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Methods in Ecology and Evolution

PRACTICAL TOOLS

IDEAcology: An interface to streamline and facilitate efficient, rigorous expert elicitation in ecology

Stephanie K. Courtney Jones[1,2] | Sonya R. Geange[1,3,4] | Anca Hanea[5] | James Camac[5] | Victoria Hemming[6] | Ben Doobov[7] | Andrea Leigh[8] | Adrienne B. Nicotra[1]

[1]Division of Ecology and Evolution, Research School of Biology, The Australian National University, Canberra, Australian Capital Territory, Australia; [2]Conservation Research, Environment Policy Sustainable Development Directorate, ACT Government, Canberra, Australian Capital Territory, Australia; [3]Bjerknes Center for Climate Research, Bergen, Norway; [4]Department of Biological Sciences, University of Bergen, Bergen, Norway; [5]Centre of Excellence for Biosecurity Risk Analysis, School of BioSciences, The University of Melbourne, Melbourne, Victoria, Australia; [6]The Martin Conservation Decisions Lab, Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, British Columbia, Canada; [7]Lightning Rock, Mitchell, Canberra, Australia and [8]University of Technology Sydney, School of Life Sciences, Broadway, New South Wales, Australia

Correspondence
Stephanie K. Courtney Jones
Email: sk.courtneyjones@gmail.com

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Abstract

1. Here, we demonstrate how IDEAcology aids in preparing for and implementing a structured expert elicitation using the IDEA protocol, an iterative quantitative expert elicitation framework.
2. Expert judgement is used to inform decision-making on environmental assessment and management when imminent decisions are required, and quantitative data are absent or uninformative. Structured elicitation protocols can help improve the final judgements derived from experts, but they can also be administratively heavy and time-consuming, requiring manual collation of experts' estimates and rationales, construction and dissemination of summary plots for discussion and collating final estimates post-discussion. These challenges highlight the need for a centralised portal that enables synchronous access by all contributors, real-time structured facilitation of discussion, whether in person or online, and streamlined data management.
3. To meet this need, we developed the IDEAcology interface (www.ideacology.com) to support data collation, summary, interactions and ultimately the deployment of structured expert elicitation using the IDEA protocol. The IDEAcology interface is designed to be a central portal for scientists and practitioners to easily implement structured expert elicitation projects, while also facilitating data management by providing a reliable and efficient way for elicitation managers to design and run an elicitation, and for experts to input, visualise and cross-examine estimates.
4. The key advantages that IDEAcology provides include an easy-to-use interface with synchronous access to a single platform, reducing logistic difficulties,

facilitating transparent discussion, improving the accuracy of estimates, enabling fast and efficient reporting by providing analysis-ready data outputs and lastly, flexibility in the types of elicitation questions that can be accommodated in the interface.

KEYWORDS
expert judgement, IDEA protocol, interface, platform, quantitative estimates, structured expert elicitation

1 | INTRODUCTION

Expert judgement is used to inform decisions and assessments when quantitative data are absent or uninformative and decisions are imminent (Burgman, 2016). While expert judgement can be prone to contextual biases and heuristics, which can lead to overconfident and inaccurate assessments (Martin et al., 2012; McBride et al., 2012), judgements can be improved by employing structured elicitation protocols (e.g. Hanea et al., 2021; Morgan, 2014; O'Hagan, 2019). These protocols help experts to communicate their judgements for quantitative and probabilistic questions, along with reasoning to support their judgements. They have been shown to improve the final judgements derived, while also holding the elicitation of expert judgement to the same standards of transparency and repeatability expected of other forms of scientific data generation (e.g. Colson & Cooke, 2017). While several structured elicitation protocols exist and have associated software, they focus predominantly on the analysis outputs (e.g. The Sheffield method with SHELF, O'Hagan et al., 2006; the Classical Model with Excalibur software package, Gosling, 2018; Cooke, 1991; and Elicitator, James et al., 2010); however, there is generally limited or no capability to facilitate elicitation in these software tools (Cooke, 1991; Devilee & Knol, 2012; O'Hagan et al., 2006). In this paper, we describe an interface called 'IDEAcology', created specifically for the IDEA protocol. This interface is designed to facilitate managing an IDEA elicitation, the process prior to statistical analysis.

The IDEA protocol (Investigate, Discuss, Estimate and Aggregate) has been described in length elsewhere (Hemming, Burgman, et al., 2018; Hanea et al., 2017), but we summarise it briefly here to aid in understanding the impetus and key advantages of IDEAcology. IDEA is a structured elicitation protocol modified from the well-established Delphi procedure (Hanea et al., 2018) and was designed to derive judgements of quantitative and probabilistic estimates. Briefly, a group of experts with knowledge of previously defined questions are convened (Figure 1a). The IDEA protocol first asks experts to individually INVESTIGATE the problem before providing an initial private estimate and accompanying rationale (Figure 1b). Next, the experts convene to DISCUSS the anonymised judgements (Figure 1b). Experts are then asked to provide a final revised ESTIMATE, in which they revisit and potentially update their initial judgements (Figure 1b). Finally, expert judgements are AGGREGATED into a quantitative dataset (Figure 1c). The protocol has mostly been applied in ecological and biosecurity applications; however, it can be used outside of these domains in areas such as Defence procurement (Hemming, Armstrong, et al., 2020), metascience (Wintle et al., 2021), peer-review (Marcoci et al., 2022) and food security (Barons & Aspinall, 2020).

1.1 | Key challenges

While IDEA has shown promise in improving judgements of experts, several key challenges in implementing the IDEA protocol may arise when trying to design a survey to capture the expert's initial estimates and rationales. In this section, we elaborate on common hurdles.

1.1.1 | Expert users

Typically, experts are required to provide an upper, lower and best estimate (which form the basis of a credible interval, or a probability distribution). Experts are often not familiar with providing their judgements in these formats (Camac et al., 2021; Low Choy et al., 2009; Revie et al., 2010) and, particularly when elicitation is undertaken remotely without the assistance of a facilitator. This challenge can be overcome by using more interactive methods to help experts visualise and communicate their judgements via graphical feedback on their estimates (Grigore et al., 2017; Hemming, Burgman, et al., 2018; Hemming, Hanea, et al., 2020; Wintle et al., 2013). Similarly, interactive methods can be used to check expert judgements prior to submission (e.g. ensuring best estimates fall within upper and lower limits, or estimates fall within a plausible range). Unfortunately, few programs are available to help collect and collate the judgements of multiple individuals for these formats (an exception being MATCH; Morris et al., 2014). Elicitation managers often, therefore, elicit judgements in a basic spreadsheet format, such as Excel, using standard questions that provide no immediate feedback to experts, or a survey platform that contains some interactive feedback such as slider bars, but typically does not provide the capability to show the experts full estimates in one graphic (e.g. a range and best estimate). A secondary challenge arises with how experts' initial and final estimates are elicited. Online interfaces may require a paid licence (e.g. Qualtrics software, Qualtrics, 2022),

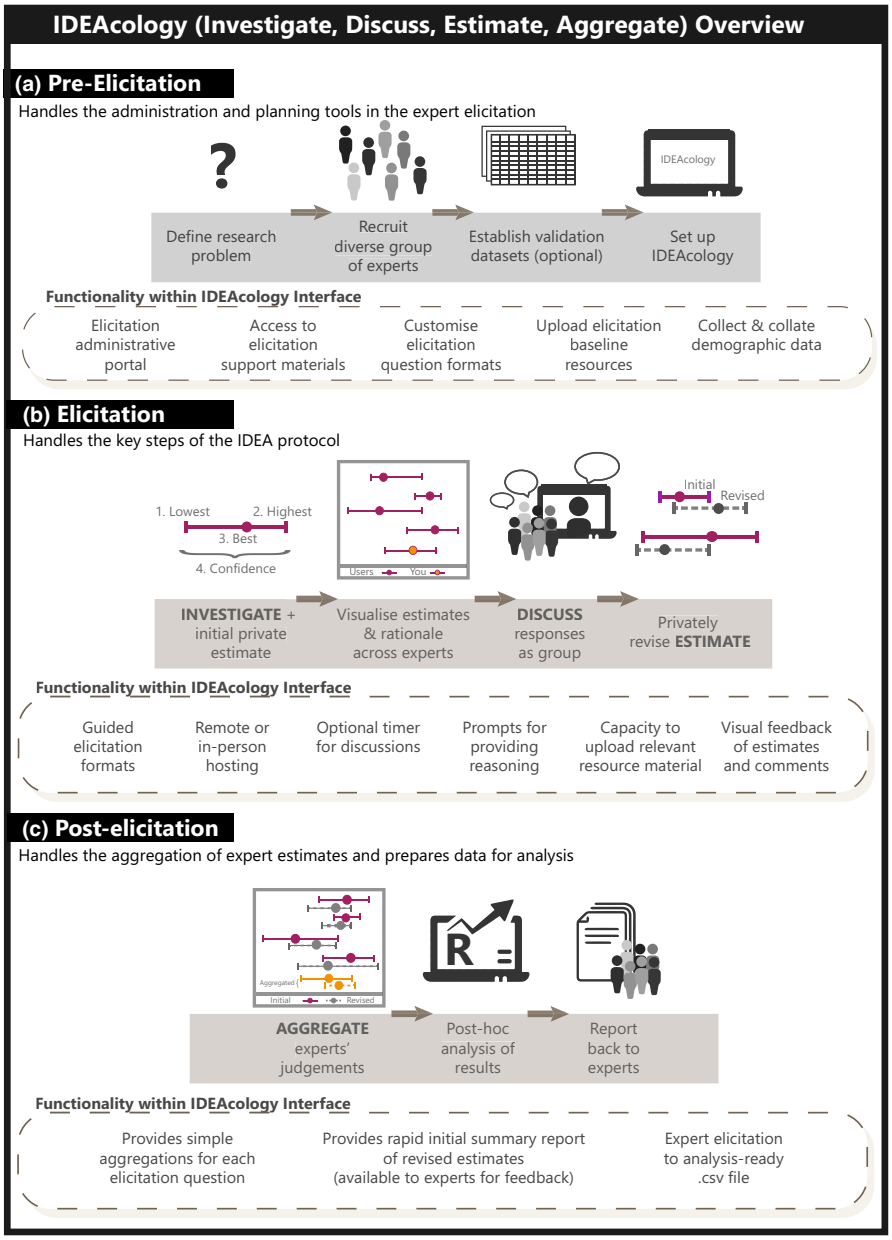


FIGURE 1 Conceptual overview and summary of the key phases for implementing the IDEA protocol (three- or four-step elicitation; briefly detailed in the grey text box) and how functionality within the IDEAcology interface assists in the process (highlighted in the dashed text box below the IDEA protocol information). Three distinct stages in the IDEAcology procedure: (a) *Pre-elicitation* handles the administration and planning tools in the expert elicitation; (b) the *Elicitation* stage handles the key steps of the IDEA protocol; (c) the *Post-elicitation* stage handles the Aggregation of expert estimates and prepares data for analysis.

which can limit who can access these platforms, while free platforms may lack security required by companies, governments, or universities for the storage of personal data. While many online interfaces now provide quick access links for experts, they may not have the capability to protect expert anonymity. Furthermore, those that do provide anonymity may provide a new anonymous unique identifier to an expert for each stage of the elicitation, which can lead to a mismatch in expert initial and final responses if the administrator or elicitation manager has not developed strategies to circumvent this.

1.1.2 | Administrator users and workshop facilitation challenges

While detailed and descriptive instructions for implementing the IDEA protocol and steps exist (Hemming, Burgman, et al., 2018), the elicitation requires attention to detail to help guide experts through the process and avoid misleading or influencing the collection of their judgements. The design and implementation of elicitation can take a considerable amount of time and remains a barrier for many seeking to improve the judgements derived from experts.

Before entering the important DISCUSSION phase, which serves as feedback for experts on their Round 1 judgements relative to the group, the administrator or elicitation manager must collate the individual estimates of experts, check for data anomalies, standardise estimates (e.g. when the four-step question format is used), plot the data, aggregate estimates (if desired) and tabulate rationales provided by the experts for each question into a feedback report. Even when online interfaces are used, these programs do not perform these functions. Instead, data are typically required to be downloaded from the platform and manually processed, which can be time consuming and prone to errors. An R

package (aggreCAT; Gould et al., 2021) and R code currently exist to do this (Hemming, 2019), but the code almost always needs to be adapted to the unique design of the elicitation requirements (e.g. to align with different data exportation formats of online survey platforms). If elicitation takes place remotely, then time may be available to adapt code (or manually input the data) and check the outputs. However, when face-to-face elicitation is undertaken, Round 1 feedback reports may need to be generated within a short period (e.g. 15-min break by the experts). This process is currently aided by preparing code to generate feedback reports prior to the workshop, but it is not uncommon for there to be syntax errors in expert responses, or oversights in the code that produce errors, which need to be rapidly corrected, resulting in delays in the elicitation process.

Once Round 1 feedback reports are prepared, experts usually need to have the Round 1 feedback open while the responses to each question are discussed. In a workshop environment this means experts require a second screen or tab to simultaneously update their Round 2 judgements. This can be tiresome for experts as they flick back and forth between documents on a single screen. For remote elicitation (where experts cannot be convened in the one location), the challenge lies with how to best facilitate discussion and interaction. Voice over Internet Protocol (VoIP) mediated technologies (e.g. Zoom, Zoom Video Communications Inc., 2021; or Microsoft Teams, Microsoft, 2022) enable experts to discuss their responses synchronously. Again, however, experts are required to switch between open windows or software programs to update their estimates during a workshop. Often all or some of the discussion needs to take place asynchronously and this requires facilitators to either collate comments and distribute to experts via email (McBride et al., 2012), which can stifle discussion (Hemming, Burgman, et al., 2018) and clog email boxes. Alternatively, an additional online interface, for example, a Slack workspace (Slack Technologies, 2022) can enable experts to communicate with each other more interactively via tagging and real time discussion updates; however, this requires setting up yet another interface and experts learning the nuances of using it.

1.1.3 | Post-elicitation

The final step of the IDEA protocol involves AGGREGATING the judgements after the experts submit their second private estimate. It is important to note that the IDEA protocol specifies that there is no pressure for experts to reach consensus, there is no 'behavioural aggregation'. Rather, during the discussion phase, the facilitator encourages open conversation and exploration of the rationale behind different estimates so the experts can reach their own conclusions (Clemen & Winkler, 1999; Hanea et al., 2017; Hanea et al., 2018). This creates a challenge in aggregating the variable estimates of experts. There are multiple ways that expert judgement can be aggregated, for example, quantile averaging or expert weighting (refer to Cooke, 1991; Hemming, Hanea, et al., 2020; McAndrew et al., 2021; Hanea, Wilkinson, et al., 2021; Hemming, Hanea et al., 2021). There still is a requirement to download and store data from the elicitation in a format that can be readily used by other software packages.

2 | THE IDEACOLOGY INTERFACE

The IDEAcology interface was designed as a template to plan and facilitate the implementation of the IDEA protocol by reducing logistical difficulties and providing a reliable and efficient way for experts to input, visualise and cross-examine the estimates of their peers, reducing ambiguity, while also facilitating data management.

In designing the IDEAcology interface, we sought to implement the following processes in a dedicated platform: (i) simplify the expert elicitation process, including streamlined pre-elicitation project management; (ii) meet ethics and confidentiality requirements; (iii) foster transparent discussion among experts; (iv) facilitate data management and (v) provide fast and efficient reporting back to experts and (vi) provide cost-effective quantitative assessments in both face-to-face and remote formats with comparable efficacy. All these processes aimed to improve accessibility of, and practitioner engagement with scientific information (Walsh et al., 2015). The IDEAcology interface, including training materials, can be freely accessed here: www.ideacology.com. Standard use of the IDEAcology platform is free to access; however, customised features are possible (e.g. more secure database facilities) with an associated administration fee.

As we developed and trialled the IDEAcology interface, we incorporated user feedback from administrators and experts. This feedback was used to improve accessibility and logic of the elicitation process. For example, in discussion with practitioners and researchers routinely running expert elicitations using the IDEA protocol, there was a need for flexibility in the type of elicitation questions possible to account for use in a wide range of ecological questions and management applications. In addition, there was a need for visualisation tools for the INVESTIGATION phase of the expert estimates to provide illustrative feedback and to facilitate interaction and discussion among experts during the DISCUSSION phase. During beta-phase tests of the interface, expert users noted the benefit of having the interface embedded in the discussion process, with real-time data visualisation: '*The percent cover visualization is really useful, as is the translation into number of individuals*'; '*Good to see everyone's scores together…*'; '*Great to have the online elicitation tool as part of the discussions…*'; '*I think the [interface] is really useful… I really enjoyed being able to see everyone's thoughts together on the same page, and thought it was a great way to ground discussion*' (expert interface user comments on using IDEAcology during INVESTIGATE and DISCUSSION phases, 2019).

3 | IDEACOLOGY WORKFLOW

Here, we outline the workflow of the IDEAcology interface and how it assists in the implementation of the IDEA protocol. The structure

of the interface aligns with the four phases of the IDEA protocol: INVESTIGATION, DISCUSSION, ESTIMATION and AGGREGATION.

3.1 | Pre-elicitation in IDEAcology

3.1.1 | Administrator users

IDEAcology has an administrator portal that guides the project team through the development of an expert elicitation process. Where possible, the pre-elicitation process is automated, including sending email invites for experts to register on the interface, email alerts to experts for elicitations and access for experts to the ethics documentation and requirement to sign an online ethics form. The administrator portal includes the planning tools needed in preparation for the elicitation (e.g. ethics requirements, data storage, project materials; see Hemming, Burgman, et al., 2018 for detailed description). The 'project material' section supports customisable formats for elicitation questions and visualisation tools to suit end-user needs (Figure 1a) and enables the project team to upload resources, to provide shared baseline information that experts can use to inform their quantitative estimates. A wide variety of question formats can be supported, so long as the answers are quantitative estimates that can be presented numerically as lower, higher and best estimates. IDEAcology supplies a range of support materials, including training manuals, tutorials, examples of ethics approvals, resource pages and template user consent forms and agreements. Additionally, Administrator users can provide materials to use to familarise experts with the elicitation process and question format; for example, practice questions to build familiarity with the types of questions and numerical quantities or probabilities (Hemming, Burgman, et al., 2018; Cooke, 1991; see Section 5 for example question and response formats).

3.1.2 | Expert users

Once an expert has electronically accepted an invitation and completed the user agreement, IDEAcology guides them through registration on the interface. The interface collects and collates customisable demographic information, which can be used to keep track of the group diversity and mitigate potential bias in expert selection. This may include, for example, experience and skills of experts provided in a description or quantitative format (e.g. years of experience) or type of experience (modelling, field surveys, management, laboratory etc.), gender, age and self-rating of experience (Hemming, Burgman, et al., 2018; Hemming, Walshe, et al., 2018). This information is stored securely to comply with ethical considerations (see *Interface Availability* for more details on data storage and compliance). In experimental settings, it may also be used to explore correlates of judgement with demographic variables (Burgman, Carr et al., 2011; Burgman, McBride, et al., 2011; Hemming, Burgman, et al., 2018; McBride et al., 2012; Mellers et al., 2015).

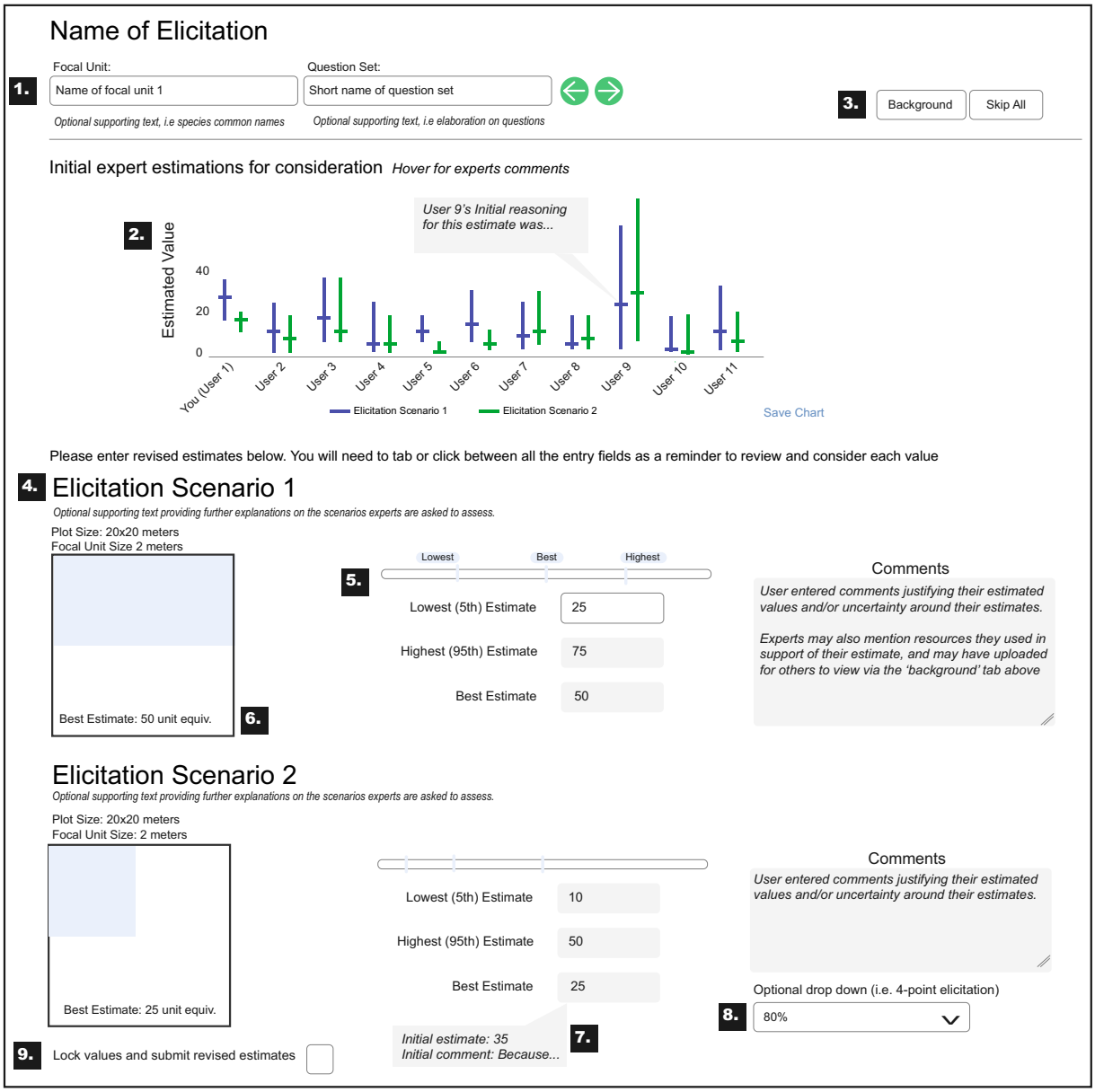
3.2 | Elicitation in IDEAcology

3.2.1 | Expert users

IDEAcology guides the experts through the INVESTIGATION, DISCUSSION and ESTIMATION phases of the IDEA protocol. At the beginning of the elicitation, experts can be provided with access to the practice questions and general knowledge resources to provide shared baseline information (e.g. species-specific information or distribution data).

INVESTIGATION: The interface guides experts through the elicitation to provide their initial estimates in a prescribed order (upper and lower limits first, then best estimate), which (1) reduces the chance that users will anchor on their first or best estimate, which may be influenced strongly by availability bias (Figure 2) and (2) prevents best estimates occurring outside an expert's prescribed bounds. The process uses either a three-point (the lower and upper bounds followed by best estimate) or four-point (the lower and upper bounds, best estimate and estimated confidence) elicitation method (Camac et al., 2021; James et al., 2010; Low Choy et al., 2009; McBride et al., 2012). To provide illustrative feedback, the experts' estimates are plotted (e.g. Figure 2), helping to address inconsistency and/or confusion in interpreting bounds and confidence in the expert's own estimates (Camac et al., 2021; McBride et al., 2012; Wintle et al., 2013). The expert is also prompted to make notes explaining the reasoning behind their estimates and may be asked to rate their experience with the subject matter, or to make a personal assessment of their confidence in their estimate (Figure 2). The experts are also able to upload any associated resource material in support of their estimates, which can then be accessed by other experts during the discussion phase (Camac et al., 2021; Hemming, Armstrong, et al., 2020). In some cases, the elicitation manager may choose to give experts the option to skip questions that are outside their expertise. Experts can enter estimates at their own pace and to edit until they have submitted the values.

DISCUSSION: The initial estimates, explanations and resource materials uploaded by experts aid discussion of similarities and differences among expert estimates. The facilitated discussion phase of the elicitation can be conducted in person or remotely via an online video conferencing platform, enabling the recruitment of individuals with relevant and diverse expertise and potentially saving expert time (Hemming, Armstrong, et al., 2020; Hemming, Burgman, et al., 2018). The interface presents a visualisation of the initial estimates from all experts (Figures 1b and 2) as well as a collated set of anonymised rationales. The screen shows the lower, upper and best estimates of all experts side-by-side, with experts numbered to protect anonymity, a cornerstone of the Delphi procedure (Hanea et al., 2018). The visualisation tool provides a representation of the uncertainty surrounding best estimates through the lower and upper estimates for each expert, which may be attributable to different schools of thought, disciplinary background and professional context. Further, visualisation of expert estimates alongside the anonymised rationales offers opportunities to cross-examine peer



Legend to the IDEAcology interface: Discussion phase example

1. Focal unit drop down list
Choose what focal unit questions to view during the elicitatation

2. Compiled expert initial estimates
Visualization of each user's initial estimate for a scenario, with comments justifying their decisions.

3. Access to uploaded resources
If any of the experts provided contextual material during their initial estimate it can be found here for reference, i.e. PDFs

4. Multiple scenario options
Titles reflect elicititation scenario structures, i.e. time based contrasts (current vs. future distributions); spatial (urban vs. natural landscapes), with supporting details in smaller text

5. Prescribed estimate formats
User must enter values in pre-determined order, i.e. lower, upper, best, confidence

Entered values are reflected in sliding scale (customized axis limits) and visualization plot

6. Visualization support tools
Plot options can reflect user estimates using area or abundance plots, which integrate user-defined focal unit and plot estimates for scaling

Plots toggle between currently entered lowest, best and upper estimates and text indicates current option displayed

7. Integratation between initial and revised estimates
Cells display initial estimate value prior to entering revised values, and comments can be retrieved by hovering over cell

8. Optional dropdown box
Can be used for 4-point elicitation (% confidence), or to ask supporting questions, i.e. assess familiarity with focal units or scenarios

9. Saving structure
Users may save each focal units value before moving on to the next focal unit

Values aren't finalized until the elicitation manager closes the elicitation enabling revisitation

FIGURE 2 An example of an expert elicitation using the IDEAcology interface. Here experts can view a visualisation of the collated initial experts' estimates, with users anonymised by number. This visualisation is used during the DISCUSSION phase to aid discussion of similarities and differences among expert estimates. Below the visualised initial estimates, experts' view the panel to re-assess their initial estimates. Numbers in the legend to the IDEAcology interface highlight and detail the key features of the interface.

estimates and unfounded assumptions, as well as identify sources of ambiguity or new information to help mitigate subjective biases in the expert elicitation process. Each question has an optional timer window (minutes in real time during the DISCUSSION phase, possible either online or face-to-face) that can be set and paused by the facilitator to keep discussions focused.

ESTIMATION: With the IDEAcology interface, experts can privately review and reassess their initial estimates either during or following the discussion. While revision of the initial estimates is required, estimates do not have to be changed (i.e. consensus is not required). A growing body of evidence suggests that experts tend to anchor on their initial judgements, with those updating their judgements following insights from the discussion typically moving towards the realised truth (Burgman, McBride, et al., 2011; Hemming, Armstrong, et al., 2020; Hemming, Walshe, et al., 2018; Wintle et al., 2021). To prompt the expert to actively revise estimates, the elicitation form displays their initial estimates and rationale and requires the estimates to be actively re-entered (following the same format as in the INVESTIGATION phase). The interface also requires the expert to enter additional reasoning to justify changes from their initial estimates, or lack thereof, based on insights shared during discussions within the DISCUSSION phase. Once experts have completed and submitted their revisions, the values are locked and are unable to be changed (Figure 2).

3.3 | Post-elicitation in IDEAcology

AGGREGATION: Aggregation and analysis of expert elicitation requires a contextualised approach and project teams may prefer to analyse the information gained from expert elicitation in a different and more nuanced way. While the IDEA protocol ends with a mathematical aggregation of the estimates, no specific type of aggregation is prescribed by IDEA. The IDEAcology platform aggregates expert estimates using the commonly used equal weighted quantile aggregation method (O'Hagan et al., 2006). This aggregation method calculates the mean lower, upper and best estimates across experts. These summarised statistics, in combination with expert individual estimates, are used during the Discussion stage. Quantile averaging is also applied to the final round of estimates and can be exported as a separate summary statistic .csv file. Alternative aggregation methods such as linear pooling using equal weighting or performance-based weighting (when using calibration questions with answers known by the elicitation manager, but not by the experts, Cooke, 1991) are not implemented within IDEAcology. Instead, these can be calculated off-platform using specialised software (e.g. Excalibur: Hemming, Armstrong, et al., 2020; aggreCAT: Gould et al., 2021).

3.4 | Analysis-ready data outputs

While IDEAcology provides strong support, there are still aspects of the elicitation process that cannot be proceduralised within the IDEAcology interface. For example, IDEAcology will only provide a simple aggregation at the conclusion of the elicitation process; however, the IDEAcology analysis-ready data output allows administrators to plug into a different tool and aggregate with the most appropriate aggregation method (Figure 1c). When calibration questions are used (and included in the pre-elicitation set up and preparation stage), IDEAcology data output includes expert estimates and calibration data compiled into the same data format, allowing the .csv data to be accessed and used within packages that calculate performance weighted aggregations.

The IDEA protocol and subsequently IDEAcology were designed to support elicitation of quantitative and probabilistic estimates; for example, estimating consequences of different decision alternatives or parameters in models. This assumes that many of the qualitative judgements required to structure the question or the model are made prior to embarking on an elicitation (Hanea, Wilkinson, et al., 2021; Mukherjee et al., 2018; Nyumba et al., 2018; Sutherland et al., 2018). To help explain the estimates provided by experts and stimulate discussion, qualitative rationales are also collected for each question asked.

While there has been significant attention to qualitative methods for expert elicitation, the steps involved in collecting, cleaning and aggregating this quantitative data are often unique to quantitative expert elicitation and may not translate across to qualitative methods. Despite this, the platform does support the collection of qualitative rationales and evidence to help support and explain quantitative estimates and stimulate the discussion phase. This enables the project team to better understand the justification for judgements provided by experts, and if desired to use the collated set of anonymised notes of expert rationale in the raw data in a .csv format to text mine (Curtis et al., 2018; Eichstaedt et al., 2018; Wintle et al., 2021) independent of the IDEAcology interface.

4 | IDEACOLOGY USE IN CONSERVATION AND NATURAL RESOURCE MANAGEMENT

We have engineered flexibility in the types of questions that can be accommodated in the interface based on feedback on beta prototypes and recognising the need to accommodate a wide range of ecological questions and management applications. By providing an interface, we aim to increase the uptake of structured expert elicitation to support decision making in conservation and management. Possible conservation and management questions

to which IDEAcology could be applied include estimation of differences in abundance (e.g. Adams-Hosking et al., 2016), distributional changes (e.g. Cummings et al., 2020) and response to multiple drivers of ecosystem change (e.g. Legge et al., 2022; Singh et al., 2017). Quantitative estimates can be sought for differing habitats or ecosystem services (e.g. Armoškaitė et al., 2020), extinction risk (e.g. Geyle et al., 2021), uncertainty surrounding environmental models (e.g. Refsgaard et al., 2006), exposure to environmental perturbations or disturbances (e.g. Donovan et al., 2016; Petit et al., 2020) or management interventions or thresholds (e.g. Bolam et al., 2021; Dorrough et al., 2020). For example, an application of IDEAcology may be quantifying best practice management interventions for best efficacy (Camac et al., 2021) or define thresholds in monitored variables to indicate when and where management or intervention is required, that is, decision triggers to facilitate timely responses (e.g. Foster, O'Loughlin et al., 2019).

5 | CONCLUSIONS

Expert judgement has great potential to inform a range of conservation and natural resource management applications. Indeed, structured expert elicitations such as the IDEA structured protocol, are routine to augment and expedite empirical resources when imminent decisions are required, yet quantitative data are absent or uninformative. One of the key hurdles to implementation of the IDEA structured protocol is that there is no streamlined approach to the elicitation, analysis and feedback of estimates provided by experts, with elicitation managers often using a combination of Excel and survey platforms combined with manual data entry or R-coding to provide feedback. These manual processes typically pose a barrier for uptake of the protocol or can lead to mistakes being made. Hence our focus on developing the IDEAcology interface was to support and streamline this process.

The IDEAcology interface was designed to improve uptake and application of the IDEA protocol as a pragmatic basis to facilitate conservation and natural resource management decision making and policy (Camac et al., 2021). The flexibility and user-friendly nature of the interface provides multiple benefits such as automated visualisations of the initial individual and aggregated expert judgements and analysis-ready data outputs at the conclusion of elicitations. This in turn reduces the time between elicitation phases and streamlines the deployment of the IDEA protocol for fast and efficient reporting that can be used to inform recommendations for future directions in research and management.

AUTHOR CONTRIBUTIONS

Adrienne Nicotra, James Camac, Sonya Geange and Anca Hanea conceived the project and developed early iterations of the work. All authors contributed to interface design, development and testing. James Camac and Anca Hanea advised on the quantitative components of IDEAcology. Stephanie Courtney Jones wrote the initial drafts with writing contributions from all authors.

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CONFLICT OF INTEREST STATEMENT

We declare no conflict of interest.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/2041-210X.14017.

DATA AVAILABILITY STATEMENT

The IDEAcology interface and further information, including training materials can be found at http://www.ideacology.com/. IDEAcology works across multiple platforms (Windows and Mac compatible) and browsers and is designed to be compatible with as many different devices as possible, including computers, laptops and handheld devices (tablets and smartphones). The interface is cloud-based, removing any infrastructure requirements and ensuring ready availability, aside from the need for internet connectivity. IDEAcology is a cloud-based solution and consists of a web-based frontend with a database backend (often referred to as a two-tier architecture). All data within the system are stored in the backend database. The database itself is highly locked down following industry standard methodologies to ensure security and confidentiality of the data. The database can only be accessed directly by Lighting Rock (the company developing the interface) technical personnel. The system is compliant with the General Data Protection Regulation (GDPR); however, it should be noted that the GDPR is mostly a framework of rules that apply to how organisations manage data and the technical implementation is only a small part of this. Users have the option to delete their personal data from the system in the profile section; however, they are instructed to contact the elicitation manager or a site administrator if they want their data removed from specific elicitations (personal data are not stored in elicitations).

All data collected can be securely stored in a cloud-based database to ensure data integrity and reliability. Importantly, the project team can specify the hosting arrangements depending on their security needs, for example, an internal provider or in-country cloud provider. The system enables trained users to create and

manage elicitations without ongoing technical assistance from the developers.

ORCID

Stephanie K. Courtney Jones https://orcid.org/0000-0002-0905-0624
Sonya R. Geange https://orcid.org/0000-0001-5344-7234
Anca Hanea https://orcid.org/0000-0003-3870-5949
James Camac https://orcid.org/0000-0003-4785-0742
Victoria Hemming https://orcid.org/0000-0003-3220-6161
Andrea Leigh https://orcid.org/0000-0003-3568-2606
Adrienne B. Nicotra https://orcid.org/0000-0001-6578-369X

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