports to look back to see why past decisions were made, and update or modify the reports to help them make decisions in the present or future. The process of documenting the decision-making process could also potentially help share and communicate common issues, successes, and failures, and promote greater sharing of knowledge on best practice in conservation (Schwartz et al., 2019).

Second, it presents a formalized approach to combining evidence from diverse sources on different aspects of a conservation management action's implementation to reach an evidence-based decision. Previously, combining diverse forms of evidence has been a major, controversial challenge for evidence-based decision-making (Gillson et al., 2019; Gutzat & Dormann, 2020), where two different approaches have generally been pursued: (1.) focusing on making generalized recommendations from the scientific literature (which has been criticized for offering "a view from nowhere"; Shapin, 1998); and (2.) focusing almost exclusively on what is perceived as "locally relevant" evidence (Christie, Amano, et al., 2021; Sutherland & Wordley, 2017) that has been derived from the same or very similar specific context to the decision-maker's (such as ILK; Wheeler & Root-Bernstein, 2020). Neither of these approaches is reasonable or realistic in contemporary conservation (Adams & Sandbrook, 2013; Sutherland et al., 2017). If we place too much emphasis on generalized recommendations from scientific evidence, we risk alienating practitioners (reinforcing "a perception of the disconnected ivory tower of science"; Rose, 2018) and ignoring other important forms of locally relevant evidence that can guide decision-making (Adams & Sandbrook, 2013; Wheeler & Root-Bernstein, 2020). Alternatively, if we focus only on highly specific, locally relevant evidence from sources such as undocumented knowledge, we may ignore important scientific evidence, create conflict (e.g., see (Redpath et al., 2013), and limit our knowledge of effective actions to only those that have been conducted locally, potentially leading to misinformed decisions (Cook et al., 2010; Dicks et al., 2014; Persson et al., 2018).

This tool's approach provides a way of harmoniously combining these two differing standpoints, particularly by drawing on the concept of local co-assessment of evidence (Sutherland et al., 2017). This method assesses the local relevance and applicability of scientific evidence to the local setting of interest through directly integrating undocumented knowledge as an equally valuable form of evidence. Our tool further integrates the key factors of feasibility, acceptability, and costs that ultimately play a major role in practitioners' decision-making, facilitating the inclusion of evidence from a diverse group of stakeholders to contribute to an evidence-based decision (Kadykalo, Buxton, et al., 2021; Kadykalo, Cooke, & Young, 2021; Wheeler & Root-Bernstein, 2020). This approach draws upon Aristotle's three intellectual virtues: *episteme* (scientific knowledge), *techne* (technical knowledge or "know how"), and *phronesis* (prudence or wisdom in practice; Flyvbjerg, 2004). By combining these diverse forms of evidence and real-world constraints within a transparent, structured decision-making process, we believe our tool provides a realistic, pragmatic way to facilitate more evidence-based decision-making by conservation practitioners.

The third strength of the tool is its versatility; we have deliberately designed as a generic template that can easily be modified and adapted through collaboration and co-

design to produce customized versions (Rose et al., 2017). As has been demonstrated in medicine (Rosenbaum et al., 2018), this type of tool can be used in situations where there is a great deal of available evidence, and in situations where evidence is severely lacking or absent from any or all sources (e.g., scientific, undocumented knowledge, or otherwise). In either scenario, the abundance, sources, and quality of evidence used to inform decisions can be transparently documented and does not prevent use of the tool. Our collaborative team of researchers and conservation practitioners will continue to ensure that the tool is further refined, adapted, and embedded in the decision-making processes of more conservation organizations by promoting the tool with outreach activities, training, and guidance. We are particularly keen to expand the base of users to beyond those in the UK and USA to integrate more feedback from practitioners working in underrepresented parts of the world, particularly decision-makers who are (or work closely with) Indigenous Peoples and Local Communities (IPLCs). We believe that future work can improve upon the generic template we have developed and make aspects of the process more advanced in a modular fashion. The code used to develop and deploy the tool is open source and available from Zenodo (and linked GitHub repository — see *Data Availability* section).

To make the most of the tool, we strongly recommend that users first consider the Strategic Evidence Assessment Framework (Sutherland, Downey, et al., 2021) to decide how much time they should invest in using the tool, collating evidence, and completing the various different sections. This framework suggests that the time invested in using evidence-based decision-making tools should be scaled based upon the uncertainty and the magnitude of risk associated with a decision (Sutherland, Downey, et al., 2021). The versatility of the tool means that users could spend a great deal of time thoroughly completing each section, or could spend a smaller amount of time quickly reviewing a more constrained set of evidence without a detailed consideration of aspects such as costs for example. This is ultimately the responsibility of the user and their organization to decide based upon weighing up the risks associated with the decision and the uncertainty associated with the likely effectiveness and consequences of any proposed actions.

For decisions carrying great risk and/or there is great uncertainty associated with the impacts of proposed actions, we would recommend that the tool is completed thoroughly alongside other Decision Support Frameworks that practitioners may already use (e.g., the Conservation Standards or structured decision-making tools). Some users suggested that, for decisions carrying high risk or high uncertainty, our tool could be as a starting point from which to implement more complex, comprehensive Decision Support Frameworks to thoroughly interrogate different aspects of the decision-making process (e.g., considering a wider theory of change using the Conservation Standards and Miradi). Equally, if practitioners are comfortable using a certain Decision Support Framework, they could potentially integrate some sections and concepts supplied by our tool's template into their existing processes to inform their decision-making. However, for decisions with low risk and low uncertainty, it may be deemed appropriate to undertake a rapid assessment using our tool of only the evidence that is rapidly and readily available. Either way, the advantage and principle of the tool is that whichever approach is adopted, the details of the evidence and reasoning used is documented and transparent so that it is clear whether the process was a shallow or deep dive into different sources of evidence (Rosenbaum et al., 2018).

Of course, like any decision-support tool, the E2D tool has some limitations. Clearly, it can only act as a guide to users, and we can only encourage (but not enforce) the documentation, reporting, or sharing of their decision-making process. Therefore, the scope for internal and external individuals and organizations to review, quality check, and revisit decisions is the responsibility of the user (see Section 3.2). The tool also cannot stop users selectively picking the types of evidence they consider (e.g., ignoring scientific evidence) or falling foul of several decision-making biases (Tables S2 and S4, also highlighted in the tool), which has catalyzed a movement toward more Evidence-Based Conservation (Cook et al., 2010; Sutherland et al., 2004). However, as has been found in medicine where the concept for this tool originated (Rosenbaum et al., 2018), this limitation should be counteracted by the transparent nature of the tool, enabling others to see exactly what evidence (if any), judgments, and reasoning informed the decision.

4.2 | Current and future links to other decision-making tools and frameworks

The E2D tool was designed to adapt a medical framework, which is typically used to assess whether to recommend the use of treatments and drugs to treat a specific disease, to the case of assessing whether certain conservation actions or interventions are likely to achieve a focal goal. This tool therefore sits within wider decision-making frameworks such as the Conservation Standards (CMP, 2020) and Miradi tool, which address the planning of conservation projects on a more holistic scale using results chains, for example. Our tool can therefore be used within this framework to more directly, and potentially in

greater depth, examine the evidence for and against different alternative conservation actions or interventions to specifically address a single threat or goal. The outputs and decisions from using the E2D tool can then be linked back into the Conservation Standards framework and Miradi tool to consider the wider strategy and how actions may interact. We are committed to future work to directly integrate our tool's process into frameworks such as these and particularly provide tools that explicitly assess the reliability and relevance of diverse sources of evidence (i.e., allowing the direct combination of scientific evidence with undocumented knowledge). We believe that the tool in its current form works best for single project-based decisions with relatively short implementation or decision timescales (e.g., several hours or days to decide what to do) — but of course the tool is designed to be used over a longer timescale, whereby decisions are revisited and reconsidered based upon new evidence and insights, and actions adapted and modified to improve and refine outcomes (i.e., linking Adaptive Management and Evidence-Based Conservation in a complementary way; Gillson et al., 2019; Dubois et al., 2020).

4.3 | Future directions and conclusion

Overall, we believe the power of the E2D tool is to transparently show the evidence and reasoning that were used to make decisions for future reference and enquiry. This lays the foundation for greater internal and external scrutiny of how decisions were made and whether different sources of evidence were missed or ignored (whether intentionally, through ignorance, or issues of accessibility). Ultimately, we hope that the template provided by the E2D tool offers a way forward to making transparent and evidence-based decision-making more routine and mainstream in conservation and natural resource management (as well as other related disciplines).

We also hope that we can encourage more practitioners to use the tool rigorously and integrate diverse sources of evidence into their decision-making (Rose et al., 2017; Sturm & Tscholl, 2019) by creating a community of practice around the tool, along with free accessible guidance on evidence assessment (e.g., in evidence synthesis — see https://synthesistraining.github.io/), and specific training on the tool's use (e.g., via online videos, outreach events, and guidance documents through repositories like Applied Ecology Resources; https://www.britishecologicalsociety.org/applied-ecology-resources/search/; Cadotte et al., 2020). We are pleased to report that many of the practitioners that tested versions of this prototype tool are now working to embed the use of the E2D tool in their organizations' decision-making processes, alongside the use of the Conservation Evidence database and website (www.conservationevidence.com), through the Evidence Champions scheme run by Conservation Evidence. We believe that further work to gather feedback and improvements for our tool and other Decision Support Frameworks (particularly from users from underrepresented backgrounds) is key; we can learn lessons from clinical medicine where inclusive and comprehensive user-testing forms a key component of the ongoing development of interactive E2D frameworks (Rosenbaum et al., 2018). Such work will also help to promote the uptake of the tool amongst a wider, more diverse community of conservation practitioners. We encourage others to modify, apply, and operationalize the tool based on their specific needs so we can better equip, encourage, and help those working on the frontline of conservation to make more transparent decisions based on the best available relevant evidence.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Alec P. Christie and William J. Sutherland conceived the project and the main conceptual ideas. All authors contributed to the design of the framework and to the writing of the manuscript.

DATA AVAILABILITY STATEMENT

Code to reproduce and adapt the Evidence-to-Decision tool is available via Github and permanently indexed on Zenodo: https://doi.org/10.5281/zenodo.5521432. The tool and guidance on its use are freely available from www.evidence2decisiontool.com.

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