Appendices

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Appendix A Aligning the ccviR with COSEWIC Assessments and Recovery Planning

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is responsible for preparing assessments for nominated species across Canada. A status report includes the best available information on the wildlife species in Canada, an evaluation of the relative impact of direct threats to a species (including the threat of climate change, and the species vulnerability), and an assessment of the status of the species (e.g., extinct, extirpated, endangered, threatened, special concern, not enough information to make a determination, or the species is not at risk). Once prepared, status reports are delivered to the competent minister. The report provides plays a role in subsequent SARA processes, such as listing, recovery, and permitting.

This section explores opportunities and challenges to utilise the outputs of the ccviR to inform COSEWIC assessments and recovery planning for threatened species across Canada. We focus primarily on the use of the ccviR to inform the assessment of threats within a COSEWIC report, using the International Union for Conservation of Nature-Conservation Measures Partnership (IUCN-CMP) unified threats classification system, we then explore other areas of the COSEWIC status reports and recovery planning that information from the ccviR may be useful. While climate change vulnerability is a component of the broader threat assessment of a COSEWIC status report it involves a distinct assessment process, we therefore discuss this separately in Section A.2.1 below.

A.1 Using the ccviR to inform the assessment of threats

To understand the opportunities to integrate the ccviR with COSEWIC assessment of threats (using the IUCN-CMP unified threats classification system), we start with a description of both processes and conclude with a summary of key differences and potential solutions.

A.1.1 Calculating vulnerability with the ccviR

See Section 7.1 of the ccviR website for a detailed description of scoring the CCVI.

A.1.2 Assessments of threats using the IUCN-CMP unified threat classification scheme

The main threat assessment component of the COSEWIC assessment follows the IUCN-CMP (International Union for Conservation of Nature-Conservation Measures Partnership) unified threats classification system. COSEWIC currently utilises Version 1.0 of the IUCN-CMP, but this will be updated to Version 4.0 (Salafsky et al., 2025). We therefore focus our review on the categories used in Version 4.0 of the IUCN-CMP threat classification system.

The unified threat classification system identifies proximate/direct threats acting on a species across 11 broad categories (described as Level 1 threats); one of these categories relates specifically to climate change (Threat 11). Each Level 1 category is further divided into Level 2 categories. For climate change there are three Level 2 categories:

- **11.1 Changes in Physical and Chemical Regimes.** *Includes: ocean acidification, shifting aquatic oxygen minimum zone, changes in salinity, changes in atmospheric CO2 affecting plant growth, loss of sediment, changes in ocean currents, changes in jet stream, changes in cloud cover.*
- **11.2 Changes in Temperature Regimes.** *Includes: heat waves, cold spells, freeze/thaw cycles, oceanic temperature changes, marine heat blobs, loss of snowpack or glaciers, melting of sea ice.*
- **11.3 Changes in Precipitation & Hydrological Regimes.** *Includes: rainfall patterns, droughts, timing of rains, reduced snow accumulation, increased severity of floods, sea-level rise, shrinkage or loss of lakes.*

Each category of threat is assessed according to their 'scope' (**Table 1**), 'severity' (**Table 2**), and 'timing' (**Table 3**). Scope and severity are then combined to determine a level of 'impact' to the species abundance or occurrences based on a confusion matrix (**Table 4**). The threat is typically assessed across the whole of the species' Canadian range, although for genetically distinct or wide-ranging species assessment of sub-populations and/or threat locations (refer to table **Error! Reference source not found.** for a definition) may also be undertaken (COSEWIC, 2021a). The assessment also focuses on the level of severity experienced in three generations or 10 years whichever is longer.

Table 1 Scope as assessed using the IUCN-CMP threat calculator (WLRS, 2023)

Category	Definition
Pervasive	Affects all or most (71–100%) of the total population or occurrences
Large	Affects much (31–70%) of the total population or occurrences
Restricted	Affects some (11–30%) of the total population or occurrences
Small	Affects a small (1–10%) proportion of the total population or occurrences
Negligible	Affects a negligible (< 1%) proportion of the total population or occurrences

Table 2 Severity as assessed using the IUCN-CMP threat calculator (WLRS, 2023)

Category	Definition
Extreme	Within the scope, the threat is likely to destroy or eliminate the occurrences, of an ecological community, system, or species, or reduce the species population by 71-100%
Serious	Within the scope, the threat is likely to seriously degrade/reduce the affected occurrences or habitat or, for species, or reduce the species population by 31–70%
Moderate	Within the scope, the threat is likely to moderately degrade/reduce the affected occurrences or habitat or, for species, or reduce the species population by 11–30%

Slight	Within the scope, the threat is likely to only slightly degrade/reduce the affected occurrences or habitat or, for species, or reduce the species population by 1–10%
Negligible	Within the scope, the threat is likely to negligibly degrade/reduce the affected occurrences or habitat or, for species, or reduce the species population by <1%
Neutral or Potential benefit	Within the scope, the threat is likely to improve or not affect occurrences or habitat or, for species, to be neutral or to improve (a net benefit) the species population by >0%)

Table 3 Timing as assessed using the IUCN-CMP threat calculator (WLRS, 2023)

Category	Definition
High	Continuing
Moderate	Only in the future (could happen in the short term [< 10 years or 3 generations]), or now suspended (could come back in the short term)
Low	Only in the future (could happen in the long term), or now suspended (could come back in the long term)
Insignificant / Negligible	Only in the past and unlikely to return, or no direct effect but limiting

Table 4 Impact as assessed using the IUCN-CMP threat calculator

		Scope					
		Pervasive	Large	Restricted	Small	Negligible	Unknown
Severity	Extreme	Very High	High	Medium	Low	Negligible	Unknown
	Serious	High	High	Medium	Low	Negligible	Unknown
	Slight	Medium	Medium	Low	Low	Negligible	Unknown
	Negligible	Low	Low	Low	Low	Negligible	Unknown
	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Neutral or potential benefit	Not a threat	Not a threat	Not a threat	Not a threat	Not a threat	Unknown

A.1.3 Using the ccviR to inform the IUCN-CMP threat classification assessment.

While the vulnerability rating from the ccviR and the assessment of climate impacts from the COSEWIC assessment are likely to be correlated there are critical differences between the two processes that limit their direct alignment. Based on our review, we identified the following key differences, implications, and potential remedies:

1) **Spatial scales**

   COSEWIC:

   - Assesses the Canadian range of the species using the Extent of Occurrence (EOO) and Area of Occupancy although may also include assessments at a sub-population or threat location.

- Requires assessors to follow standardised guidance for creating and choosing spatial data at these scales.
- The assessment area is the whole range for the species, sub-population or threat location.

The ccviR:

- Provides flexibility in defining the species range (within North America) to facilitate rapid assessment.
- Assesses the impacts of climate change to the range within the defined assessment area (which may only capture a portion of the species range).

The implications of these differences:

- The species range polygon from an existing ccviR assessment may not reflect the range requirements for a COSEWIC assessment.
- The ccviR polygon provides information on impact across the range, not specifically on occurrences within the defined range.
- Some responses in the ccviR (including questions related to sensitivity and adaptive capacity) may change as a result of changing the species range (for example, barriers around the species range) requiring some of these questions to be reassessed if the range is adjusted.

Potential pathways forward include:

- Use existing ccviR assessments to highlight locations where climate change may be a problem for portion of the species range, and use this to prioritize further investigation.
- Create or update a ccviR assessment with a spatial area that conforms to COSEWIC requirements and
- Review information contained in a ccviR assessment and update to better reflect the context for the updated species range.
- Allow users to either upload information on species occupancy within a range or assume the same thresholds for impacts to the species range as apply to impacts the population in the COSEWIC severity rating.

2) Temporal scales

COSEWIC:

- Considers a timeframe of 10 years or three generations, whichever is longer.

The ccviR:

- Assesses changes to 2050 (from a baseline in 1990).

The implications of these differences:

- The rating from the ccviR may indicate a more extreme change than one experienced by a species across 10 years (e.g., short lived species) or underestimate the level of change experienced for substantially longer-lived species.

Potential pathways forward include:

- Repeating the ccviR assessment with climate data that better represents the timeframe used in the COSEWIC assessment.
- Guide users on how to interpolate the results of a ccviR assessment to consider what the impacts may realistically be within 10 years or three generations.

3) Assessment criteria

COSEWIC assessments:

- Require an impact rating that combines scope and severity:
  - Scope measures the spatial extent of the threat across the population and occurrences (with quantitative ranges)
  - Severity measures the impact of the threat on occurrences or habitat (qualitatively), and the population (quantitatively).
- Assess direct threats only
- Requires threats to be disaggregated into Level 2 headings when possible.

The ccviR:

- Produces a relative (qualitative) rating of climate change vulnerability to a species' *range* (within the assessment area), not occurrences.
- Combines direct and indirect climate threats based on exposure, sensitivity and adaptive capacity.
- Was designed to assess relative climate change vulnerability of species in a rapid manner, and therefore includes four coarse response categories per question to assess vulnerability.

The implications of these differences:

- It can be challenging to map outputs between the two assessments. For example, it is difficult to relate impacts to the species range from the ccviR to the severity categories for occurrence and habitat. Similarly, it cannot be assumed that the highest vulnerability category for the ccviR exactly aligns with the highest threat impact category for COSEWIC.
- The ccviR output considers impacts across the species range or assessment area, not occurrences or populations.
- The ccviR output considers factors that are not relevant to Level 2 climate change threats considered by a COSEWIC assessment (e.g., indirect impacts).
- The questions and the response categories for some ccviR questions may not be informative for assessing COSEWIC severity categories.

Potential pathways forward include:

- Existing ccviR assessments can be used at a high level to indicate whether climate change is potentially a threat requiring more detailed assessment by COSEWIC.
- Select information from the ccviR report could be relevant to informing COSEWIC Level 2 threats.
- If it can be assumed that impacts to a species' range are equally detrimental as impacts to the population (e.g. losing 30% of a species' range is as severe as losing 30% of the species population), then the thresholds from the COSEWIC severity rating for population level impacts could be applied to impacts at a range level produced by the ccviR to determine severity.

Based on our review, we believe the most logical uses of information from current version of the ccviR for COSEWIC threat assessments are:

- 1) To identify that climate change may be a problem for a species, thus triggering a more thorough threat assessment.
- 2) Highlight sources of information that could be considered when making estimates of severity and scope.

A.2 Using the ccviR for other components of COSEWIC status reports

In this section we explore additional areas of the COSEWIC status report where the ccviR may be of use.

A.2.1 Climate Change Vulnerability

COSEWIC guidelines (COSEWIC, 2021a) state that climate change vulnerability is to be explicitly considered as part of the threat component of COSEWIC status assessment assessments. There is a clear opportunity for the ccviR to provide this important information with little to no amendments.

COSEWIC guidelines recommend using the framework proposed by Foden et al., (2013), which like the ccviR, considers exposure, sensitivity and adaptive capacity and applies a trait based assessment (we note the assessment methods differ slightly from the ccviR). While a formal analysis is not required for the vulnerability assessment, using a tool such as the ccviR could help to make these assessments consistent across reports. Importantly, vulnerability assessments can use the temporal scales used in the ccviR.

A.2.2 General Information Contained in a COSEWIC Status Report

COSEWIC Status reports contain general information about a species (**Table 5**). Some of this information aligns with information that is provided by the ccviR (**Error! Reference source not found.**). This information is likely to be somewhat insensitive to mismatches in temporal and spatial scales, or easily adapted, and therefore the ccviR could help to provide some of this information. The extent to which information compiled in a ccviR is useful to this part of a COSEWIC assessment will be improved with clear documentation of the sources of information, methods of assessment, and date of assessment provided by the users.

Table 5 Information contained in a COSEWIC Status report (COSEWIC, 2021a). We have bolded those headings that the ccviR could help to inform.

Section	Sub-sections
Wildlife species description and significance	• **Name and classification** • Morphological and life stage descriptions of the species • The designatable units • Special significance
Aboriginal (Indigenous) Knowledge	• Cultural significance to Indigenous Peoples
Distribution	• **Global / Canadian range** • **Population structure** • **Extent of Occurrence and Area of Occupancy** • Fluctuations and Trends in Distribution
Biology and Habitat use	• **Life cycle and reproduction** • **Habitat requirements** • **Movements, migration, dispersal** • **Interspecific Interactions** • **Physiological, behavioural, and other adaptations**

	• **Limiting factors**
Population size and trends	• **Data sources, methodologies, uncertainties** • Abundance • Fluctuations and trends • Fragmentation • Rescue effect
Threats	• **Current and future threats** • **Number of threat locations**
Protection, status, and recovery actions	• Legal protection and status • Non-legal status and ranks • Land tenure and ownership

A.2.3 Assessments of Status

COSEWIC assesses the status of species (from Extinct to not at risk) (COSEWIC, 2021b). According to Young et al., (2016), the ccviR index was designed to work in concert with these status assessments not to replace them. For example, in prioritizations of management, Young et al., (2016) suggest that among species that scored 'Highly Vulnerable', those more imperiled may be prioritized for management over those less imperiled. Alternatively, information on status and vulnerability could be used to determine the likelihood of recovery actions being successful and therefore the most cost effective actions to take.

Because the ccviR was designed to be used in concert with the COSEWIC status assessments it does not assess factors such as population size, range size, and demographic factors to avoid double counting when considering conservation status alongside vulnerability (Young et al., 2016). Despite this, we believe that some information from the ccviR could be used to help inform status assessments. For example, information on the species range, and the expected change in range size in the future, provided by the ccviR may identify species that are imperiled due to small ranges now or in the future (Criteria B)(COSEWIC, 2021b). Information about exposure, sensitivity, and adaptive capacity, may be used to inform judgements about the trajectory of the species, and the severity of any declines in the population (Criteria A) (COSEWIC, 2021b). Documenting this information in the generated output reports of the ccviR could help to make this information readily available and consistently interpreted.

A.3 Recovery Strategies

In Canada, a recovery strategy is a planning document that identifies what needs to be done to stop and/or reverse the decline of a species listed under the Species at Risk Act (ECCC, 2024). It sets goals and objectives and identifies the key actions to be undertaken. Detailed planning is done at the subsequent action plan stage (ECCC, 2024). In preparing a recovery strategy, the competent Minister may adopt a multi-species or an ecosystem approach. There is no prescribed timeline by when recovery is to be achieved, and there is flexibility in how recovery options are determined and assessed (although assessment of the full EOO is required).

Specifically, a recovery strategy will (ECCC, 2024):

- describe the species and its needs
- identify the threats to survival of the species
- identify the species' critical habitat unless it is not possible to do so

- where critical habitat is identified, provide examples of activities that are likely to result in its destruction
- set the goals, objectives and approaches for the species recovery
- identify information gaps that should be addressed; and
- state when one or more action plans relating to the strategy will be completed

There are opportunities at each stage of recovery planning for the ccviR outputs to be useful. The ccviR can help assessors to understand how climate change will impact the habitat of the species being considered. This could help to identify where critical habitat may be lost, and where it may exist in the future. This will aid in considering climate resilient options for species recovery (e.g., avoiding areas that will become unsuitable in the future). Likewise, options for reducing the impact to species could be evaluated to understand how they are likely to alter exposure, sensitivity, and adaptive capacity and therefore decrease the vulnerability of a species to climate change. In multi-species recovery plans, the index could be used to compare where actions may reduce the vulnerability of multiple species in a region.

A.4 Conclusion

Our review suggests there are both opportunities and challenges to using the ccviR to inform COSEWIC status reports and recovery planning. The most direct use for the ccviR is to inform the climate change vulnerability of a COSEWIC threat assessment. Differences in temporal and spatial scales, as well as difference in assessment criteria make it difficult to align the outputs of the ccviR to inform COSEWIC threat assessments.

Appendix B Deriving more accurate expert judgements

B.1.1 Expert judgement: What is it? When to Use It?

Expert judgement is to inform critically important decisions across an array of domains, from ecology to engineering (Adams-Hosking et al., 2016; Burgman, 2015; Colson and Cooke, 2017; Martin et al., 2012a; O'Hagan, 2019). While expert judgement should not replace the careful collection of data or the thoughtful synthesis of existing evidence it can be useful when these forms of data are not available and decisions need to be made.

B.1.2 Where Does Expert Judgement Enter the ccviR?

Expert judgement enters the ccviR at many stages, including:

- Spatial data: These files are required when calculating exposure and spatial vulnerability. Expert judgement was used to design, collect, and analyse data and to develop the model underpinning that data. Likewise, you will be using your own expert judgement to determine the best sources of information to use in the assessment.
- The calculations underpinning the ccviR, including the categories assessed, the construction of responses categories, and the methods for scoring and aggregation are substantially based on expert judgement.

- The exposure results and vulnerability questions (Sections B and C) require assessors to draw on their expert judgement to make informed judgements about the vulnerability and adaptability of a species, based on their knowledge of the species and its traits.

While it is useful to be aware of where expert judgement enters the ccviR, in this section we focus on expert judgements to inform exposure and vulnerability questions (Sections B and C), and how they can be improved.

B.1.3 Are Expert Judgements Reliable?

Expert judgement is a remarkably useful form of data when other data are unavailable or incomplete. However, individual and group expert judgements can be prone to repeatable and predictable cognitive and motivational bias (**Table A 1**), which can result in overconfident or inaccurate data and poor outcomes for assessments (Burgman, 2015; O'Hagan, 2019).

Despite this, a large body of research has demonstrated that expert judgement can be substantially improved by applying the following steps (Hanea et al., 2021; Hemming et al., 2018):

1) Develop clear and hypothetically verifiable questions ideally related to quantities and probabilities.

2) Elicit judgements from a diverse group of individuals.

3) Use established protocols such as eliciting an individual estimate, asking the group to discuss their estimates, and then allowing individuals to revise their estimates.

4) Take the aggregate of expert judgements.

5) Capture and communicate uncertainty (which can be considered in decisions and assessments)

6) Document the steps to allow review and critical appraisal (hallmarks of scientific data).

We discuss these steps and their rationale in more detail below.

Table A 1 Biases common to human judgements, from (McBride et al., 2012).

Bias	Description
Individual biases	
Anchoring bias	Final estimates are influenced by an initial salient estimate, either generated by the individual or supplied by the environment.
Availability bias	People's judgments are influenced more heavily by the experiences or evidence that most easily come to mind. For example, events that have had recent news coverage.
Central Tendency Bias	When provided with a categorical or Likert scale people avoid the endpoints/extreme options, selecting mid-point responses.
Confirmation bias	People search for, or interpret, information (consciously or unconsciously) in a way that accords with their initial beliefs.
Framing	Individuals draw different conclusions from the same information, depending on how that information is presented.
Overconfidence	The tendency for people to have greater confidence in their judgments than is warranted by their level of knowledge. This may result in intervals that frequently miss the mark.

Group biases	
Dominance	Social pressures induce group members to conform to the beliefs of a senior or forceful member of the group.
Egocentrism	Individuals tend to give more weight to their own opinions than to the opinions of others than is warranted.
Groupthink	When groups become more concerned with achieving concurrence among their members than in arriving at carefully considered decisions.
Halo effects	When the perception of an attribute for an individual or object is influenced by the perception of another attribute or attributes.
Polarisation	The group position following discussion is more extreme than the initial stance of any individual group members.

B.2 Improving Individual Judgements

One of the most effective ways to mitigate biases is to consult a group of people, yet this is not always possible. Here we list some simple strategies that can be used to improve individual estimates for the ccviR (Wintle et al., 2022).

B.2.1 Ensure the Questions Are Clear and Unambiguous

It is important that assessors consistently interpret the questions and responses as they were intended. The ccviR uses coarse categorical response for each question, descriptions of the likelihood and magnitude are often qualitatively described which may lead to ambiguity in how to answer the question. For these questions we suggest that you define your understanding of the different terms before making an assessment. For example, for question C2c "*Dependence on a specific disturbance regime likely to be impacts by climate change"*, What does strongly impacted mean for your species in this assessment area, where would you draw the line between that and moderately? Record your reasoning in the comments of the question.

B.2.2 Embrace Counterfactual Thinking

Expert judgements can be easily affected by heuristics and biases such as availability, confirmation, and anchoring (**Table A 1**). The biases may result in skewed best estimates and overconfident interval judgements (Tversky and Kahneman, 1974). For example, studies show that people are more likely to select responses in the middle of the range and avoid extremes even if this does not match their true opinion (termed the 'central tendency bias', CTB) (Douven, 2018). For the ccviR this may lead to assessors selecting the 'Increase' and 'Somewhat Increases' categories more often than assessors believe is true for a species.

To reduce the influence of these heuristics, it is recommended that you actively consider diverse forms of evidence when making your judgements. Lord et al., (1984), found the accuracy of point estimates improved when individuals considered the opposite. This might be achieved by asking the following questions when informing your estimates:

- Optimistic scenario: Think of plausible and realistic reasons why the species may have high resiliency and/or high adaptive capacity? What category would you select?

- Pessimistic scenario: Think of plausible and realistic reasons why the species may be vulnerable / or experience reduced adaptive capacity. What category would you select?
- Most likely scenario: Given the weight of evidence from the optimistic and pessimistic scenario. What is the most likely category for this species?

Alternatively, you can make a judgement and then consider why your initial judgement may be wrong and provide a second estimate. Taking the average of these estimates has been shown to yield a more accurate estimate than when individuals provided an second estimate without considering the opposite (Herzog and Hertwig, 2009).

B.2.3 Document Key Information

A hallmark of scientific data is that it is documented with sufficient information to enable critical elements of review and revision. Expert judgement is no different. When making judgements, it is important to document who provided the estimates, how these estimates were derived, including relevant data sources, methods, and key uncertainties. We recommend that you use the comments box to document this information or create an online repository.

B.3 Improving Judgements with the Group

The expert judgement literature repeatedly shows that the average of judgements from a group of experts, elicited in a structured way, routinely performs as well or better than the most well-credentialled expert (termed the 'wisdom of the crowd' phenomenon') (Burgman et al., 2011; Hemming et al., 2018; Mellers et al., 2014). Furthermore, the best performing expert can rarely be identified *a-priori* from criteria we normally associate with someone having expert performance such as years of experience, peer recommendation, and publications (Burgman et al., 2011; Hemming et al., 2018, 2020a; Tetlock and Gardner, 2015). These criteria can lead to unfounded biases in who is considered an expert (Burgman et al., 2011; Hemming et al., 2018; Tetlock and Gardner, 2015).

The performance of the group is largely explained as a statistical phenomenon (Lorenz et al., 2011; Mavrodiev et al., 2012). That is, individuals are seen as random independent samples. If those samples are diverse then not does the information pool related to the questions increase (Clemen and Winkler, 1999), but the errors made by individuals are more likely to cancel each other out (Budescu and Chen, 2014; Larrick and Soll, 2006). Interestingly, studies investigating the performance of the crowd find that participants need not be experts and can be biased, as long as they have some information related to the questions that can be combined for prediction (Budescu and Chen, 2014)

The take home message is that assembling a diverse group of individuals will be a more reliable strategy for obtaining good judgements than using your own judgement, or the judgement of a single individual. However, eliciting group judgements can be time consuming, and introduces a whole new set of considerations to manage interaction and group composition. Apply the following steps to help reap the benefits of group judgements.

B.3.1 The right number of experts

Based on simulations and pragmatic considerations an optimal size for a group of experts is typically between 5 and 12. Below this number, group judgements are sensitive to outliers, while beyond this the input of additional individuals adds very little to the information provided (Hemming et al., 2018; Hogarth, 1978; Hora, 2004; Vercammen et al., 2019). The number of experts selected will be a trade-off between resources and time, and the need to for reliable results. In this case we suggest two heads are better than one, and more heads tend to be even better, however beyond nine experts the contribution of additional experts will add little to the final judgements.

B.3.2 Recruit a Diverse Group of Individuals

To improve the likelihood that group judgements will bracket the truth, it is important to consider the diversity of the group. As a minimum, diversity should aim to cover the knowledge space of the questions (Cooke and Goossens, 2000; Keeney and von Winterfeldt, 1991). Demographic diversity can also be a proxy for cognitive diversity (Page, 2008), therefore recruiting individuals to represent a diversity of gender, age, affiliation, race etc. is recommended to further improve the diversity of judgements from the group (Hemming et al., 2018; Page, 2008).

B.3.3 Protect independence of judgements

It is important that individuals are free to express their true opinion. However, group interactions can influence individual opinions through dominance, group think and other biases. To guard against this, individuals should be asked to provide an initial anonymized and independent judgement. This typically results in a diversity of judgement from the group of experts. If asked to revise their judgements, individuals strongly anchoring to their initial judgements, only adjusting if there is sound evidence presented in the discussion to do so (Hemming et al., 2018).

In terms of the ccviR, individuals can complete the assessment individually in the ccviR, and then export their results for comparison, discussion, and aggregation.

B.3.4 Feedback and Discussion

Once individuals have entered their responses, they can be provided feedback on their judgements relative to the group, and invited to review and update their judgements, and/or, enter a discussion phase before updating their judgements.

Feedback on judgements helps to communicate to assessors how their judgements have been understood, and how they compare to the wider group. Feedback of group judgements typically reveals differences in opinion, which can be attributed to linguistic uncertainty, or different lines of evidence being used by the assessors. When asked to revise their judgements, feedback can result in improved judgements (Mukherjee et al., 2015; Wintle et al., 2013).

If group judgements are collected as part of the ccviR process, we recommend providing anonymized feedback to individuals about the spread of judgements for each question, as well as any accompanying rationales and data sources provided (an example is provided in **Error! Reference source not found.**). We then recommend convening individuals to discuss the feedback (this could be via an in-person workshop, or a video call). The point of discussion should be to encourage critical thinking, respectfully consider the opinions of others, and alternative sources of information, rather than force consensus. Individuals can then revise their estimates if there is a good reason to do so. This protocol aligns with the IDEA protocol which has demonstrated that judgements are often meaningfully improve following discussion and feedback (Burgman et al., 2011; Hemming et al., 2018, 2020a).

B.3.5 Aggregating Judgements

There are many ways in which group judgements can be aggregated, including equal weighted aggregation, or performance weighted aggregation. Evidence suggests that equal weighted aggregation performs as well as many performance-weighted metrics (Hemming et al., 2020b).

Appendix C Understanding and treating uncertainty

C.1 Understanding your uncertainty

Uncertainty can arise in the ccviR for three main reasons (Regan et al., 2002) (**Table A 2**):

- Natural variation and randomness.
- Epistemic uncertainties (i.e., data gaps): Lack of knowledge, insufficient data, limitations of measurement devices, the effect of extrapolations and interpolations.
- Linguistic uncertainty: Arises because our natural language, including scientific language, is under specific, ambiguous, vague, context-dependent or displays indeterminacies.

Table A 2 Taxonomy of uncertainty (Gregory et al., 2012, p124, adapted from Regan et al. 2002)

Name	What this looks like
Natural variation and randomness	Variation through space and time
Natural variation (non-random)	Inherent variability associated with the system across space and time.
Natural variation (Randomness)	Stochastic events and unpredictable natural variation.
Sources of epistemic uncertainties	When we are uncertain about facts concerning events or outcomes because:
Measurement error	We cannot measure things precisely
Systematic error	We have not calibrated our instruments with each other
Model uncertainty	We do not know how things interact
Subjective judgement	We use judgement to interpret data, observations or experience. This results in uncertainty in individual judgements and uncertainty caused by differences across experts.
Sources of linguistic ambiguity	When we are not communicating effectively because:
Vagueness	Language permits borderline cases. Vagueness can be numeric (e.g., how many 'tall' trees?), or non-numeric (e.g., how to define habitat suitability?).
Ambiguity	Words have more than one meaning, not clear which intended (e.g., 'natural' environment, forest 'cover').
Context dependence	Descriptions not used in context (e.g., an oil spill is 'big' on my driveway would be considered 'small' in the ocean)
Under specificity	There is unwanted generality (e.g., 'it might rain tomorrow' vs there is a 70% probability of rain at a location tomorrow).
Indeterminacy	Words used at one point in time mean something different at another point of time.

C.1.1 Resolving uncertainty

The extent to which uncertainties can be reduced for the ccviR (which is meant to be rapid) is limited:

- **Natural variation and randomness:** cannot be reduced by more studies. Instead, variation should be captured by selecting all categories that reasonably apply.
- **Linguistic uncertainty:** is typically treated through adjustments to the questions and response categories which can only be done by the developers of the ccviR. However, reading the text boxes will help to improve the alignment of your assessment and the criteria listed. In addition, documenting your interpretation of questions and categories will help to ensure you are consistent between your assessments and help to improve interpretation of your assessment by others. Reporting incidences of ambiguity to developers will also help to identify common areas requiring attention in any subsequent iterations.
- **Epistemic uncertainties:** caused by a lack of information can sometimes be reduced by undertaking further studies to collect better data, and or test hypotheses related to the uncertainty (Runge et al.,2011; Stantial et al., 2023). Such research can be useful but typically requires a substantial investment in time and resources which may not be feasible, can unintentionally redirect limited resources away from management towards learning (McDonald-Madden et al., 2010), and may delay critical decisions (Martin et al., 2012b). To avoid delaying the assessment and associated management, we recommended that you capture your uncertainty. Then following the assessment, you can examine whether the uncertainties change the final vulnerability score, and if so, whether the uncertainty can be resolved through monitoring and research; and whether management would change if the uncertainties were resolved. If the answer to these questions is 'Yes' then there may be value in resolving these uncertainties (Runge et al., 2011; Stantial et al., 2023). If not, then decisions can still be made by using the principles of risk analysis (e.g., applying the precautionary, most likely, or optimistic scenario to decide which management actions to take)(Burgman, 2004; Hemming et al., 2022).

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