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RESEARCH NOTE

Understanding the drivers of expert opinion when classifying species as extinct

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Article impact statement: Data availability, time of the last sighting, and population decline are critical attributes favored by assessors when inferring extinction.

Abstract

The criteria as laid out by the International Union for the Conservation of Nature (IUCN) Red List are the gold standard by which the extinction risk of a species is assessed and where appropriate biological extinctions are declared. However, unlike all other categories, the category of extinct lacks a quantitative framework for assigning this category. Given its subjective nature, we surveyed expert assessors working on a diversity of taxa to explore the attributes they used to declare a species extinct. Using a choice experiment approach, we surveyed 674 experts from the IUCN Species Survival Commission specialist groups and taskforces. Data availability, time from the last sighting, detectability, habitat availability, and population decline were all important attributes favored by assessors when inferring extinction. Respondents with red-listing experience assigned more importance to the attributes data availability, time from the last sighting, and detectability when considering a species extinction, whereas those respondents working with well-known taxa gave more importance to the time from the last sighting. Respondents with no red-listing experience and those working with more well-known taxa (i.e., mammals and birds) were overall less likely to consider species extinct. Our findings on the importance assessors place on attributes used to declare a species extinct provide a basis for informing the development of specific criteria for more accurately assessing species extinctions.

KEYWORDS
conservation status, discrete choice experiments, expert elicitation, extirpation, IUCN Red List, threat

Resumen

Los criterios establecidos por la Unión Internacional para la Conservación de la Naturaleza (UICN) son la regla de oro con la cual se evalúa el riesgo de extinción de una especie y en donde se declaran las extinciones biológicas. Sin embargo, como con todas las demás categorías, la categoría "extinto" carece de un marco de trabajo cuantitativo para asignar esta categoría. Dada su naturaleza subjetiva, pedimos a los asesores expertos que trabajan con la diversidad de taxones que exploraran los atributos que usan para declarar extinta a una especie. Mediante un experimento de elección, sondeamos a 674 expertos de los grupos especialistas y de trabajo de la Comisión de Supervivencia de Especies de la UICN. La disponibilidad de datos, el tiempo desde la última detección, la detectabilidad, la disponibilidad del hábitat y la declinación poblacional fueron atributos importantes que los asesores favorecieron al inferir las extinciones. Los respondientes con experiencia con la lista roja les asignaron mayor importancia a los atributos de disponibilidad de datos, tiempo desde la última detección y detectabilidad cuando consideraron la extinción de una especie, mientras que los respondientes que trabajan con taxones conocidos le dieron más importancia al tiempo desde la última detección. En general fue menos probable que los respondientes sin experiencia con la lista roja y aquellos que trabajan con los taxones más conocidos (es decir, mamíferos y aves) consideraran extinta a una especie. Nuestros descubrimientos sobre la importancia que los asesores colocan sobre los atributos utilizados para declarar extinta a una especie proporcionan una base para orientar el desarrollo de criterios específicos para evaluar de manera más acertada las extinciones de las especies.

PALABRAS CLAVE
amenaza, estado de conservación, experimentos de elección discreta, extirpación, Lista Roja UICN, recabación de expertos

【摘要】
《世界自然保护联盟 (IUCN) 红色名录》设定的标准是评估物种灭绝风险以及在适当的情况下宣布生物灭绝的黄金标准。然而, 与所有其它濒危等级不同的是, "灭绝"等级缺乏一个确定该等级的量化框架。鉴于划分这个等级存在主观性, 我们访问调查了研究多种类群的专家评估员, 以探究他们宣布物种灭绝时考虑的因素。本研究利用选择实验的方法, 调查了来自世界自然保护联盟物种生存委员会专家组和工作组的 674 名专家。我们发现, 在推断物种灭绝时, 数据可获得性、距离最后一次发现的时间、可监测性、栖息地可获得性和种群下降情况都是评估者关注的重要属性。曾参与红色名录工作的受访者在分析物种灭绝时, 更重视数据可获得性、距离最后一次发现的时间和可监测性, 而那些研究人们认识较多的类群的受访者则更重视距离最后一次发现的时间。没有参与过红色名录工作的受访者和研究人们认识较多的类群 (即哺乳动物和鸟类) 的受访者总体上更少考虑物种灭绝的问题。以上关于评估者对宣布物种灭绝影响因素的重视程度的结果, 可以为制定更准确地评估物种灭绝的具体标准提供依据。**【翻译: 胡怡思; 审校: 聂永刚】**

关键词: 濒危等级, 专家引导, 灭绝, 离散性选择实验, IUCN 红色名录, 威胁

INTRODUCTION

The world is in the midst of a mass extinction event caused by human actions that have resulted in climate change, habitat loss, and overexploitation (Scheffers et al., 2011). Recent analyses suggest that the current extinction rate may be 1000 times higher than that indicated by background extinction rates, and projected rates may be 10 times greater still (Akçakaya et al., 2017; Butchart et al., 2005; Scheffers et al., 2011). However, determining whether a species still persists is not without its challenges and consequences. For example, a situation may arise where a species is declared extinct when it is still extant, resulting in the loss of directed conservation resources, which then leads to the species becoming extinct due to the lack of conservation effort, known as Romeo error (Collar, 1998). Alternatively, a species declared extinct may be rediscovered, known as the Lazarus effect, potentially leading to a loss of trust in conservation professionals. Akçakaya et al. (2017) suggested that the conservation costs are higher for listing extant species as extinct, either due to a Romeo error or the Lazarus effect. However, if a species is not listed as extinct, the current rates of biodiversity loss are underestimated and misuse of limited conservation resources may result.

Whether a species is extinct is conceptually simple: either it is or it is not (i.e., when the population size [n] = 0). However, uncertainties often arise in determining when $n = 0$ due to data availability. As such, extinction may be defined as when there is no reasonable doubt that the last individual has died (IUCN, 2012).

The global gold standard for assessing the extinction risk of a species is the International Union for the Conservation of Nature (IUCN) Red List criteria. The IUCN Red List categories include extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, and data deficient. More recently, the category of critically endangered (possibly extinct) was added, which may be used when a species is in "all probability already extinct" (Akçakaya et al., 2017). In such a case, there is a slight chance that the species may be extant and thus cannot be listed as extinct until adequate surveys have failed to find the species. These categories are designed to assess extinction risk and are supported by quantified criteria applied to a set of variables, such as population size and geographic distribution (Mace et al., 2008). For example, criterion A is based on population size reduction, B on the geographical range, C on small population size and decline, and so on. Each criterion has an associated set of thresholds related to each extinction risk category. As such, there are a number of different ways a species can be listed as, for example, critically endangered. However, for a species to be listed as extinct, only a definition is officially provided; that is, there is no reasonable doubt that the last individual has died (IUCN, 2012). Although no explicit set of quantified variables with associated thresholds is given for the category of extinct, implicitly, there is only one variable and one threshold: the population size equals zero. As such, the amount of data required for this level of precision, compared with other categories, is extremely high.

For many species, their persistence is uncertain due to a lack of data to infer whether $n = 0$. This may be due to a number of reasons, for example, fieldwork in the species' range may be limited due to inaccessibility, safety, or lack of adequate knowledge about the species distribution (Butchart et al., 2005). Conversely, the species may be challenging to detect because it is cryptic, nocturnal, or silent. These factors (or attributes) influence opinion regarding the continued persistence of a species; however, the relative importance assessors place on these factors is unclear.

A number of modeling approaches have been proposed (Boakes et al., 2015), with much of the original model development focusing on the temporal distribution of sightings and their relationship to time since the last sighting (Boakes et al., 2015). More recently, a modeling approach has been proposed that uses two models, one threat-focused and the other focused on records and surveys, that include a cost–benefit framework (Akçakaya et al., 2017; Butchart et al., 2018; Thompson et al., 2017).

We used choice experiments, a stated preference method developed in marketing, to explore attributes of importance when inferring extinction. This method is now widely used in environmental economics and more recently in conservation, for example, for the selection of flagship species (Veríssimo et al., 2014) and to examine stakeholders preference for forest attributes (Nordén et al., 2017), wild meat consumption (Shairp et al., 2016), and valuation of marine reserves (Rogers, 2013). We hope to provide an insight into the decision-making process of experts when assessing species extinction and help inform the development of solutions for inferring extinction, given the problems around data availability.

METHODS

Choice experiment design and pilot study

We initially used IBM Statistics 25 to design a pilot choice experiment so that the main effects of attributes on preferences could be estimated from orthogonal independent attribute variables. We then used a shifted or cyclic design to pair these scenarios in which a constant was added to each attribute level of an orthogonal design to produce two more alternatives. We piloted the survey with surveygizmo.com in August 2014 with a sample of 27 staff and postgraduate students from the Durrell Institute of Conservation and Ecology, University of Kent. Based on the feedback received, we made substantial changes to the design (e.g., regarding the initial framing and the number of levels of different attributes). We conducted a second pilot survey in November 2017 with Bristol Online Surveys (www.onlinesurveys.ac.uk). This survey sampled 32 conservation scientists from among the authors' personal associates. We made only minor changes in the visuals and framing of the choice experiment as a result.

We used the results of this second pilot survey to produce the final Bayesian prior distributions needed for the choice experiment. We used Ngene 1.0.1 to produce a D-efficient Bayesian design for the main survey (Jaeger & Rose, 2008). We chose this design type because it maximizes statistical efficiency in estimating preference parameters by minimizing D error over the prior distribution of the parameters while accounting for uncertainty (Jaeger & Rose, 2008). To allow for uncertainty, we used 500 Halton draws and assumed all parameter priors had normal distributions. We then compared the mean Bayesian D error of over 50,000 Bayesian designs and selected the one with the lowest error (0.555). This design had 12 choice situations, one of which is shown in Figure 1. The design was attribute balanced, meaning each attribute level occurred equally often, which minimizes the variance in parameter estimates (Mangham et al., 2009).

The final survey included six attributes (Table 1) chosen to encompass the key aspects considered by IUCN Red List assessors when assessing whether a particular species is likely to be extinct. These aspects are linked to the IUCN Red List's definition of extinct, which explicitly mentions, besides population decline, the need for exhaustive surveys that take into account not only the existing habitat, but also the life history and behavior of the species (IUCN, 2012).

Neither option was provided to reduce noise resulting from forced choices, and the experiment was unlabeled to ensure that respondents based their choice decisions on the attributes provided rather than any prior knowledge of specific species (Blamey et al., 2000; Kontoleon & Mitsuyasu, 2006). In addition to the choice sets, we included demographic questions (e.g., age, gender, and nationality), prior experience with the IUCN Red List assessment, IUCN specialist group membership, and professional affiliation (i.e., academia, nongovernmental organization [NGO], and government) (Table 1). Our protocol received ethical approval from the Research and Ethics Committee of the School of Anthropology and Conservation, University of Kent.

Data collection

Our survey (through Bristol Online Surveys, www.onlinesurveys.ac.uk) was launched on November 26, 2018 and remained open for 2 weeks (Appendix S1). A link was sent via email by the IUCN Species Survival Commission (SSC) Chair's Office to all leaders of specialist groups and taskforces of the IUCN SSC with a request to send it on to their members.

Analyses

We used NLogit 4.0 to construct multinomial logit (MNL), random parameters logit (RPL), and latent class models (LCM)

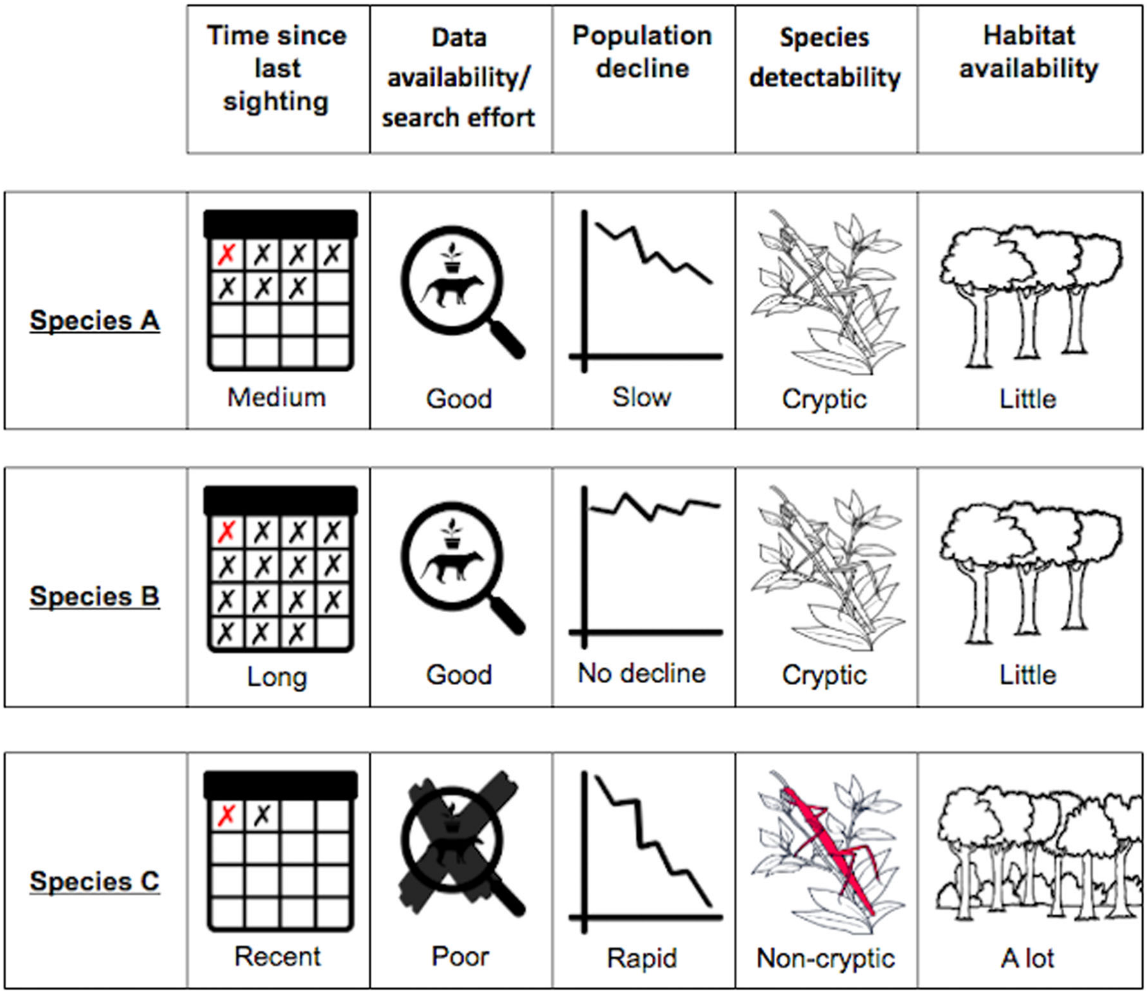

FIGURE 1 Example of a choice situation presented in the experiment, including the instruction given to respondents. Respondents were asked to select one option: A, B, C, or none.

with NLOGIT 5.0 (Econometric Software, New York). The MNL provides the simplest but most econometric restrictive analysis of the discrete choice data. The MNLs are often used to initially explore broad trends in preferences and model specifications, such as the impacts of socioeconomic variables on choice patterns (Hensher et al. 2005). However, for this model type, we assumed that individuals with the same traits have the same preferences (Train, 1998). To allow for a more realistic understanding of the preference patterns of our respondents, we constructed LCMs and RPLs, both of which have been widely used in conservation to understand preferences (Hanley et al., 2018; Moro et al., 2013; Veríssimo et al., 2014). Exploring this heterogeneity is important due to the international makeup of the IUCN SSC as well as the enormous diversity of taxa the commission members assess; members may use the red-listing process differently due to differences in the biological traits of the taxa they are assessing.

For the RPL, we selected data availability as a random parameter because this was the only attribute for which coefficients could logically take either sign depending on a respondent's attitudes toward uncertainty. To further explore the issue of uncertainty in determining trade-offs between attributes, we explored several interactions between choice attributes and respondents' traits. We explored the interaction between red-listing experience and all choice attributes (Table 1) because we expected experience applying the criteria in a real-world context to influence trade-offs. We also considered data availability and time from the last sighting and interactions of both these factors with well-known taxa and academic affiliation (Table 1). The choice attributes data availability and time from the last sighting were selected because they are closely linked to human effort and thus have more potential for uncertainty. The choice of the respondent variables, well-known taxa and academic affiliation, was based on the expectation that how well-known a taxa is affects an assessor's tolerance of uncertainty and that academics are less amenable to dealing with uncertainty than practitioners.

For the LCMs, we kept a similar focus, selecting as respondent segmenting variables red-listing experience, academic affiliation, and well-known taxa. We used three statistical criteria (Appendix S1) to select the most parsimonious model (Scarpa & Thiene, 2005; Veríssimo et al., 2014). Because the three

TABLE 1 Extinction-risk attributes and attribute characteristics (i.e., levels) used in a choice experiment with expert assessors of likelihood of species extinction

Choice attribute	Level	Description
time since the last sighting	recent, medium, long	amount of time since species was last sighted
data availability	poor, good	amount of information on the existence of the species considering the search effort
population decline	no decline, slow, rapid	whether the species population is in decline and, if so, the speed of decline
detectability	cryptic, noncryptic	easy of detect of the species in the field
habitat availability	small area, large area	amount of habitat available to the species
Respondent trait		
well-known taxa	whether a species is in a well-researched group (defined inthis study as birds andmammals)	
red-listing experience	whether respondent hasprevious experienceapplying IUCNInternational Union forConservation ofNature Red List criteria	
academic affiliation	whether respondent has anacademic affiliation	

criteria considered were not in alignment in terms of which model to select (Appendix S1), we chose the most parsimonious among the two models suggested (Hinsley et al. 2015). This model had six respondent segments (Appendix S2).

RESULTS

A total of 674 respondents took part in the survey, of which 57 were discarded due to missing or invalid information. This resulted in 7404 completed choice sets from 617 respondents. Respondents were 78% male and had a median age of 49 years. Sixty-nine percent had a PhD. Respondents were from 69 countries. Sixty percent were European or North American, 14% were Latin American, 14% were Asian, 6% were African, and 6% were from Oceania. Forty-nine percent of respondents were academics, 23% were affiliated with NGOs, and 16% were government employees. In terms of taxonomic expertise among respondents, mammals were the most represented (35% of respondents). Other popular groups included birds (14%) and reptiles and plants (12% each). Less popular taxa included amphibians (7%), invertebrates (7%), fish (6%), and fungi (1%). Last, most respondents (71%) had participated in the process of listing species on the IUCN Red List.

When respondents were treated as a homogenous group, as in the MNL, all attributes had a significant effect on choice (Table 2). Increased data availability was associated with a higher probability of actual extinction, as was a longer time since the last sighting, faster population decline, higher species detectability, and lower habitat availability.

The RPL showed similar trends, although the inclusion of the interaction among respondent traits allowed for a more detailed understanding. The RPL interaction terms for population decline and habitat availability, the trends followed those for the MNL. The interaction terms revealed that respondents with red-listing experience assigned more importance to the attributes data availability, time from the last sighting, and detectability when considering a species extinction, whereas those respondents working with well-known taxa gave more importance to the time from the last sighting variable. We also uncovered that respondents with no red-listing experience and those working with more well-known taxa (i.e., mammals and birds) were overall less likely to consider species extinct.

Regarding the LCM, the most parsimonious model failed to show explanatory power when it came to identifying variables that meaningfully segmented respondents. Only one segment had a statistically significant factor (Appendix S2), and even then it had only a single one. This suggests that the existing data set was not suitable for segmenting respondents. Therefore, we explored heterogeneity based on the RPL model.

DISCUSSION

In our choice experiment, the key factors for declaring extinction included data availability, time from the last sighting, and population decline. This is important because it provides a hierarchy of variables relied on by assessors of extinction. As such, our study is a starting point for understanding the factors that experts generally rely on to determine extinction.

All attributes in the choice sets returned significant estimates (Table 2). This was expected given that we selected attributes that are included in the IUCN's description of the extinct category. It is, therefore, reassuring that when provided with the information, assessors made use of all the attributes in their assessment. However, the strength of preference and the direction of coefficients revealed more information on attributes positively or negatively favored by assessors. For example, habitat availability produced a strongly negative estimate (Table 2), academic as an attribute level was not significant, and red-listing experience also had a negative effect. However, it is important to note that choice experiments represent a hypothetical situation, and in the case of assessing extinction, the reality of the experiment may vary depending on the taxa. For example, many taxa, such as plants (Margulies et al., 2019) and insects (Leather, 2009), lack data for many of the attributes in conservation assessments, including assessments of extinction. It would, therefore, be interesting to conduct further choice experiments in which no data are incorporated in the data availability attribute level for each of the attributes, rather than as a single

TABLE 2 Main effects estimates of utility function for each attribute for multinomial logit (MNL) (McFadden pseudo $R^2 = 0.17$) and random parameters logit (RPL) (McFadden pseudo $R^2 = 0.22$) in a survey of expert assessors of likelihood of species extinction[a]

Attribute	MNL mean effect estimates (SE)	RPL mean effect estimates (SE)[b]	RPL standard deviation estimates[b] (SE)
Alternative-specific constant	3.54** (0.08)	3.23** (0.17)	
Data availability	1.30** (0.04)	0.92** (0.15)	2.145** (0.08)
Time from the last sighting	0.92** (0.03)	0.87** (0.06)	
Population decline	0.93** (0.03)	1.11** (0.06)	
Detectability	0.60** (0.04)	0.54** (0.07)	
Habitat availability	–0.81** (0.04)	–0.88** (0.08)	
Assessor red-listing experience		–0.65** (0.19)	
Well-known taxa		–0.24* (0.10)	
Assessor an academic		–0.06 (0.10)	
Data availability × academic		–0.05 (0.13)	
Data availability × well-known taxa		0.13 (0.13)	
Data availability × red-listing experience		0.42** (0.15)	
Time from the last sighting × academic		0.02 (0.05)	
Time from the last sighting × well-known taxa		0.11* (0.05)	
Time from the last sighting × red-listing experience		0.17* (0.07)	
Population decline × red-listing experience		–0.08 (0.08)	
Detectability × red-listing experience		0.18* (0.09)	
Habitat availability × red-listing experience		–0.18 (0.10)	

[a]Significance: **, 1%; *, 5% level.
[b]Number of interaction terms included to explore the role of uncertainty.

attribute. This is further illustrated by the fact that there was a significant positive interaction between time from the last sighting and well-known taxa. With well-known taxa, which are likely to be well-studied, time from the last sighting may be an appropriate proxy for other attributes in assessments of extinction. However, for those species that are poorly known, the time from the last sighting may have a greater level of uncertainty associated with it (Scheffers et al., 2011; Solow et al., 2012). Finally, there was a significant positive interaction between the red-listing experience and three of the attributes: time from the last sighting, detectability, and, in particular, data availability. This suggests that those with red-listing experience acknowledge the uncertainty in extinction assessments and, therefore, put greater weight on the availability of data. This acknowledgment of uncertainty is accounted for in some recent methods, such as systematic methods to minimize geometric uncertainty when range size is disputable (Lee et al., 2019).

Future work could involve further nuance of the classification of taxa as well-known or charismatic. For example, birds and mammals may be well-known relative to some other taxa; however, not all birds and mammals are well-known. Likewise, whereas birds and mammals may be considered charismatic relative to other taxa, not all birds and mammals would be considered charismatic. Thus, the description of well-known taxa is confounded by what is charismatic within a group, between a group, and within biodiversity as a whole (Courchamp et al., 2018). Further, the degree of charisma that a species holds may prevent the declaration of extinction, but may also attract the attention and funding needed to conduct the exhaustive surveys required for an IUCN designation of extinct. If more people are working on a species, then it may be too political or sensitive to describe a species as extinct, thus delaying the process of extinction declaration. This effect may be heightened given previous conservation failures, such as that of the ivory-billed woodpecker's (*Campephilus p. principalis*) supposed rediscovery, which led to a misdirection of valuable conservation funds (Scheffers et al., 2011; Solow et al., 2012). Finally, there are a number of examples of species deemed extinct (or likely extinct) that were rediscovered. Understanding attributes used in these cases may provide further insight into extinction declaration attribute preference and biases. Likewise, at the other end of the spectrum, understanding why certain species have only recently been discovered may provide additional insights.

Currently, when deciding whether to assign the category of extinct to a species, the sole criterion experts have to refer to is when the population size equals zero, although this is not explicitly stated in the IUCN criteria (IUCN, 2012). However, as with other IUCN Red List criteria, guidance is provided (IUCN

Standards & Petitions Committee, 2022). Multiple criteria, such as a reduction in population size or geographic distribution, exist for other red-list categories, representing tangible measures to judge which category is most appropriate (Mace et al., 2008). Analogous categories could be created for the criteria of extinct, and our results provide a starting point for a discussion as to what these criteria should look like. Because the declaration of extinction has larger implications than moving a species to any of the other red-list categories (Butchart et al., 2005), there is an urgent need for the existence of specific criteria for assigning the category of extinction.

Finally, the survey did not receive an equal number of responses across all taxa. Respondents were volunteer members of specialist groups, working within the official structures of the IUCN, which although a key group to understand given their role in the red-listing process, they commonly do not fully represent, for example, traditional and Indigenous knowledge (Fernández-Llamazares & Cabeza, 2018). Further, we chose to allow for flexibility in interpreting the attributes and levels to allow for the survey to work across diverse taxa. It was impossible to have standard values, for example, for what constitutes a long time since the last sighting for all taxa across fauna, flora, and funga. We acknowledge this added uncertainty in some of our estimates.

In conclusion, our results showed there are differences when people are carrying out assessments as to whether a species is extinct. Certain groups rely more on or less heavily on certain criteria when conducting such assessments. By understanding which attributes assessors use in their decisions to declare a species extinct, new guidance can focus on these attributes that assessors appear to be predisposed toward. These biases can be used to rank the most important variables for determining extinction in the future and thus inform best practice guidelines for new IUCN criteria.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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