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Attitudes about Acceptable Risk in the Context of the Biodiversity Crisis

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ATTITUDES ABOUT ACCEPTABLE RISK IN THE CONTEXT OF THE BIODIVERSITY CRISIS

By

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List of abbreviations

DGKnowledge – Domain-Generic Knowledge

DSKnowledge – Domain-Specific Knowledge

ESA – Endangered Species Act

MFQ – Moral Foundations Questionnaire

MFT – Moral Foundations Theory

SEM – Structural Equation Modeling

SPOIR – “significant portion of its range,” a key line from the Endangered Species Act

TIPI – Ten Item Personality Index

Abstract

Crafting and enforcing conservation policy requires making normative judgements about what levels of risk are acceptable. These judgements include crucial decisions that impact which species qualify as "endangered." If a government's policies are going to represent the values of the public they govern, then public attitudes should be understood. Unfortunately, essentially nothing is known about public attitudes as they pertain to acceptable risk and the biodiversity crisis.

My research aims to address this gap using data from an internet-based survey (n=1050). I focused on the Endangered Species Act of 1973 which defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range." Because a species' risk of extinction increases with decreasing geographic range, the phrase "significant portion of its range" requires a judgement about what level of risk is acceptable. I then examined how the public's attitudes regarding risk differs both from the guidance provided by conservationists and the practices of government agencies.

I also explored the extent to which variation in attitudes could be explained by relevant knowledge, social identity, level of education, personality, moral foundations, and numeracy. I then used structural equation modeling to model the relationships between predictors.

1 Introduction

My research aims to understand what levels of risk people find acceptable when conserving endangered species and to explore what predictors might explain those attitudes. Appreciating the importance of these questions requires an understanding of the severity of the biodiversity crisis and why the answer is a normative judgement.

1.1 The Biodiversity Crisis

The scope of the biodiversity crisis is indicated by a variety of circumstances. Human enterprises over the past century or two have increased the rate of species extinction by perhaps three orders of magnitude (Pimm et al., 2014). The consequence being that 20% of the approximately 40,000 species of vertebrates known to inhabit the planet are believed to be threatened with extinction (Hoffman et al., 2010). Of the species that will escape total extinction, many have been severely diminished by human activities. For example, among studied species of terrestrial mammals, the average species has been extirpated from two-thirds of its former geographic range (Ceballos et al., 2017). Those losses lead to large portions of the earth's terrestrial surface having lost more than half of the native species that had been present before the impact of humanity. Those losses also represent a basic threat to ecosystem health. The particular causes of these losses include habitat destruction and degradation (e.g., pollution), over-exploitation, introduction of non-native species, and deterioration of basic ecological relationships, especially predator-prey relationships (Diamond 1989; Wilson 2002; Maxwell et al. 2016).

1.2 The Normative Nature of Assessing Acceptable Risk

Public policy pertaining to many disparate domains of life involve judgments about what constitutes acceptable risk, such as policies pertaining to traffic laws, building codes, human health and pollution. Judgments about acceptable risk are informed by science but they are ultimately normative in nature.

Primary influences on these judgments include: (i) statutory guidance, (ii) decisions or guidance provided by policy makers, (iii) the common practice of experts, and (iv) public attitudes (Hunter & Fewtrell, 2001). Significant effort has been made to understand public attitudes as they pertain to acceptable risk of environmental policies pertaining to pollution (Paustenbach, 2015). However, essentially nothing is known about public attitudes as they pertain to acceptable risk for the biodiversity crisis (Vucetich & Nelson, 2018).

1.3 The Endangered Species Act as An Ideal Framework

Efforts to lessen the biodiversity crisis include a variety of public instruments:

- international agreements such as European Union's Habitat Directives (Epstein et al., 2016), *Convention on International Trade in Endangered Species* (CITES; Bauer et al., 2018*), and the Convention on Biological Diversity* (Le Prestre, 2017*);*
- formal tools for decision making, such as The Red List of Threatened Species developed by the International Union for Conservation of Nature**,** IUCN (Butchart et al., 2005); and

- scores of federal laws from many different nations – laws whose explicit purpose is to stem the loss of biological diversity (Bagheera, 2018).

One federal law in particular is often cited as a benchmark for other federal laws, the U.S. Endangered Species Act, 1973 (ESA).

The explicit purpose of the ESA is (section 2[b]): "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" and "to provide a program for the conservation of such endangered species and threatened species." Importantly, the ESA provides a legal definition for an endangered species, which is "any species which is in danger of extinction throughout all or a significant portion of its range" (section 3.6). In part because a species' risk of extinction increases with decreasing geographic range, the phrase "significant portion of its range" (SPOIR) is an expression of what counts as acceptable risk. As an act of central important to the conservation of endangered species that appropriately conceptualizes endangerment as an issue of acceptable risk, the ESA serves as an ideal framework for exploring normative attitudes related to the biodiversity crisis.

Unfortunately, the meaning of SPOIR has been subject to considerable debate among scholars and policymakers (e.g., Vucetich et al., 2006; Bruskotter et al., 2014; Nelson et al., 2016; Vucetich & Nelson, 2018; Waples et al., 2007, 2015). Some policy enforcers (Waples et al., 2007) have proposed the following interpretation: "If the species were to become extirpated from these areas, at that point would the entire species be at risk? If so, then these areas represent a significant portion of the species' range." This

interpretation would leave a threatened species' habitat to continually shrink until any further loss would cause extinction. This level of effort is the absolute minimum that could still conceivably be labeled conservation. This interpretation also ignores any ecological value a species might offer, a value formally recognized in the ESA (section 2[b]). There has been no effort to ascertain what attitudes members of the American public might have about acceptable risk in this context. An important objective of my research is to determine whether public attitudes align with this limited concept of conservation.

1.4 Research Goals

With the previous considerations in mind, my objective is to determine what levels of risk people find acceptable when conserving endangered species and what predictors best explain these attitudes. More precisely, I will evaluate the extent to which attitudes about acceptable risk are predicted by one's knowledge, social identity, personality, and moral foundations while taking account that knowledge may also be influenced by one's social identity, the level of education, and numeracy. These relationships are depicted in Figure 1.

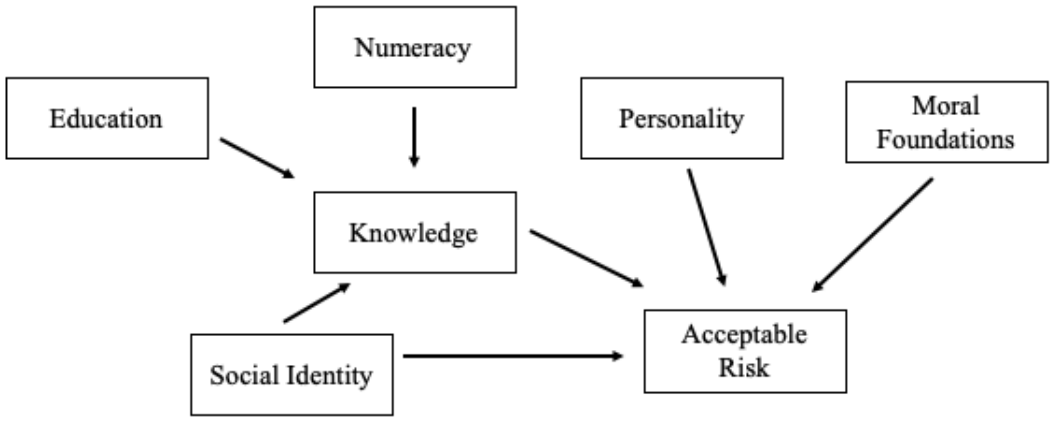

Figure 1. A hypothesized model depicting the relationship between predictors for acceptable risk in the context of the biodiversity crisis.

2 Literature Review

Although no research has been conducted to explore public attitudes about acceptable risk as it pertains to the biodiversity crisis, a variety of predictors have been used to explain both other attitudes related to conservation and the environment and other contexts for acceptable risk. I explore those relationships here.

2.1 Knowledge

When compared to other predictors, knowledge is relatively mutable. It is likely much easier to educate a person than to shift their social identity or personality. Knowledge might be uniquely useful to someone looking to intervene in attitudes about acceptable risk in wildlife management, if it proves to be a good predictor.

A recent study in Chile asked participants to answer a set of questions related to human-environment systems knowledge and a set of questions related to self-reported pro-environmental behaviors (Díaz-Siefer et al., 2015). Human-environment systems knowledge relates to environmental problems caused by humans, and items on the scale covered topics such as the greenhouse effect, renewable energy, and potential toxins released by common household items. Pro-environmental behaviors included activities such as reusing shopping bags and minimizing water usage. The authors found there was indeed a positive correlation between human-environment systems knowledge and pro-environmental behaviors ($n = 950$, 0.25, $p \leq 0.001$).

A more focused study explored the relationship between boaters and the Florida manatees in Tampa Bay, Florida (Aipanjiguly et al., 2003). The Federal Manatee Recovery Plan identifies the reduction of boat collision as a critical part of manatee recovery. Boaters with greater knowledge about manatees were more likely to support manatee conservation and engage in behaviors that minimized harm to manatees ($n = 504$, $r = 0.26$, $p < 0.001$).

Regarding acceptable risk, research has linked the effects of information transparency to behaviors related to sexually transmitted diseases (Garcia-Retamero & Cokely, 2011). Message framing shaped behavior in participants towards either screening for STDs or taking precautions against getting STDs. The addition of a simple visual aid to either method mitigated the effects of message framing, increased understanding of relevant statistical information, and still increased the occurance of behaviors that minimized risk.

It can be important to distinguish domain-generic and domain-specific knowledge. For the case I am evaluating, one might expect that greater general knowledge about the environment would be associated with having a lower threshold for what counts as acceptable risk for the loss of biodiversity. However, the influence of domain-specific knowledge in this case might be more complex. More specifically, the ESA is often portrayed as being politically controversial (Bruskotter et al., 2018). As such being strongly opposed to (or in support of) the ESA could be associated with more knowledge about the ESA than among those who do not have strong feelings about the ESA. For this reason, it would be important to evaluate the influence of both knowledge that is domain-specific and knowledge that is domain-generic. Unfortunately, there are currently no scales for testing knowledge of the ESA.

2.2 Social Identity

Other research indicates attitudes about environmental policy are also importantly shaped by one's social identity. Specifically, membership within certain stakeholder groups may increase or decrease support for or opposition to the ESA (Bruskotter et al., 2018). Those who identify as an environmentalist, animal rights advocate, conservationist, or wildlife advocate are more likely to support and less likely to oppose the ESA when compared to the rest of the population. In contrast, those who identify as a gun rights advocate, farmer/rancher, hunter, or property rights advocate are like more likely to oppose and less likely to support the ESA when compared to the national average. These results are not surprising as membership within these identities may increase likelihood of conflict with

the ESA. For example, a developer who identifies as a property rights advocate may find themselves unable to build on land that is critical habitat for an endangered species. It is worth noting that even among property rights advocates, the identity least supportive of the ESA, more than two-thirds of respondents expressed support.

2.3 Personality

The idea that personality might be broken down into five traits has early roots in the work of W. McDougal (1932) and D. W. Fiske (1949) though many researchers since have contributed to further definition of these traits (most notably Tupes & Christal, 1961; Norman, 1967; Smith, 1967; Goldberg, 1981; Costa & McCrae, 1990). These traits are now most commonly referred to using labels identified by W. T. Norman and are collectively known as the "Big Five" personality traits, the five-factor model, or the OCEAN model, an acronym of the five personalities. The traits and a selection of associated words (identified by Barrick & Mount, 1991) are as follows:

- Openness to Experience: imaginative, cultured, curious, original, broad-minded, intelligent, artistically sensitive
- Conscientiousness: careful, thorough, responsible, organized, planful, hard-working, achievement-oriented, persevering
- Extraversion: sociable, gregarious, assertive, talkative, active
- Agreeableness: courteous, flexible, trusting, good-natured, cooperative, forgiving, soft-hearted, tolerant
- Neuroticism: anxious, depressed, angry, embarrassed, emotional, worried, insecure

Each of these personalities exists on a spectrum, with a high pole and a low pole. Neuroticism is sometimes referred to as "emotional stability," a reference to the low pole. There are many scales developed from these traits, but traditionally participants are asked to rate how well they identify with words from each end of the spectrum.

In a study on the "green" personality, researchers found that extraversion, conscientiousness, and openness to experience were positively correlated with pro-environmental behaviors (Brick & Lewis, 2016). Openness to experience had the strongest correlation ($n = 345$, $r = .28$, $p < 0.001$). The measure for pro-environmental behavior focused on reducing emissions and included questions about diet, recycling habits, and travel habits. A similar study (Milfont & Sibley, 2012) explored the relationship between personality and both a value of protecting the environment and self-reported past electricity conservation. A value for protecting the environment was most strongly correlated with agreeableness and conscientiousness ($r = 0.14$, $p < 0.01$) and to a lesser extent with openness to experience ($r = 0.07$). Self-reported past electricity conservation was correlated with agreeableness ($r = 0.15$, $p < 0.01$) and conscientiousness ($r = 0.14$, $p < 0.05$). Agreeableness, extraversion, and openness to experience have also been found to be positively correlated with sympathetic attitudes towards animals (Furnham et al., 2003).

All five personalities have also been shown to have significant correlation with risk acceptance (Kam, 2012). A measure of risk acceptance asked respondents to gauge their level of agreement with seven statements about risk (e.g. "I prefer friends who are

exciting and unpredictable."). Openness to experience showed the strongest correlation (n = 1700, r = 0.41, p < 0.01), followed by extraversion (r = 0.29) and agreeableness (-0.09).

2.4 Moral Foundations

Moral Foundations Theory (MFT) suggests that differences in moral reasoning stem from variation in value placed upon five independent moral foundations (Haidt & Graham, 2007). These five foundations are Harm/care, Fairness/reciprocity, Ingroup/loyalty, Authority/respect, Purity/sanctity, though each is frequently referred to using only one of the two traits. Liberals tend to rate Care and Fairness most highly where conservatives tend to value all foundations equally.

Research out of Sweden has explored the relationship between MFT and personal climate change norms (Jansson & Dorrepaal, 2015). The scale for measuring personal climate change norms included seven items that focused on feelings of personal responsibility (e.g. "I think it is important to have my climate impact in mind in my everyday behaviors."). Harm and Fairness were both found to have a positive correlation with the measure (n = 1013, r = 0.33, p < .01).

2.5 Numeracy

Numeracy is the ability to apply mathematical concepts to real world situations. It can be seen as the quantitative equivalent of literacy. Common measures for numeracy test basic math skills that many people struggle to apply correctly. For example, imagine being asked "A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How

much does the ball cost?" A person might mistakenly answer ten cents rather than calculate the correct answer (five cents).

Numeracy is positively associated with a range of decision-making tasks (Cokely et al., 2018), but I am not aware of any research that links numeracy to environmental attitudes. Because the biodiversity crisis is communicated in terms of numbers (e.g., proportion of species threatened with extinction and portion of lost geographic range), attitudes about acceptable risk as it pertains to the biodiversity crisis may be influenced by numeracy.

3 Methods

The analysis presented in this paper includes 3 items that I treated as response items (acceptable risk) and 75 items as candidate predictors or contributing to psychometric scales used as candidate predictors: Political orientation (1 item); Domain-Generic Knowledge (18); Domain-Specific Knowledge (17); MFQ items (15); Numeracy (7); Social Identities (7); TIPI (10). The items were presented to participants in the same order as the preceding list.

3.1 Survey Design

3.1.1 Acceptable Risk

I measured acceptable risk with respect to the loss of biodiversity by averaging responses to three items that I developed on the basis of a review of the ESA:

A. What percentage of species threatened with extinction would be acceptable?
B. What percentage of historic habitat loss would be acceptable?
C. Extinction is a process that involves regional extinction at various places throughout a species' historic range. How much [what percentage] of a species' historic range should be lost before federal law steps in to protect a species?

Respondents could only answer numerically, though no limit prevented them from responding with illogical values over 100. An important difference between the first question and the following two is that Question A frames acceptable risk in the context of the total number of threatened species. Questions B and C ask about acceptable risk to individual species. Question B and C are of particular importance in addressing the lack of clarity surrounding the definition of endangered species in the ESA, and specifically the concept of SPOIR.

Because these questions can be challenging to answer, I provided respondents with some relevant information before answering each question, at the risk of potentially anchoring their responses. Before Question A, respondents 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." Before Question B, respondents were provided the following information: "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." It could be cause for some concern if responses to Question A clustered around 20% or if responses to Questions B and C clustered around 50%.

3.1.2 Knowledge

Two separate knowledge scales were used in this study.

3.1.2.1 Human-Environment Systems Knowledge

This scale was an adaptation of a scale of the same name created by Díaz-Siefer et al. (2015). I considered this form of knowledge domain-generic because it covered a broad range of topics related to human impact on the environment including climate change, pollution, and resource availability. The scale included 18 multiple-choice items. Because the original study was conducted in Chile, one question had to be altered to reflect the target population of this study ("Which category uses the most water in the Unites States?"). Scoring and options regarding water-use by sector were adjusted to reflect usage in the United States.

3.1.2.2 Endangered Species Act Knowledge

This measure of knowledge was developed over eight rounds of pilot study. Details on its development can be found in Appendix B. The scale was comprised of 17 items to which respondents could answer "True", "False", or "I don't know." I considered this form of knowledge domain-specific because all of the questions pertained only to the Endangered Species Act. The complete version of this scale can be found in Appendix C.

3.1.3 Social Identity

Respondents were asked to indicate the extent to which they identified with various identities, i.e., Animal Rights Advocate, Hunter, Environmentalist, Gun Rights Advocate, Conservationist, Property Rights Advocate, and Farmer or Rancher. The response to these items was a 5-point Likert scale ("Not at all" to "Very strongly"). A respondents' indication of strength of self-identification with one group was not constrained by the strength of self-identification with any other group. This mirrors the usage of these identities in research by Bruskotter et al. (2018). Participants were also asked to rate their political ideology on a 7-point Likert scale ranging from "Very liberal" to "Very conservative."

3.1.4 Personality

Personality was measured using the Ten-Item Personality Index (TIPI), an efficient measure of the Big-Five personality traits, developed by Gosling, Rentfrow, and Swann (2003). In the TIPI, participants rate the extent to which they feel each of 10 pairs of words applies to them. Responses are given on a seven-point Likert-style scale ranging from "Disagree strongly" to "Agree strongly." Half of the items are reverse coded.

3.1.5 Moral Foundations

To measure Moral Foundations, I used the moral relevance portion (part 1) of the Moral Foundations Questionnaire (MFQ, Graham et al., 2011). Respondents rate the extent to which each of 16 items is relevant to their decision about whether something is right or

wrong. Responses are given along a 6-point Likert-style scale ranging from “Not at all relevant” to “Extremely relevant.”

3.1.6 Numeracy

To measure numeracy, I used a 7-item version of the Berlin Numeracy Test (Coakley et al., 2012). Respondents were asked to not use a calculator, although there was no way to enforce this. Responses were open-ended but required a numerical answer. Because responses are open-ended, I expect this to be a more challenging version of the test than multiple choice versions.

3.2 Sample

The sample for this study was collected using Qualtrics’ Research Core, an online survey platform. Responses were collected in August 2018. Ratios for age, education, gender, and race were used to create a sample representative of U.S. citizens, based on 2010 U.S. Census data. All participants were Americans of age 18 or older. Qualtrics included a speed check to automatically terminate less thoughtful responses, measured as surveys completed in less than one-third of the median soft launch total response time. In total, 1050 respondents participated in the study. The survey and the plan I used to implement the survey were approve by Michigan Technological University's Human Subjects Committee (IRB# M1508 [949408]).

3.3 Data Preparation

Following a common practice, I pooled the care and fairness dimensions of the MFQ into a single dimension, often referred to as *binding values*, and I pooled the remaining three dimensions into a set often referred to as *individualizing values* (Haidt & Graham, 2007). I let *education* be a binary response, indicating those who had some college or less and those with an associate, bachelor, or graduate degree.

Of the 1050 survey participants, 909 provided sensible answers [0,100] for all three items about acceptable risk. On this full data set I evaluated some basic properties of the sample (e.g., Cronbach's alpha for three acceptable risk items, to evaluate the appropriateness of combining those items and treating them as a single response).

Because I had a large data set (n=909), I had the opportunity to create a *test* data set and a *validation* data set. Each participant was randomly assigned to the test data set or the validation data set. Doing so resulted in a test data set of 461 participants and a validation data set of 448. The rational for this division was to test and modify initial hypotheses on the test set and then replicate those results on the validation set.

Missing data were treated as incorrect answers for the two knowledge scales and the numeracy test. For identification with social groups, missing data were treated as the lowest level of identification. For political ideology, MFQ and TIPI, missing data were treated as neutrality and given a value equal to the center of the scale.

4 Results

Below is a table showing the correlations between *acceptable risk* and all possible predictors as well as the demographics used to ensure a representative sample. Three of the demographics are categorical but were coded as binaries. *Gender* was coded with female as 1 and male as 2. Education was coded with high school or less as 1 and some college or more as 2. Race was coded with non-Hispanic white as 1 and all other options as 2.

Table 1. Correlation matrix of Acceptable Risk and all potential dependent variables.

	Acceptable Risk	Gender	Age	Education	Race	HES Know	ESA Know	BNT	Animals-and-Nature	Guns-and-Land	Politics	Extraversion	Agreeableness	Conscientiousness	Emotion	Openness	Individualizing	Binding
Acceptable Risk	1	<0.01	0.9	1	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	0.82	0.62	<0.01	<0.01	<0.01	<0.01	0.49	<0.01
Gender	-0.1	1	0.3	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	0.03	0.99	0.36	0.49	0.37	<0.01	0.84	0.35	0.69
Age	0	-0.03	1	0.49	0.19	0.8	0.44	0.66	0.53	0.96	0.6	0.53	0.19	0.37	0.93	0.3	0.12	0.3
Education	0	0.1	-0.02	1	0.1	<0.01	0.14	<0.01	<0.01	0.32	0.2	<0.01	0.72	<0.01	0.05	0.07	<0.01	0.21
Race	0.14	-0.14	0.04	0.05	1	<0.01	<0.01	<0.01	0.96	0.75	<0.01	0.22	0.1	<0.01	0.68	0.18	0.26	0.13
HESKnow	-0.33	0.21	0.01	0.12	-0.21	1	<0.01	<0.01	0.24	<0.01	0.94	0.01	<0.01	<0.01	<0.01	<0.01	0.55	<0.01
ESAKnow	-0.1	0.13	-0.03	0.05	-0.11	0.28	1	<0.01	<0.01	0.22	0.27	0.59	<0.01	<0.01	<0.01	<0.01	<0.01	0.09
BNT	-0.2	0.17	-0.01	0.13	-0.11	0.45	0.18	1	<0.01	<0.01	0.59	<0.01	<0.01	<0.01	<0.01	0.18	0.72	<0.01

Animals-and-Nature	0.07	0.05	-0.02	0.16	0	-0.04	0.16	-0.1	1	<0.01	<0.01	<0.01	0.99	0.98	0.03	<0.01	<0.01	<0.01
Guns-and-Land	0.27	0.07	0	0.03	0.01	-0.24	0.04	-0.2	0.53	1	<0.01	0.03	<0.01	<0.01	0.18	<0.01	<0.01	<0.01
Politics	0.01	0	-0.02	-0.04	-0.15	0	0.04	0.02	-0.16	0.11	1	0.43	0.04	0.02	0.18	<0.01	<0.01	0.38
Extraversion	0.02	-0.03	-0.02	0.13	0.04	-0.08	0.02	-0.09	0.2	0.07	-0.03	1	0.05	0.01	<0.01	<0.01	0.07	<0.01
Agree - ableness	-0.2	-0.02	-0.04	0.01	-0.05	0.21	0.18	0.12	0	-0.19	0.07	-0.06	1	<0.01	<0.01	<0.01	<0.01	<0.01
Conscient - iousness	-0.18	0.03	-0.03	0.1	-0.11	0.21	0.18	0.18	0	-0.19	0.08	0.08	0.44	1	<0.01	<0.01	<0.01	0.03
Emotion	-0.1	0.18	0	0.06	0.01	0.15	0.12	0.09	0.07	-0.04	0.04	0.15	0.43	0.45	1	<0.01	0.03	0.03
Openness	-0.11	-0.01	-0.03	0.06	0.05	0.13	0.15	0.04	0.17	-0.1	-0.12	0.31	0.27	0.38	0.26	1	<0.01	0.05
Individ - ualizing	-0.02	-0.03	-0.05	0.11	0.04	0.02	0.14	-0.01	0.38	0.14	-0.1	0.06	0.18	0.17	0.07	0.21	1	<0.01
Binding	0.11	0.01	-0.03	0.04	0.05	-0.2	0.06	-0.21	0.35	0.33	0.03	0.09	0.09	0.07	0.07	0.06	0.72	1

4.1 Acceptable Risk Statistics

The results of the three items related to acceptable risk are summarized in Figure 2, presented as a box-and-whisker plot. Cronbach's alpha for this set of responses is appropriately high, i.e., $\alpha = 0.80$ (n=909). The items in figure 2 are: (A) What percentage of species threatened with extinction would be acceptable?; (B) What percentage of historic habitat loss would be acceptable?; (C) Extinction is a process that involves regional extinction at various places throughout a species' historic range. How much 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).

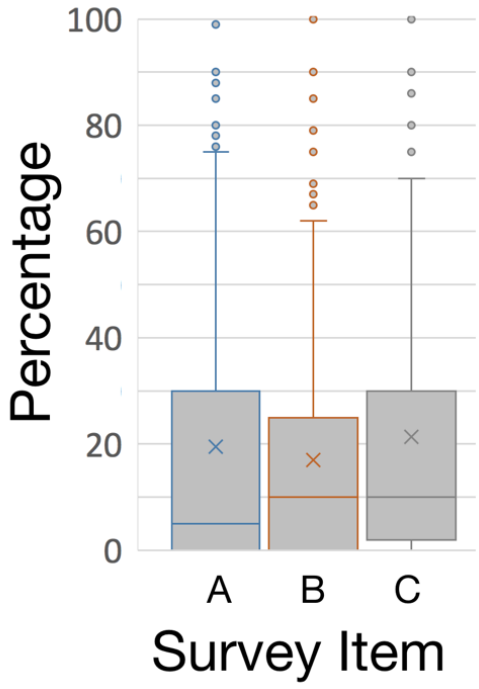

Figure 2. Distribution of items related to acceptable risk

4.2 Knowledge Statistics

The two knowledge scales (domain-specific and domain-general) were correlated ($r=0.28$, $p<10^{-15}$, $n=909$). The histogram of responses for the domain-specific knowledge scale indicated a minor mode at zero, reflecting my decision to treat missing responses as wrong answers (Fig. 3, upper panel). This mode was not apparent for the domain-generic knowledge scale (Fig. 3, lower panel).

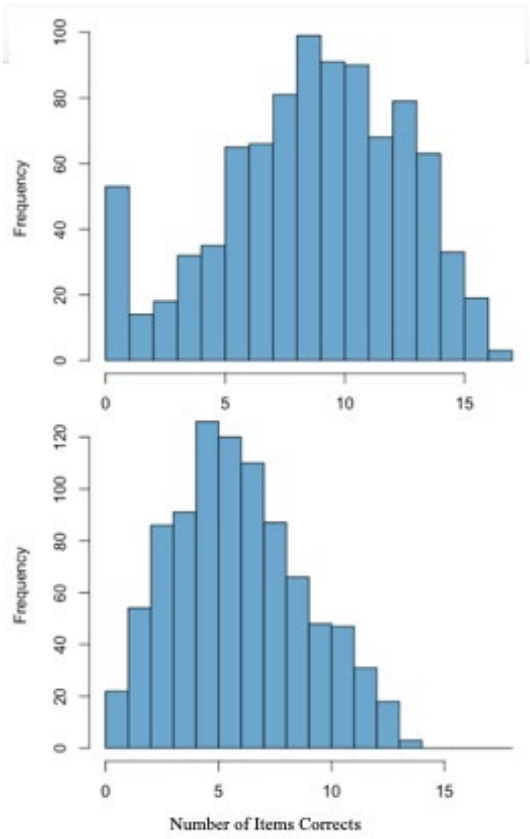

Figure 3. Distribution of scores for the domain-specific (upper panel) and domain-generic (lower panel) knowledge scales (n=909).

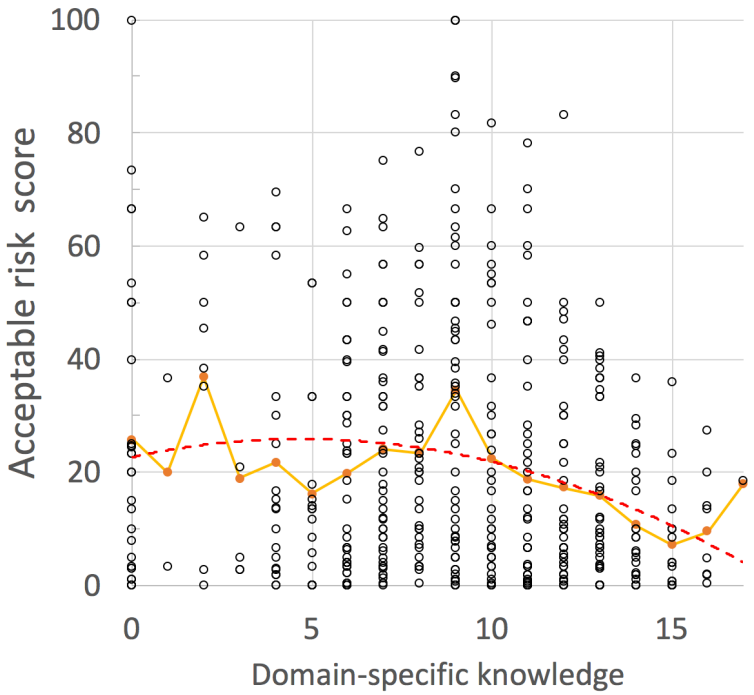

Figure 4. Relationship between scores on the domain-specific knowledge scale and acceptable risk score (n = 481).

Figure 4 depicts the relationship between scores on the domain-specific knowledge scale and acceptable risk score (n = 481). Mean risk score for each level of knowledge is depicted by the orange line. The linear relationship (not depicted graphically) is statistically significant ($p < 10^{-3}$, $R^2 = 0.03$). A model with a linear and quadratic term performs better (AIC is 7 points smaller); however, the linear term of that model is somewhat large ($p = 0.11$). A model with only the quadratic term (red dashed line) is statistically significant ($p < 10^{-5}$, R^2 =0.04) and has an AIC score that is just 0.5 greater than the model with linear and quadratic terms.

4.3 Social Identity Statistics

Responses to the social identities were all positively intercorrelated (Table 2). Among the highest correlations are environmentalist/animal-rights-advocate (r=0.69, $p<10^{-16}$, N=461), environmentalist/conservationist (r=0.62, $p<10^{-16}$), gun-rights-advocate/property-rights-advocate (r=0.57, $p<10^{-16}$), and hunter/farmer-or-rancher (r=.56, p<10–16). Factor analysis gives a similar impression (Table 3). That is, factor analysis suggests two groupings: (i) environmentalist, conservationist, and animal rights advocate; and (ii) property rights advocate, gun rights advocate, hunter, and farmer or rancher. With respect to factor analysis, I ran the *factanal()* function in R three times, each time using the "promax" rotation and each time assuming a different number of factors (1, 2 and 3 factors). The p-values for the hypotheses that z factors are sufficient:

p=5.4×10^{-66} (z=1, df=14, χ^2=349.46),

p=1.1×10^{-18} (z=2, df=8, χ^2=102.92),

p=0.01 (z=3, df=3, χ^2=10.72).

On the basis of those statistics I considered in more detail the two-factor model. In this two-factor model, the first factor accounts for 30.9% of the variance (and had an SS loading of 2.17) and the second factor accounts for 27.9% of the variance (and had an SS loading of 1.96). The correlation between the two factors is -0.64. The pattern of factor loadings (Table 3) further suggests the appropriateness of the same two groupings that is suggested by the correlation table.

Table 2. Correlations and p-values for responses (n = 461) pertaining to respondent's self-identification with various social identities. For convenience, the strongest correlations are marked with an *.

	animal rights advocate	conser-vationist	environ-mentalist	farmer or rancher	gun rights advocate	hunter	property rights advocate
animal rights advocate	1	<.01	<.01	<.01	<.01	<.01	<.01
conser-vationist	0.52*	1	<.01	<.01	<.01	<.01	<.01
environ-mentalist	0.69*	0.62*	1	<.01	<.01	<.01	<.01
farmer or rancher	0.37	0.38	0.42	1	<.01	<.01	<.01
gun rights advocate	0.25	0.42	0.25	0.41	1	<.01	<.01
hunter	0.22	0.36	0.35	0.56*	0.53*	1	<.01
property rights advocate	0.40	0.58*	0.40	0.51*	0.57*	0.39	1

Table 3. Loadings for a two-factor factor analysis (n = 461). Correlation between the two factors is -0.64.		
	Factor 1	Factor 2
Animal Rights Advocate		0.793
Conservationist	0.306	0.515
Environmentalist	-0.127	0.989
Farmer or Rancher	0.546	0.154
Gun Rights Advocate	0.909	-0.226
Hunter	0.671	
Property Rights Advocate	0.692	

Given an interest to reduce the number of candidate predictors, I considered from this point forward three indicators of social identity: an average score for responses to the first social grouping (hereafter, the *animals-and-nature* social identity), an average score for responses to the second social grouping (hereafter, the *guns-and-land* social identity), and political identity. I included political identity separately given the importance placed on that last predictor in other recent work (e.g., Feinberg & Willer, 2013).

4.4 Analysis of test data

A full model based on the data that I collected would include more than 14 predictors (e.g., five predictors are associated with the Big Five Personality Scale). I used the test

data set and stepwise regression to judge, in exploratory fashion, whether some variables can be disregarded for the second stage of analysis which will focus on using the final dataset to evaluate the hypothesis represented by Figure 1. I used the stepAIC function from the MASS package in R to perform the stepwise analysis, which builds the next model on the basis of AIC.

4.4.1 Forward Stepwise Regression

The result of this stepwise regression is summarized in Table 4. In summary, the results suggest that acceptable risk may be influenced by domain-general knowledge, identifying with a social identity (*guns-and-land*) and a personality trait (*agreeableness*). Those predictors appear in all three models that performed well ($\Delta AIC<2$) and those predictors always have p-values <0.01.

Table 4. Results of exploratory analysis on the test data set (n = 461) using a forward stepwise regression.

The candidate predictors for this analysis were scores of the domain-specific knowledge scale (*DSKnowledge*), domain-generic knowledge scale (*DGKnowledge*), 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. We also included a squared term for *DSKnowledge* (Fig. 4 for rationale). Model 7 did not result from the stepwise procedure; we built it *post priori* to better understand the potential predictive influence of the variables in that model. Predictors significant at α=0.05 are marked with *, significant at α=0.01 are underscored, and significant at $\alpha=10^{-3}$ are double-underscored.

Model	**AIC**	**ΔAIC**	**R^2**	**Predictors (coefficients ± standard errors)**
1	2764.5	31.1	.14	Intercept (36.57±2.27), DGKnowledge (-2.78±0.33)
2	2744.5	11.1	.18	Intercept (24.61±3.36), DGKnowledge (-2.44±0.33), guns-and-land (3.96±0.84)
3	2736.5	3.1	.19	Intercept (37.12±5.18), DGKnowledge (-2.24±0.33), guns-and-land (3.63±0.84), agreeableness (-2.61±0.83)
4	2734.3	0.9	.20	Intercept (42.99±5.90), DGKnowledge (-2.26±0.33), guns-and-land (3.70±0.83), agreeableness (-2.69±0.83), extraversion (-1.45±0.71)*
5	2733.8	0.4	.21	Intercept (39.56±6.28), DGKnowledge (-2.32±0.33), guns-and-land (3.63±0.83), agreeableness (-2.61±0.83), extraversion (-1.57±0.71)*, education (2.93±1.86)
6	2733.4	0	.21	Intercept (42.07±6.48), DGKnowledge (-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	.17	Intercept (44.07±5.55), DGKnowledge (-2.37±0.36), animal-and-nature (1.64±.86), agreeableness (-2.98±0.84), numeracy (-0.58±0.71), politics (0.15±.54)

These results in Table 4 also suggest that (i) if any dimensions of personality are important predictors of *acceptable risk* those dimensions would be *agreeableness*, *extraversion*, and *conscientiousness*, (ii) if any element of knowledge is an important predictor that element would be *DGknowledge,* (iii) if social identity is an important predictor it is best accounted for by the guns-and-land social identity, and (iv) *education* might have a small influence. Although the predictive power of *education* on *acceptable risk* is small, it is plausibly an important predictor for *DGknowledge*. None of the models in Table 4 include *numeracy*. Nevertheless, there is sufficient reason to expect it influences *acceptable risk*. The expectation rises from the very quantitative nature of the survey items that result in the response variable, *acceptable risk*. For these reasons, I move forward into the next phase of analyzing the test data, which is to conduct SEM considering only these predictors: *DGknowledge*, *guns-and-land*, *agreeableness*, *extraversion, conscientiousness, education,* and *numeracy*.

4.4.2 Structural Equation Modeling

I used the lavaan package in R to build an SEM to analyze these predictors based on Figure 1, using my test set of data. I've called this Model 1, and the results are depicted in Figure 5. For the scales I used, knowledge is a strongest predictor of *acceptable risk,* stronger than social identity. Agreeableness, extraversion, and conscientiousness are all weak predictors, though taken together, they support that

personality plays some small part in predicting *acceptable risk*. Knowledge partially mediates the relationship between social identity and *acceptable risk*. Education is a weak predictor of *DGknowledge* and is the only path that was not significant at the 0.05 level.

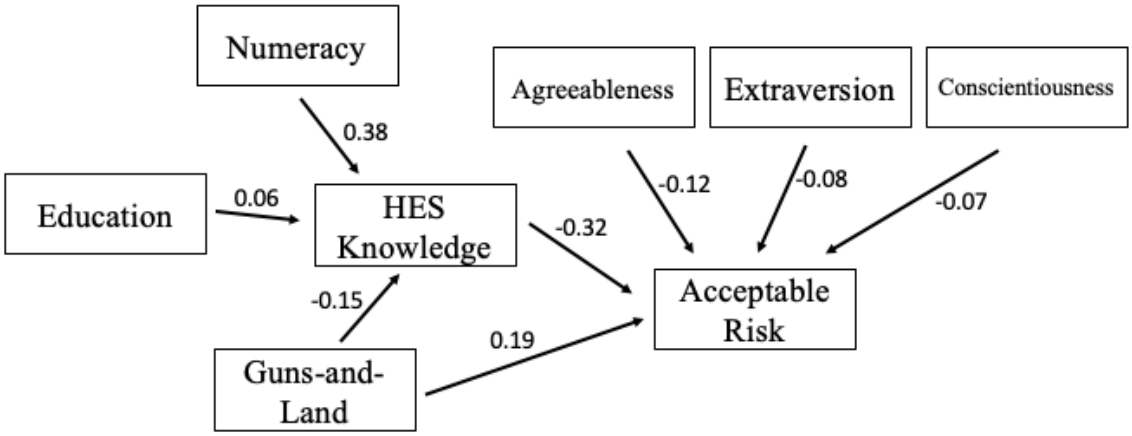

Figure 5. Structural Equation Model 1, identity predicts knowledge

I compared this to a possible alternative, where HES Knowledge predicts Guns-and-Land. This considers the possibility that people join certain social groups based on the knowledge that they have about human impact on the environment. I labeled this Model 2, and the results are depicted in Figure 6.

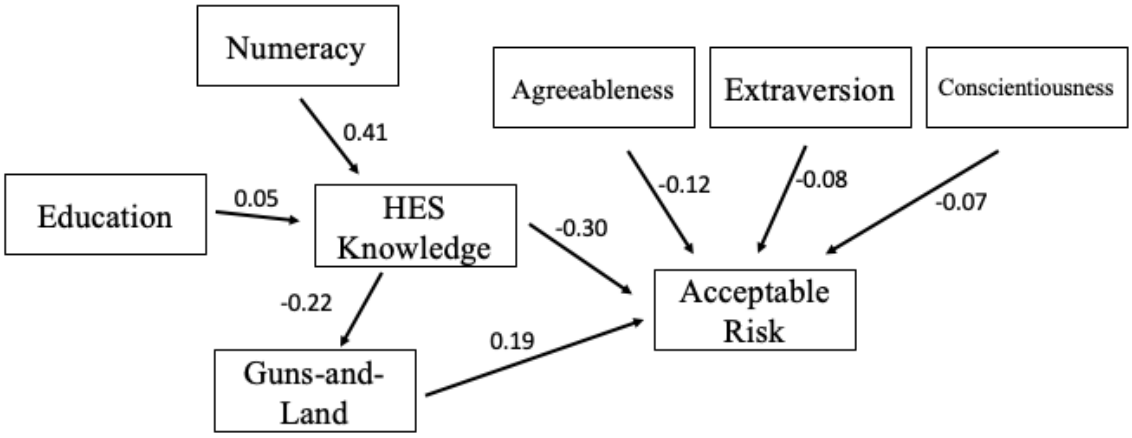

Figure 6. Structural Equation Model 2, knowledge predicts identity

The measures of model fitness for Model 1 (Chi Square 18.62, RMSEA 0.08 with 90% confidence from 0.04 to 0.12, GFI 0.96, CFI 0.94, SRMR 0.03) are generally better than the measures of fitness for Model 2 (Chi Square 39.73, RMSEA 0.08 with 90% confidence from .07 to .11, GFI 0.95, CFI .88, SRMR 0.06). While some measures are in an acceptable range regardless, the CFI is only acceptable (0.90 or better) in Model 1. The chi square is also indicative that Model 2 is not a great fit.

As might have been predicted from the stepwise regression, the personality traits were all fairly weak predictors. I wanted to explore a model that removed them entirely, still using the test set of data. This is depicted in Figure 7 and named Model 3. The measures of fitness are generally improved (Chi Square 2.94, RMSEA .03 with 90% confidence from 0.00 to 0.10, GFI .99, CFI 1.00, SRMR .02), and all are now within an acceptable range. Specifically, the RMSEA has dropped below 0.05.

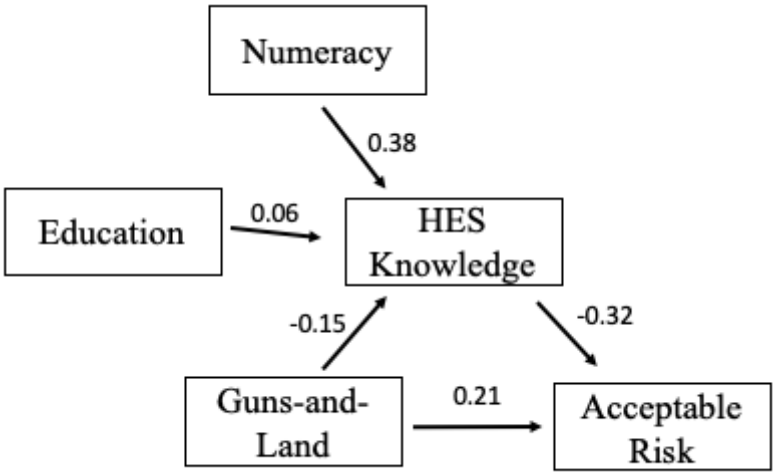

Figure 7. Structural Equation Model 3, without personality

4.5 Analysis of validation data

Confident that I had a good model, I tested Model 3 using the validation set of data. This is depicted in Figure 8 and named Model 4. While the predictive power of knowledge and social identity are somewhat diminished, the fitness of the model improves further (Chi Square .62, RMSEA 0.00 with 90% confidence from 0.00 to 0.07, GFI 1.00, CFI 1.00, SRMR 0.01).

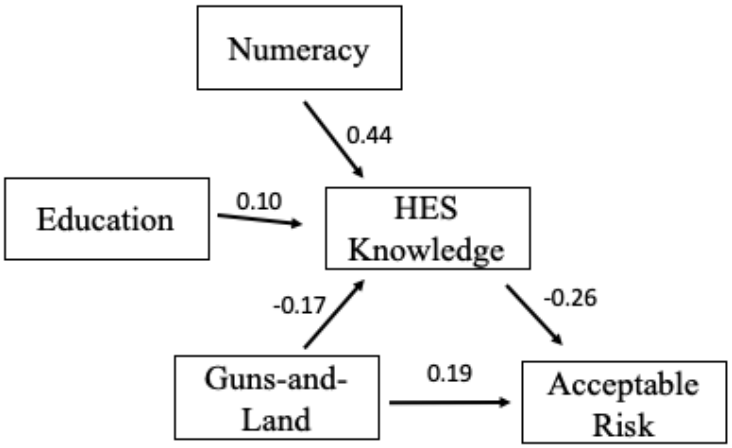

Figure 8. Structural Equation Model 4, validation set

5 Discussion

Conservation policy requires making normative judgements about what levels of risk are acceptable in the management of endangered species. There are four potential influences for these judgements: (i) statutory guidance, (ii) decisions or guidance provided by policy makers, (iii) the common practice of experts, and (iv) public attitudes (Hunter & Fewtrell, 2001). Understanding the first three is required for full appreciation of the fourth.

In the United States, important statutory guidance is provided by the Endangered Species Act. My survey used the ESA as a framework and was sent to an American audience, but these concepts apply to conservation policy internationally. Unlike previous conservation policy in the United States, the ESA provides a definition for "endangered species" that includes the concept of "significant portion of its range." This distinction importantly suggests that conservation should aim to do more than merely prevent a species from becoming extinct. Unfortunately, it is insufficient when assessing acceptable

levels of risk because it is unclear what portion of a species' range is required to qualify as "significant."

In recent years, the trend in guidance provided by policymakers has been towards weakening the ESA. According to records kept by the Center for Biological Diversity, in the 90s and early 2000s, approximately 5 pieces of legislation were proposed each year that would reduce the protections provided by the ESA. In 2011, when republicans took control of the House of Representatives, the number jumped to 30. In 2018, the number was 52. The United States Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) suggested in a proposal that "significant portion of its range" should be interpreted as only as little as the species needs to avoid extinction (Waples et al. 2007).

A common practice of experts in conservation is to express extinction risk in terms of the estimated probability of extinction over a specified period of time. A recent tendency is to consider a species endangered if extinction risk exceeds 5 percent over 100-year period (Doak et al., 2015). For comparison, one estimate of the natural background rate of extinction is that on average approximately one species out of every 100,000 should go extinct over a 100-year span (De Vos et al., 2015). While perhaps more generous than guidelines proposed by FWS and NMFS, this interpretation by conservationists is still many magnitudes greater than natural rates of extinction. It may be that conservationists temper guidelines with expectations about what is realistic or practical.

Historically, very little has been known about public attitudes as they pertain to acceptable risk for the biodiversity crisis (Vucetich & Nelson, 2018). One major goal of this survey is to explore these attitudes and to see how they measure against guidance provided by experts and policymakers. The results are summarized in figure 2. Item A asks about acceptable risk in relation to percent of species threatened with extinction. These numbers may be especially pertinent to IUCN and their Red List index. Items B and C ask about acceptable risk as it pertains to habitat loss for individual species. A median response of 10 for both items means that the majority of adult Americans believe a species should be protected when it has been reduced to 90% or less of its historic range. This is a far lower threshold for endangerment than proposed by government agencies or even conservationists.

Another major goal of this research is to better understand the root causes of variation found in these attitudes. Membership within the *guns-and-land* social identity and knowledge about human impact on the environment were the two most important predictors. These results match two possible explanations - social identity theory and the knowledge deficit hypothesis.

A social identity approach would argue that membership within a social group influences conservation attitudes. Even experts are prone to having their attitudes about the listing of endangered species influenced by the expectation of peers' assessment (Heeren et al., 2017). In the stepwise regression, the composite *guns-and-land* social identity was found to be a potential predictor of *acceptable risk*. The component identities – farmer or rancher, gun rights advocate, hunter, and property rights advocate –

align with important lobby groups that oppose the ESA such as the National Rifle Association and the American Farm Bureau Federation. Leaders within social groups commonly have more extreme views than laymembers (Nilsen et al. 2007), which may be the case here. Ultimately, the *guns-and-land* social identity was a fairly weak predictor of *acceptable risk*, with correlating at 0.19, with an additional 0.04 (0.17 × 0.26) explained indirectly through *DGknowledge.* Those familiar with the North American Model of Wildlife Conservation may be surprised to find hunters are willing to take greater than average risks in the management of endangered species.

The knowledge deficit model argues that the attitudes of the public vary from the attitudes of experts due to a lack of relevant knowledge. The findings show that *DGknowledge* is the best predictor of *acceptable risk*, correlating at 0.26. This could be seen as moderate support for the knowledge deficit model. Because the effect is small, intervention in the form of education is unlikely to have a strong impact. Fortunately, because public acceptance of risk is already so low, intervention is unlikely to be necessary. Social identity, numeracy, and personality in the form of *agreeableness* are all predictors of *DGknowledge*. *Education* is the least predictive, which is perhaps less surprising when remembering that this is not a form of knowledge taught in most higher education programs.

Personality was the only other predictor for *acceptable risk*. Although the items in *acceptable risk* are all numeric in nature, *numeracy* was not revealed to be an important predictor. Political identity, often a focus in conversations about the ESA, was also not an

important predictor. Neither the individualizing nor binding moral foundations ended up anywhere in the model.

My recommendation to those in a position to utilize the analysis of this research is to remember that the public's acceptance for risk in relation to the biodiversity crisis is very low, arguably even lower than that recommended by conservationists. If policy is going to reflect the values of the governed, enforcement needs to dramatically adjust its ambitions to reflect the values of the public.

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A Discussion of Pilot Studies

Before the main study, there were eight rounds of pilot studies. The primary need for multiple rounds of pilot studies was to develop the ESA knowledge scale (discussed further in Appendix B), though other portions of the survey also saw considerable revision. All versions of the pilot study were conducted using Amazon's Mechanical Turk. Sample sizes generally ranged from 200 to 250.

The earliest versions of the survey provided some respondents with a visual aid to better understand statistical information related to risk. Visual aids can be an excellent means of guiding action by way of informed ethical decision-making, but they were eventually removed because the goal of the study is to understand existing attitudes, not guide respondents towards any particular response.

In version 5, as the visual aid was removed, I tested the inclusion of a Social Desirability scale. Questions related to acceptable risk are normative value-judgements, but my concern was that respondents would feel there was a most socially acceptable "correct" way to answer those questions. I was unable to find evidence of bias towards more socially desirable answers.

In version 6, I transitioned to the MFQ from the World Value Survey (WVS). The WVS is a much smaller scale, and I wanted to explore the greater options allowed by the MFQ.

B Development of the ESA Knowledge Scale

Because of its potential use for intervention, knowledge can be a uniquely valuable predictor. One challenge of this survey was in deciding the most appropriate domain of knowledge to test. If the domain of knowledge was too broad, I thought I might lose any strength of relationship to my response items. If the domain of knowledge was too specific, I thought I might struggle to find enough respondents in my sample with high ratings.

Initially, the knowledge scale was a single test covering a range of subtopics related to extinction. Some of these were questions very specific to the ESA, but many hit a wider range of topics. For the 4th iteration of the study, I divided the knowledge scale into two separate tests – one more specific and one more generic. After the discovery of the Human-Environment Systems knowledge scale used by Díaz-Siefer et al. (2015), I used a slightly modified version of their scale for the domain-general scale and focused on creating my own ESA knowledge scale.

I began with a set of 33 questions of varying difficulty. Because so few people are very familiar with the ESA, it is easy to create a set of questions that are too hard. I experimented with a multiple choice version, but performance was too low, so in future iterations, I returned to a T/F(/I don't know) method. I used Item Response Theory to pair down the larger sets of questions to a set of 17 that performed sufficiently well.

C The ESA Knowledge Scale

The Endangered Species Act is the primary federal law designed to protect endangered species. Please indicate whether the following statements are true, false, or you do not know. Please DO NOT look up answers online.

1) There are more than 500 species protected by the Endangered Species Act.
2) There are endangered species in only half of the states in the U.S.
3) The Endangered Species Act is thought to have prevented the extinction of more than 100 species.
4) The Department of Agriculture enforces the ESA.
5) The Endangered Species Act allows for protecting genetically distinct populations.
6) Black bears are protected by the Endangered Species Act.
7) Whooping Cranes are protected by the Endangered Species Act.
8) Hawksbill Sea Turtles are protected by the Endangered Species Act.
9) The Endangered Species Act acknowledges that humans are an important cause of extinction.
10) The Endangered Species Act allows for the protection of critical habitat for endangered species.
11) The Endangered Species Act forbids killing an endangered species that is about to harm a person.
12) The Endangered Species Act protects more plant species than animal species.
13) The Endangered Species Act does not protect any fish species.
14) The Endangered Species Act only protects species for which there is a human-identified cause of decline.

15) States agencies can receive federal funding to implement endangered species conservation.
16) A species can be listed in the Endangered Species Act due to a commercial, recreational, or scientific overuse.
17) The only way for a species to receive protection under the Endangered Species Act is through petitioning by the public.