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What is an endangered species?: judgments about acceptable risk

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Abstract

Judgments about acceptable risk in the context of policy may be influenced by law makers, policy makers, experts and the general public. While significant effort has been made to understand public attitudes on acceptable risk of environmental pollution, little is known about such attitudes in the context of species' endangerment. We present survey results on these attitudes in the context of United States' legal-political apparatus intended to mitigate species endangerment. The results suggest that the general public exhibit lower tolerance for risk than policy makers and experts. Results also suggest that attitudes about acceptable risk for species endangerment are importantly influenced by one's knowledge about the environment and social identity. That result is consistent with notions that risk judgments are a synthesis of facts and values and that knowledge is associated with one's social identity. We explain the implications of these findings for understanding species endangerment across the planet.

Introduction

Judgments about what constitutes acceptable risk influence many public policies, including building codes, traffic laws, and policies pertaining to human health and pollution. Judgments about acceptable risk are informed by science, but are ultimately normative, i.e. judgments about what *ought* to be acceptable. In developing policy, primary influences on these judgments include: statutory guidance, decisions or guidance by policy makers, the common practice of experts, and public attitudes (Hunter and Fewtrell 2001). While much is known about public attitudes pertaining to acceptable risk regarding environmental pollution (Paustenbach 2015), essentially nothing is known about attitudes pertaining to acceptable risks and acceptable losses for the biodiversity crisis (Vucetich and Nelson 2018).

The biodiversity crisis is indicated, for example, by humans having increased the rate of species extinction by three orders of magnitude or more (Pimm *et al* 2014). Of ~40 000 known species of vertebrates, 20% are believed to be threatened with extinction (Hoffmann *et al* 2010). Among species that will escape total extinction, many have been severely diminished. For example, terrestrial mammals have been extirpated from, on average, two-thirds of their former geographic ranges, leading to large portions of the Earth's terrestrial surface having lost more than half of the native mammalian species (Ceballos *et al* 2017). Those losses risk the health of ecosystems.

Efforts to lessen the biodiversity crisis include international agreements and national legal instruments (Cretois *et al* 2019). Among national instruments, one law to which many others are often compared—sometimes favorably, other times not—is the US Endangered Species Act (Ray and Ginsberg 1999). We use the specific context of that law to better understand the broader concern of what constitutes acceptable risk and acceptable loss with respect

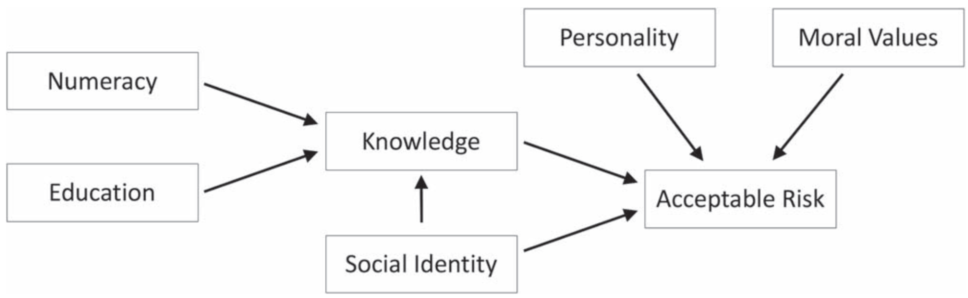

Figure 1. Conceptual model depicting prediction of variables influencing acceptable risk in the context of the biodiversity crisis.

to the biodiversity crisis. The explicit purpose of the ESA is (United States 1973, section 2.2) 'to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved.' The ESA also provides a legal definition for an endangered species: 'any species which is in danger of extinction throughout all or a significant portion of its range' (United States 1973, section 3.6). In part because a species' risk of extinction increases with decreasing geographic range, the phrase 'significant portion of its range' is an expression of what constitutes acceptable risk. That interpretation of that phrase and its implications for the legal definition of an endangered species has been subject to considerable debate (e.g. Vucetich *et al* 2006, Bruskotter *et al* 2014, Waples *et al* 2015, Nelson *et al* 2016, Vucetich and Nelson 2018).

Here, we describe Americans' views on acceptable risk and evaluate the extent to which they are explained by various individual-level attributes, in particular, one's knowledge about the environment and strength of identification with groups that advocate for and against the ESA. We also evaluated the influence of personality traits, moral foundations and numeracy (figure 1).

Figure 1 represents a set of hypotheses supported by various research. In particular, attitudes about environmental policy are related to one's knowledge of relevant issues (Aipanjiguly *et al* 2003), and knowledge about the environment is, in some cases, related to pro-environmental behavior (Díaz-Siefer *et al* 2015).

One's knowledge may be influenced by experience and education as well as being constructed through the influence of groups to which one identifies, i.e. one's social identities (SI). Social identity theorists explain that individuals interact with group members, develop a sense beliefs and behaviors that are 'prototypic' of the group, and then tend toward those beliefs and behaviors (Hornsey 2008). This kind of influence has been implicated for conservation policy (Lute *et al* 2014, van Eeden *et al* 2019). For example, 92% of those who self-identify as an 'environmentalist' express a positive attitude about the ESA; yet, only 69% of those who self-identify as a 'property rights advocate' are supportive (Bruskotter *et al* 2018). Other recent work indicates that one's political identity may be important for understanding environmental attitudes and behaviors (e.g. Feinberg and Willer 2013).

The relationship between knowledge and social identity is almost certainly reciprocal. For the purpose of this paper, we begin with the hypothetical notion that the dominant relationship is social identity's influence on knowledge. This notion is sensible to the extent that a person acquires a social identity—such as being an environmentalist—early in life, before an age where they could acquire detailed objective knowledge about the environment (like that evaluated by the survey reported on in this study). While we begin with this hypothetical notion, we do not take it fully for granted (see *Results*).

Environmental attitudes are also associated with one's basic moral values. For example, personal climate change norms are positively associated with two moral values (care and fairness) and negatively associated with another (authority, Feinberg and Willer 2013, Jansson and Dorrepaal 2015). Aspects of personality (extraversion, conscientiousness, and openness) have been associated with attitudes and self-reported behaviors pertaining to the environment (Milfont and Sibley 2012, Brick and Lewis 2016).

Finally, risk-related attitudes about the environment have also been associated with numeracy (Kahan *et al* 2012), the ability to reason with fundamentally numerical concepts. Numeracy is positively associated with decision-making tasks (Cokely *et al* 2018). Because the biodiversity crisis is communicated numerically (e.g. proportion of species threatened with extinction and portion of lost geographic range), attitudes about risk pertaining to biodiversity may be influenced by numeracy.

Methods

In August 2018 we conducted a web-based survey of adult (>18 years), US residents using Qualtrics' Research Core, an online survey platform. The sample was selected such that distributions of age, education, gender, and race match the 2010 US Census.

Measures

The survey included three items pertaining to acceptable risk for biodiversity. Specifically, participants were informed, 'Earth is inhabited by approximately 40 000 species of vertebrates, including birds, mammals, and fish. Of these, 20% are thought to be threatened with extinction,' and then asked:

(A) 'What percentage of species threatened with extinction would be acceptable?'

Participants were also informed, 'Extinction is a process that involves regional extinction at various places throughout a species' historic range. The geographic areas where a species lives is called their 'range.' Most mammal species have been driven to extinction from half or more of their historic range because of human activities,' and then asked:

(B) 'What percentage of historic habitat loss would be acceptable?'

Finally, participants were asked:

(C) 'How much [what percentage] of a species' historic range should be lost before federal law steps in to protect a species?'

The survey also included items representing candidate predictor variables:

- A scale of environmental knowledge, comprised of 18 multiple-choice items (Díaz-Siefer *et al* 2015).
- Respondents were asked to indicate the extent to which they identified with various SI: Animal Rights Advocate, Hunter, Environmentalist, Gun Rights Advocate, Conservationist, Property Rights Advocate, and Farmer or Rancher (Bruskotter *et al* 2018). The responses were a 5-point Likert scale ('Not at all' to 'Very strongly'). We also asked participants to indicate their political ideology on a 7-point Likert scale from 'very liberal' to 'very conservative.' Similar single-item social identification measures have been shown to be reliable (Postmes *et al* 2013).
- The ten-item personality index, whose dimensions are openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability (Gosling *et al* 2003).
- The moral relevance portion of the moral foundations questionnaire (MFQ, Graham *et al* 2011), which includes 15 items representing five dimensions (care, fairness, loyalty, authority, sanctity).
- A 7-item version of the Berlin Numeracy Test (Cokely *et al* 2012).

See appendix S1 (supporting information is available online at stacks.iop.org/ERL/15/014010/mmedia), for additional detail.

Data preparation

Following a common practice, we pooled the care and fairness dimensions of the MFQ into a single dimension (hereafter, *binding values*) and pooled the remaining three dimensions (*individualizing values*, Haidt and Graham 2007). We set *education* as a binary response (those with associate, bachelor, or graduate degree in one category and those with some college or less in another).

Of the 1050 survey participants, 909 provided sensible answers for all three items about acceptable risk (i.e. answers on the range [0, 100]). We randomly assigned each of those 909 observations into a test dataset ($n = 461$) to explore hypotheses or validation dataset ($n = 448$) to test refined hypotheses.

Analysis and results

Figure 2 presents the distribution of responses for the three survey items pertaining to acceptable risk (see legend of figure 2 for precise wording of each item). For these items, the median responses are between 5% and 10% and the upper quartile is between 25% and 30% (figure 2). Note that responses to survey item A of figure 2 may be subject to an anchoring effect, as that item included information that 20% of species are currently at risk. Survey item B (of figure 2) may also entail an anchoring effect insomuch as that item included the information that 'most mammal species have been driven to extinction from half or more of their historic range because of human activities.' Whatever anchoring effect that information may have had is appropriate because we aimed to elicit responses in relationship to current conditions. Survey item C had no such anchor (except what have carried over from items A and B) as there is no definite current condition for the situation invoked by item C. These anchoring effects might raise concern about the internal reliability of those measure. However, that concern is allayed because Cronbach's alpha suggests that the ideas in the three survey items of figure 2 have good internal reliability ($\alpha = 0.80$; $n = 909$; see also appendix S2). We combined these three items into a single composite response.

Exploratory factor analysis of the social identity items suggested two groupings (appendix S3): (i) environmentalist, conservationist, and animal rights advocate; and (ii) property rights advocate, gun rights advocate, hunter, and farmer or rancher. To reduce the number of candidate predictors, we

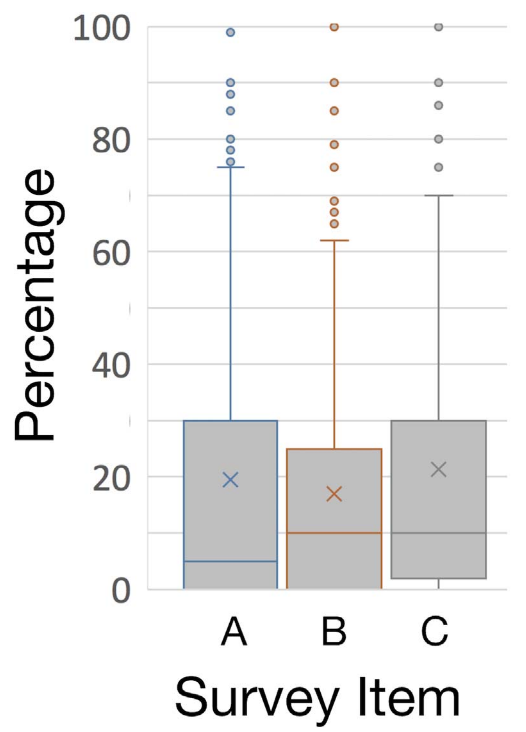

Figure 2. Distribution of responses to the three survey items pertaining to acceptable risk ($n = 909$). Survey participants were informed, 'Earth is inhabited by approximately 40 000 species of vertebrates, including birds, mammals, and fish. Of these, 20% are thought to be threatened with extinction,' and then asked (A) 'What percentage of species threatened with extinction would be acceptable?' Participants were also informed, 'Extinction is a process that involves regional extinction at various places throughout a species' historic range. The geographic areas where a species lives is called their 'range.' Most mammal species have been driven to extinction from half or more of their historic range because of human activities,' and then asked (B) 'What percentage of historic habitat loss would be acceptable?' and (C) 'How much [what percentage] of a species' historic range should be lost before federal law steps in to protect a species?' The mean responses (×) are 19.6 (A), 17.1 (B) and 21.5 (C). The median responses (horizontal bar) are 5 (A), 10 (B) and 10 (C).

analyzed three indicators of social identity: an average score for responses to the first grouping (hereafter, *animals-and-nature* identity), an average score for responses to the second grouping (hereafter, *guns-and-land* identity) and political identity. We included political identity separately given its importance in recent work (e.g. Feinberg and Willer 2013) and given that political identity was not strongly associated with either of the other two SI (see appendix S3).

Summary statistics for the candidate predictor variables are reported in the table of appendix S4. To explore the test dataset, we used an AIC-based stepwise regression algorithm, implemented with the stepAIC function from the MASS package in R. The results suggest that acceptable risk may be influenced by *knowledge*, social identity (*guns-and-land*), and a personality trait (*agreeableness*). Those predictors have p-values <0.01 and appear in all three models that performed well (ΔAIC < 2; table 1). The results also suggest that *extraversion*, *conscientiousness*, and *education* may have weak relation to *acceptable risk*. Although the predictive ability of *education* on *acceptable risk* is small, it is plausibly an important predictor of *knowledge*. None of the models in table 1 include *numeracy*. Nevertheless, there is sufficient *a priori* reason to expect numeracy is related (perhaps distally) to *acceptable risk* (see *Introduction*).

Based on those regression results and continuing to use the test dataset as a basis for ad hoc data exploration, we used the lavaan package in *R* to build a path model, whose structure is like that depicted in figure 1, where social identity is represented by *gun-and-land* and personality is represented by *agreeableness*, *extraversion* and *consciousness*. Because neither dimension of MFQ appeared in table 1 we did not include those predictors in the path model. For this path model (hereafter Model A; figure 3(a)), $\chi^2 = 18.62$ ($p = 2 \times 10^{-3}$) and root mean squared error of approximation (RMSEA) $= 0.08$ (90% CI $= [0.04, 0.12]$). See appendix S5 for other measures of fit. For context, a non-significant χ^2 value and a RMSEA < 0.08 with a 90% CI including 0 and not exceeding 0.1 indicate acceptable fit (Kline 2010).

We also built Model B, which is like Model A, except the path from social identity to knowledge is reversed (in relationship to that depicted in figure 1). Model A fit better than Model B ($\chi^2 = 39.73$, $p < 10^{-4}$; RMSEA $= 0.08$, CI $= [0.07, 0.11]$). Nevertheless, Model A's fit is marginal. Thus, we built another path model like Model A, except that it excluded the personality traits. Measures of fit for this model (Model C) were good ($\chi^2 = 2.94$ [$p = 0.23$]; RMSEA $= 0.03$, 90% CI $= [0.00\text{–}0.10]$).

The models considered thus far assume (with limited evidence) that social identity influences knowledge, more so than the other way around. To evaluate the consequences of that assumption, we built an exploratory model (Model D) with the test dataset whose structure is identical to model C, except that assumes the arrow goes from *knowledge* to *guns-and-land*, rather than the other way around. Metrics of model fit were better for model C than for Model D (details in appendix S5). Additional details for these exploratory models, including diagrams and coefficients are given in appendix S5.

Having found a model that fits the test dataset well (i.e. Model C), we then moved to the second phase of analysis which is less exploratory, more prescribed and based on the validation dataset. In particular, we built a path model with the same structure as model C using the validation dataset. This model (Model E, figure 3) also has good fit ($\chi^2 = 0.62$ [$p = 0.74$]; RMSEA < 0.01, 90% CI $= [0.00, 0.07]$).

The structure of Model E (figure 3) includes both a direct effect of *guns-and-land* on *acceptable risk* and an indirect effect (through *knowledge*). The combined magnitude of both effects is indicated by multiplying the coefficient for *guns-and-land* and *knowledge* (-0.17) by the coefficient for *knowledge* and *acceptable*

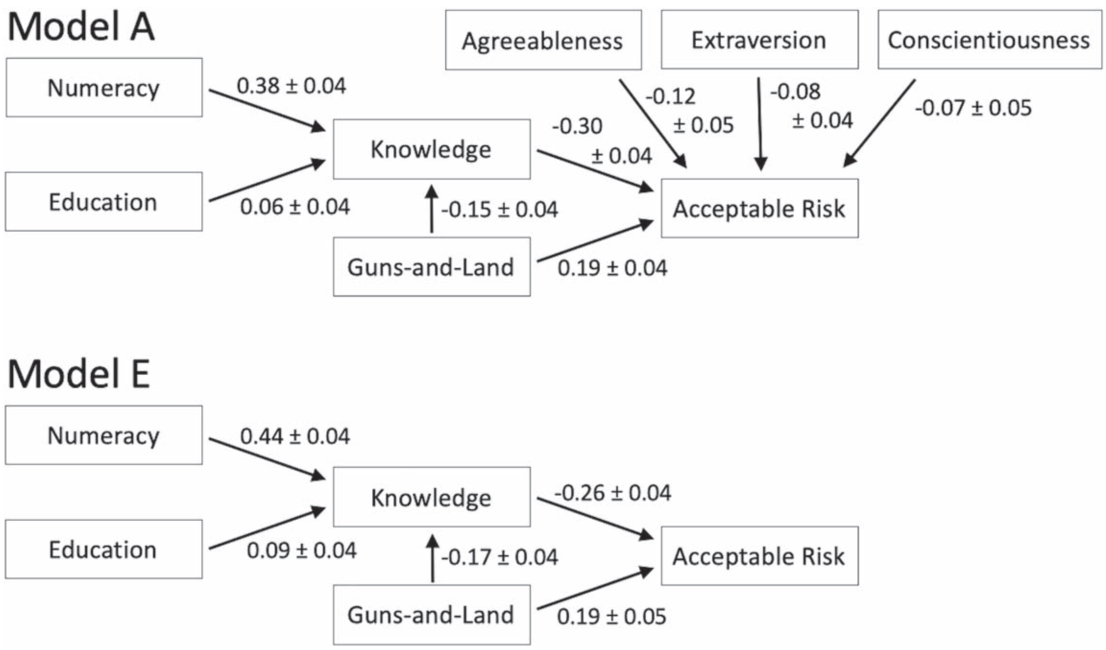

Figure 3. Standardized regression coefficients and standard errors for two path models of acceptable risk in the context of the biodiversity crisis based on samples representative of the American public with respect to age, education, gender, and race. Model A was built with the test dataset ($n = 461$), represents exploratory analysis, and includes elements of figure 1 that are also supported by the multiple regression procedure described in table 1. Model E is the only model built from the validation dataset ($n = 448$). The rationale for omitting metrics of personality from Model E are given in the main text. Models B, C, and D were built during the exploratory phase of data analysis. Descriptions, rationale and metrics of model fit for models B, C and D are given in the main text. Diagrams and coefficients for models B, C and D are depicted in appendix S5.

Table 1. Results of exploratory analysis on the test dataset ($n = 461$) using a forward stepwise regression. The candidate predictors for this analysis were scores of the knowledge scale (*knowledge*), Berlin Numeracy Test (*numeracy*), *animals-and-nature* social identity, *guns-and-land* social identity, political identity, *education*, binding values and individualizing values of the moral foundations questionnaire, and each of the five dimensions of the Big Five Personality Scale. Model 7 did not result from the stepwise procedure; we built it *post priori* to better understand the potential predictive ability of the variables in that model. Predictors significant at $\alpha = 0.05$ are marked with *, significant at $\alpha = 0.01$ are underscored, and significant at $\alpha = 10^{-3}$ are bold.

Model	AIC	ΔAIC	R^2	Predictors (coefficients ± standard errors)
1	2764.5	31.1	0.14	**Intercept** (36.57 ± 2.27), **knowledge** (−2.78 ± 0.33)
2	2744.5	11.1	0.18	**Intercept** (24.61 ± 3.36), **knowledge** (−2.44 ± 0.33), **guns-and-land** (3.96 ± 0.84)
3	2736.5	3.1	0.19	**Intercept** (37.12 ± 5.18), **knowledge** (−2.24 ± 0.33), **guns-and-land** (3.63 ± 0.84), <u>agreeableness</u> (−2.61 ± 0.83)
4	2734.3	0.9	0.20	**Intercept** (42.99 ± 5.90), **knowledge** (−2.26 ± 0.33), **guns-and-land** (3.70 ± 0.83), <u>agreeableness</u> (−2.69 ± 0.83), extraversion (−1.45 ± 0.71)*
5	2733.8	0.4	0.21	**Intercept** (39.56 ± 6.28), **knowledge** (−2.32 ± 0.33), **guns-and-land** (3.63 ± 0.83), <u>agreeableness</u> (−2.61 ± 0.83), extraversion (−1.57 ± 0.71)*, education (2.93 ± 1.86)
6	2733.4	0	0.21	**Intercept** (42.07 ± 6.48), **knowledge** (−2.27 ± 0.33), **guns-and-land** (3.48 ± 0.84), agreeableness (−2.03 ± 0.91)*, extraversion (−1.36 ± 0.72), education (3.23 ± 1.87), conscientiousness (−1.28 ± 0.83)
7	2754.5	20.2	0.17	**Intercept** (44.07 ± 5.55), **knowledge** (−2.37 ± 0.36), animal-and-nature (1.64±.86), **agreeable-ness** (−2.98 ± 0.84), numeracy (−0.58 ± 0.71), politics (0.15 ± .54)

risk (−0.26) which represents the indirect effect of *guns-and-land* on *acceptable risk* (0.04); then add that product to the direct effect of *guns-and-land* on *acceptable risk* (0.19). Those calculations indicate that the total magnitude of *guns-and-land* on *acceptable risk* is 0.23, which is comparable to the magnitude of *knowledge* (–0.26). Note that the relationship between *knowledge* and *numeracy* is stronger than *knowledge*'s relationship to *education* or *guns-and-land* (see lower panel of figure 3).

Discussion

Judgments about acceptable risk and acceptable loss in policies pertaining to the conservation of biodiversity may be influenced by law makers, policy makers, attitudes of the general public, and the common practice of experts. A common practice of experts was recently inferred by reviewing formal plans for recovering species protected by the ESA. Specifically, there has been a tendency for experts to consider a species endangered if extinction risk exceeds 5% over 100 years (Doak *et al* 2015). For context, the background extinction risk is likely on the order of 0.1 extinctions per million species-years and anthropogenic influences have increased that rate by three orders of magnitude or more (Pimm *et al* 2014). A 5% risk of extinction over 100 years greatly exceeds the anthropogenic risk of extinction that is the biodiversity crisis and for which the ESA is intended to mitigate.

The legal definition of an endangered species, as provided by the ESA, is one 'in danger of extinction throughout all or a significant portion of its range.' The explicit reference to range was added when the ESA replaced its predecessor law (Vucetich *et al* 2006). The reference to range also comports with scientific knowledge that extinction risk over time frames relevant to the biodiversity crisis tends to increase beyond the natural background rate of extinction as geographic range is decreased (Cardillo *et al* 2005, Payne and Finnegan 2007).

As mentioned in the opening statement of the *Discussion*, policy can be influenced by experts, the law and policy maker's interpretation of law. As such it is relevant that the ESA's legal definition may be interpreted through policy developed by the US Fish and Wildlife Service (USFWS). The USFWS has promulgated, over the past decade and a half, several controversial policies interpreting the reference to range as meaning, roughly: if a species is not at risk of extinction (as judged by scientific experts), then it occupies all the range required by the ESA (USFWS 2014, Nelson *et al* 2016). Policies of the USFWS are subject to litigation at which point the judiciary may strike down a policy (or delisting decision) if deemed inconsistent with law. The judiciary has done so on several occasions, where the USFWS failed (according to the judiciary) to adequately account for a species' range when deciding to delist (Enzler and Bruskotter 2009, Fitzgerald 2015).

The American public's attitude about acceptable risk for species endangerment (figure 2) seems considerably lower than acceptable risk implied by the common practice of experts or USFWS policy. For example, three-quarters of respondents indicated that special protections are warranted for species that had lost 30% or more of their historic range (referring to item C in figure 2). It seems that American society (its decision-makers, experts and constituents) do not have a common understanding of what an endangered species is, especially for species with formerly widespread geographic ranges.

International implications

The results presented here highlight an elemental indeterminacy for understanding the very essence of conservation. A large share of conservation is focused —directly or indirectly—on reducing the number of endangered species. Advancing that goal requires an adequate answer to the question, what is an endangered species? An endangered species is not adequately described as simply being at risk of extinction or at greater risk than non-endangered species. Rather, an endangered species is one whose condition has deteriorated to the point of deserving special protection. (Whether an endangered species actually gets special protection is a separate question.) What is that point of deterioration, marking the boundary between deserving special protection and not? To answer, 'It depends on the species,' is insufficient because that answer does not even touch the root concern.

The root concern is indicated by the results presented here. That is, insufficient consensus among experts, decision-makers and general publics about the general conditions that constitute endangerment, especially the normative influences on these conditions. While the specific results of this study pertain to the United States, the general concern very likely applies to many parts of the world. For example, the IUCN red list criteria do not address these concerns as they were designed explicitly as an objective categorization of species according to their being at greater or lesser risk, but not as a normative judgment about which species deserve special protections (Mace *et al* 2008, IUCN 2017, Vucetich and Nelson 2018).

Knowledge and identity

Judgments about what counts as endangerment are a synthesis of facts and values. As such, one might be concerned that the general public is insufficiently knowledgeable to make a meaningful judgment about conditions for which a species deserves special protections. While knowledge unquestionably influences such judgments (figure 3), high levels of knowledge do not remove the influence of values on such judgments (Karns *et al* 2018). For example, experts' judgments concerning the endangerment status of grizzly bears in the Greater Yellowstone Ecosystem were best explained by social norms (i.e. whether they believed their peers thought bears should be listed) and values (Heeren *et al* 2017). An unpublished result from that study suggests experts' norms and values may be driven by their social identity (i.e. norms and values were correlated with strengths to which experts self-identified with being a hunter [$|r|$'s > 0.4]). Consequently, the judgments of both experts and the general public are important to consider.

One might suppose that the distribution of responses in figure 2 would be shifted upward if respondents knew, for example, the cost of protecting endangered species. That concern is diminished by distinguishing two judgments: (i) conditions for which special protections are warranted and (ii) whether there are enough resources to offer those protections. This survey elicits attitudes about (i), not (ii). Moreover, the most relevant knowledge for (i) was given in the survey (see legend to figure 2) and evaluated through the survey's knowledge items. Even people with the lowest knowledge had relatively low levels of risk tolerance: among participants scoring in the lowest decile on the knowledge scale, the median response for acceptable range loss was 18% (item B) and 18% (item C).

With respect to judgment (ii), the USFWS is not legally bound to spend resources it does not have and the USFWS has a process for prioritizing allocation of insufficient resources. Finally, distinguishing judgments (i) and (ii) is essential for the USFWS to make a case to the US Congress and the American people that more funds should be devoted recovering species given the number of species that warrant protection.

These results also support imperatives to better understand how education can influence environmental attitudes (Gifford and Sussman 2012), how people with particular SI respond to new information (Teel *et al* 2006, Sunstein *et al* 2016), and how policy can be formed by deliberative processes that attend conflict rooted to SI (Finley 2010, Fishkin 2018). And, while much attention has recently been given to research highlighting the explanatory power of political identity for a range of attitudes, care should be taken as to not presume political identity is always the most relevant among SI (Federico and Ekstrom 2018, Bruskotter *et al* 2019).

Finally and to recapitulate, the results also suggest that policy makers and experts accept greater risk with respect to protecting biodiversity than segments of the general public who tend to accept the greatest risk, i.e. the least informed and those with the strongest connection to SI associated with political lobbies opposed to the ESA. Better protection for endangered species in the United States may not be limited by attitudes of the general public so much as the politics of conservation policy, including relationships amongst scientific experts, policy makers, and lobbies for special interests (Bruskotter *et al* 2018).

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Data

The data that support the findings of this study are openly available at: https://doi.org/10.25412/iop.10247420.v1 and https://doi.org/10.25412/iop.10247525.v1.

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