Environmental Management
https://doi.org/10.1007/s00267-021-01452-3

Factors Associated with Listing Decisions under the U.S. Endangered Species Act

Kathryn N. Smith-Hicks[1,2] · **Michael L. Morrison**[1]

Received: 25 May 2019 / Accepted: 15 February 2021

Abstract
Conservation efforts, including authorities outlined in the U.S. Endangered Species Act (ESA) of 1973, are attempting to slow the decline of species. Opinions on the success of the ESA vary widely, due in part to few species historically recovering to the point of delisting. Uncertainty surrounding the ESA relates to listing decisions and ambiguity of terminology within the ESA itself. Our goal was to evaluate the relationship, if any, of species characteristics, population metrics, threat level, and potential non-biological indicators to listing decisions under the ESA by the U.S. Fish and Wildlife Service (Service). We collected data from 143 ESA listing decisions published in the Federal Register from February 2011 to October 2014. Only 33 and 31% of listing decisions included population or range size estimates, respectively. Factors significantly correlated with ESA listing decision included taxonomic group, primary ownership of the species' habitat (federal or non-federal), whether the species is aquatic or terrestrial, and whether the species was part of a single or multiple-species listing decision. Increasing number of listed threats and time as a candidate species correlated positively with being listed as endangered. We have attempted to broadly identify the role both intrinsic (biological) and extrinsic (non-biological) factors play in listing decisions, and the importance of comprehensive data to understanding species distribution and abundance to facilitate more informed listing decisions.

Keywords U.S. Endangered Species Act · Listing decisions · Species recovery · Declining species · Extinction

Introduction

Extinction rates are now at many times the historical background rate and are likely to keep increasing (Pimm et al. 2014). Conservation efforts have slowed the decline of many species. The U.S. Endangered Species Act (ESA) of 1973 is designed to protect and recover imperiled species and the ecosystems they depend on. Some characteristics may cause a species to be more vulnerable to extinction than others, including inability to disperse efficiently (McKinney 1997; Pimm et al. 2014), low reproductive and survival rates (Purvis et al. 2000), large home ranges (i.e., individual's territory size) (Benscoter et al. 2013), and life history complexity (Koh et al. 2004). Taxonomic group is not a good predictor of extinction risk (Ando 1999; Jenkins et al. 2013); however, some characteristics of species within certain taxonomic groups can predict likelihood of extinction. Apart from actual extinction risk, there is evidence that certain factors, including if the species is perceived by the public as a higher form of life (Metrick and Weitzman 1996, Laband and Nieswiadomy 2006, Gratwicke et al. 2012) or time as a candidate species (Ando 1999, Bechtold 1999) determine if ESA protections and funding are mobilized.

The majority of declining species are experiencing the synergistic effects of multiple threats, which influence their habitat, reproductive success, and survival. Even when a threat is severe, such as widespread disease, it is rarely the single factor that leads to decline or extinction (Heard et al. 2013). For example, Gonzalez-Suarez and Revilla (2014) found that increasing extinction risk correlated with increasing number of threats to mammals on the International Union for Conservation of Nature (IUCN) Red List.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s00267-021-01452-3.

✉ Kathryn N. Smith-Hicks
kathryn.smith@ag.tamu.edu

[1] Department of Rangeland, Wildlife and Fisheries Management, Texas A&M University, College Station, TX 77843, USA

[2] Present address: Natural Resources Institute, Texas A&M University, College Station, TX 77843, USA

Numerous analyses have concluded that population isolation, overall range size, environmental fragmentation, and ecological specialization—individually and together—are also potential contributors to level of extinction risk for a species (Manne et al. 1999; Purvis et al. 2000; Henle et al. 2004; Stefanaki et al. 2015).

The process of listing a species under the ESA is extensive and requires many steps that may take several years or even decades. A species listing can be initiated either by internal assessment by the U.S. Fish and Wildlife Service (Service) or the National Marine Fisheries Service (NMFS) or by petition from private citizens or organizations. To proceed with the process of ESA evaluation, an initial assessment of the petition must conclude that there is sufficient information about species' vulnerability and exposure to threats. The Service then publishes a 90-day finding in the Federal Register either declaring the petition not sufficient for further review or prompting the Service to collect and evaluate additional information. The Service then evaluates all the information available and determines whether the species is warranted for listing (i.e., endangered or threatened), not warranted, or warranted but precluded. An amendment to the ESA in 1982 provisioned that a species remains a candidate for listing if it is warranted but precluded by other higher priority listing activities (48 FR 43098), in which case the species' status is required to be re-evaluated each year. When a species is declared warranted but precluded, it becomes a candidate for listing, and the Service or NMFS assigns a listing priority number (LPN). LPNs range from 1–12. Lower numbers indicate higher listing urgency, which is determined by magnitude and immediacy of threats, relative distinctiveness or isolation of the species according to genetic analysis, number of remaining species in the genus, and whether it is a subspecies. Section 4 of the ESA lists the five criteria, only one of which must be met, for determining whether a species is endangered or threatened: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence.

If the species is determined to be warranted for listing, a 12-month period ensues during which public comments are accepted, public hearings are held, and additional information is requested by the Service, including peer review by selected individuals. Unless sufficient evidence is presented that the species should not be listed (e.g., elimination of threats, larger population than previously known), the Service publishes a Final Rule in the Federal Register and the species is designated as endangered or threatened under the ESA. An alternative to the normal listing process is the issuance of an emergency rule by the Service or NMFS. Emergency rules bypass a large part of the process described above and immediately declare the species as endangered if the agency identifies impending threats that create significant risk to the immediate survival of the species. Once emergency listed, the Service or NMFS conducts a formal full review process.

Opinions of the success of the ESA vary. Very few species listed have recovered to the point of delisting (Abbitt and Scott 2001; Beissinger and Perrine 2001). Conversely, proponents of the ESA point out the continued survival and population-level improvement for many species protected under the ESA (Greenwald et al. 2013; Schwartz 2008). Much of the contention surrounding the ESA relates to listing decisions and perceived ambiguity of terminology within the ESA (Bean 2009; Waples et al. 2013). Determinations of species status and conservation measures under the ESA (i.e., endangered, threatened, not warranted) must be made solely on the basis of the best scientific and commercial data available, without consideration of possible economic or other effects (ESA, Section 4). Comprehensive data on population size and range extent are often scant for rare species (Pimm et al. 2014). In addition, science can only make predictions regarding risk of extinction and cannot provide guidance for how much risk is acceptable. The Service recently modified the process of evaluating candidate species by implementing a Species Status Assessment (SSA) process to improve consistency and transparency in species risk assessments (Smith et al. 2018). This policy began after the collection of data for this study.

According to previous data and research, the availability of sufficient and accurate science to conclude the risk of a species to becoming extinct, both before and after the listing of a species as endangered or threatened, is limited in many ways (Schultz 2008, Gibbs and Currie 2012). Very often, little is known about a species' distribution, abundance, and threats because there has been very little scientific investigation. It is possible that species for which there are few data regarding the immanency of risk are precluded from listing because species for which data point to clear risk of extinction receive a higher priority. Delay has also been shown to be directly linked to interest group interference (Ando 1999). Many species designated as warranted but precluded have been candidates for listing under the ESA for 10+ years, and some of those species may have slipped beyond recovery while waiting to be listed.

The cost, both ecological and social, of protecting species that do not need protection (Type I error) and of not protecting species that need protection (Type II error) are significant. Therefore, it is important to recognize which factors are potentially influencing ESA listing decisions in situations with limited scientific data and ambiguous legislative mandates. Previous studies, including those mentioned above, are consistent with the notion that extrinsic factors can influence the likelihood of protection by the ESA, as can procedural influences such as regulatory delay (Bechtold 1999). Regulatory delay (e.g., long duration as a candidate species) allows a way that bureaucratic entities can avoid decision-making, likely in response to pressure from outside interest groups (Ando 1999). For example, Bechtold (1999) suggested that the Service delayed listing of the bull trout (*Salvelinus confluentus*) by making the determination that listing was warranted but precluded. However, delay may simply be a function of the Service not being equipped to handle extremely high workloads (Smith 2016).

Our goals were to evaluate the correlation, if any, of both intrinsic (biological) and extrinsic (non-biological) species characteristics in the listing decisions under the ESA and to better understand the level of uncertainty and variation in data presented to ESA decision makers at the Service. We also seek to better understand how decisions may vary by habitat location and ownership and time spent as a candidate species. Based on the previous research on the effects of characteristics influencing extinction risk and ESA listing decision, we evaluated several predictions (Table 1). We also evaluated potential listing outcome discrepancies by assessing differences in endangerment status between ESA listing decision and NatureServe classification (discussed below), a non-legal rank used as a proxy for the potential of a species to be listed in previous analyses of ESA listing decisions (Gratwicke et al. 2012; Laband and Nieswiadomy 2006; Wilcove and Master 2005).

Methods

Data Collection

We collected all ESA listing decisions that were proposed or finalized between February 2011 and October 2014 for species in the United States. We collected Proposed Rules for species for which listing was determined to be not warranted and warranted but precluded species, and Final Rules for species listed as endangered or threatened species (hereafter “Rules”). Agency rules, proposed rules, and public notices are published in the Federal Register (http://www.regulations.gov/), the official journal of the U. S. federal government. We randomly sampled one species from multiple-species and multiple-subspecies Rules when the information was not clearly separated for each species within the Proposed or Final Rules. We included listing decisions with species grouped into a multi-species decisions by the Service because they occur in the same ecosystems or, occasionally, because they have similar life histories. This allowed us to avoid sampling the same information for multiple species listed in the same Rule. For example, eight mussel species occurring within Gulf Coast states were listed under one Rule, and the same wording and information was used to identify common threats and biological needs for each species. Therefore, the species were not evaluated independently, and so we only included one in our sample. In addition, we did not sample or evaluate species from Rules where the species were determined by the Service to not be listable entities (i.e., species was determined to not be a distinct population segment, subspecies, or species). For each species, we collected general information such as listing decision, taxonomic class, number and type of potential threats, time as candidate, and number of other species in the listing decision. We combined reptiles and amphibians into “herpetofauna” to boost sample size and categorized all invertebrates as “aquatic” or “terrestrial” (for seven total taxonomic categories: plants, terrestrial invertebrates, aquatic invertebrates, herpetofauna, fishes, mammals, and birds).

Because there is typically insufficient information included in a Rule, or available, to use more detailed criteria regarding level of threat or amount of historical habitat lost to a specific threat, we restricted analysis of threats to total number of threats specified by both the Rule and NatureServe. We accessed NatureServe, an independent organization that works closely with the IUCN (http://explorer.natureserve.org), for potential threats and conservation status ranks (G1—G5) beyond what was included in the published Rules. NatureServe status rank is the result of the

Table 1 Predicted influence of explanatory variables on likelihood of protection under the Endangered Species Act

Explanatory variable	Prediction	Citation
Body size	Increasing body size increases likelihood of protection.	Metrick and Weitzman (1996)
Taxonomic group	Reptiles and fishes less likely to be listed than other taxa.	Gratwicke et al. (2012)
	Plants less likely to be listed than animal species.	Harllee et al. (2009)
Threats	Increasing number of threats increase likelihood of protection.	Gonzalez-Suarez and Revilla (2014)
Time as candidate	Increasing time as candidate increases likelihood of protection.	Ando (1999); Bechtold (1999)

assessment of threats and levels of endangerment of species, and has been used previously as an indicator of potential for formal listings under the ESA (Metrick and Weitzman 1996; Gratwicke et al. 2012). We calculated number of threats by summing the number of threats cited by either the Rule or NatureServe: agriculture, land conversion, resource use, water diversion, commercial fishing, competing uses, exploitation, climate change, modified disturbance regimes, pesticides or herbicides, pollution (other), exotic or invasive species, species interactions, small population size, and unknown or other. We calculated time as a candidate by subtracting the date of the Proposed Rule from that on which the Service initially deemed the species warranted for full review in a 90-day finding.

We recorded population estimates, range size estimates, descriptive location information from both the published Rules and NatureServe, whether the species occupies an island or mainland, and if it is known to occur in Canada or Mexico during any part of its life. We also determined if the species' habitat occurs primarily (>50% of current range) on federal (e.g., managed by the Service, U.S. Forest Service, Bureau of Land Management, National Park Service) or non-federal lands (e.g., state, county, private) by examining range maps and descriptions of their current range in the Rules and the Protected Areas Database (https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/protected-areas).

Statistical Analyses

We conducted all statistical analyses in R (R Core Development Team 2013). We initially conducted preliminary analysis using package *Hmisc* to test for correlation among covariates. We conducted Pearson's Chi-square tests for count data to determine if ESA listing decisions (i.e., endangered, threatened, warranted but precluded, or not warranted) were independent of categorical explanatory variables (i.e., taxon, habitat ownership, island vs. mainland, aquatic vs. terrestrial, overlap with Canada or Mexico, single vs. multiple species decisions) associated with each species. We calculated Cramer's V for each contingency table to describe the degree of strength of each association. To determine which categories were contributing most to the significance of the Chi-square score, we used Pearson residuals for each cell. We considered any contribution ≥10%, the minimum amount considered a weak association (Cohen 1988), to be meaningful.

To determine correlations between continuous variables (i.e., time as candidate, number of threats) and each listing decision (coded 0,1), we used the R package *lme4* (Bates and Maechler 2009) to fit logistic regression models with generalized linear models. We determined the significance of correlations between decision outcome and continuous variables and direction of correlation by examining each logistic regression's Chi-square statistic, Wald's chi-square, and odds ratio. Odds ratio, an interpretation of the logit coefficient, was a relative measure of the probability that each variable is associated with an ESA listing decision and indicated the degree to which the explanatory variable explained the decision outcome while holding other variables constant.

Results

We collected data on 143 ESA listing decisions from 101 Rules published in the Federal Register between 10 February 2011 and 3 October 2014 (Table 2). Of the 143 decisions, 82 (57%) came from multiple-species Rules (i.e., ≥2 species or subspecies per Rule). We sub-sampled one species from each of the three multi-species Rules containing >2 species (8 gulf coast mussels, 4 subspecies of the Mazama pocket gopher, and 7 species of Hawaiian bees) to avoid collecting repeated information on multiple species or

Table 2 Count and percentage of species evaluated under the Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service (Service) from 2011 to 2014 by taxonomic group and ESA listing decision (endangered = EN, threatened = TH, warranted but precluded = PR, not warranted = NW), mean (±SD) months as candidate species, mean (±SD) months proposed for protection, and mean number of threats (±SD) cited in both the Federal Register Rules and on NatureServe

Taxonomic group	Count	EN	TH	PR	NW	Months candidate[a]	Months proposed[b]	# threats
Plants	40 (28.0%)	16	7	2	15	261.0 ± 162.2	12.3 ± 2.2	4 ± 1
Terrestrial invertebrates	30 (21.0%)	8	0	6	16	146.2 ± 145.7	12.9 ± 5.1	4 ± 1
Aquatic invertebrates	23 (16.1%)	14	3	5	1	181.5 ± 145.7	12.1 ± 1.5	5 ± 2
Herpetofauna	18 (12.6%)	6	7	1	4	155.4 ± 118.8	13.3 ± 2.4	6 ± 2
Fishes	14 (9.8%)	5	1	1	7	156.8 ± 118.8	13.0 ± 2.4	5 ± 2
Mammals	9 (6.3%)	2	1	2	4	123.0 ± 114.7	13.3 ± 2.3	5 ± 2
Birds	9 (6.3%)	0	3	0	6	111.7 ± 58.3	14.7 ± 4.6	5 ± 2
Total	143	51	22	17	53	189.2 ± 151.6	12.7 ± 2.7	5 ± 2

[a]Number of months from the time a species first was considered as a candidate species by the Service to the time a Proposed Rule was published in the Federal Register

[b]Number of months between the published Proposed and Final Rules in the Federal Register

Table 3 Count and percentage of species by threat type and utilized general habitat type, as defined by the U.S. Fish and Wildlife Service or NatureServe, in Endangered Species Act listing decisions from 2011 to 2014

Threat	Description	Aquatic	Terrestrial	Both	Total
Agriculture	Crop or livestock production	25 (48%)	30 (36%)	0 (0%)	55 (38%)
Land conversion	Urban or suburban development; road construction	23 (44%)	51 (61%)	3 (38%)	77 (54%)
Resource use	Mining, oil and gas extraction, timber harvest	20 (38%)	25 (30%)	2 (25%)	47 (33%)
Water diversion	Dams, dredging, or extraction	41 (79%)	11 (13%)	0 (0%)	52 (36%)
Commercial fishing	Indirect effects of overfishing or equipment use	0 (0%)	0 (0%)	3 (38%)	3 (2%)
Competing uses (other)	Recreational, military, etc.	6 (12%)	31 (37%)	1 (13%)	38 (27%)
Exploitation	Collection or killing by humans	4 (8%)	10 (12%)	4 (50%)	18 (13%)
Climate change	Harm due a change in the mean or variability of one or more measures of climate that persists for an extended period	20 (38%)	31 (37%)	5 (63%)	56 (39%)
Modified disturbance regimes	Altered historical fire and grazing patterns	7 (13%)	42 (51%)	0 (0%)	49 (34%)
Pesticides/Herbicides	Direct or indirect effects of pesticides or herbicides	9 (17%)	13 (16%)	0 (0%)	22 (15%)
Pollution (other)	Contamination of habitat by toxic substances	23 (44%)	2 (2%)	5 (63%)	30 (21%)
Exotic/invasive spp.	Exotic or invasive species displacing species or species' habitat	34 (65%)	38 (46%)	4 (50%)	76 (53%)
Species interactions	Depredation, parasitism, disease	8 (15%)	20 (24%)	3 (38%)	31 (22%)
Small, isolated populations	Population(s) small and relatively isolated	38 (73%)	58 (70%)	1 (13%)	97 (68%)
Unknown/Other	Other threats which do not apply to categories above or species decline is caused by an unknown factor	2 (4%)	6 (7%)	0 (0%)	8 (6%)

subspecies. Of the species evaluated, the habitat of 78 (~55%) is primarily on non-federal land while that of the remaining 65 (~45%) species is primarily on federal land. Fifty-one (35.7%) of the 143 species were designated as endangered, 22 (15.4%) were designated as threatened, 17 (11.9%) were deemed warranted but precluded, and 53 (37.1%) were considered not warranted for protection under the ESA (Table 2).

The most represented taxonomic group was plants (28%) and the least represented were birds (6.3%) and mammals (6.3%) (Table 2). The mean (±SD) time each species was a candidate (i.e., time since the species was initially deemed warranted for full review) was 189.2 ± 151.6 months. The median time that species designated as endangered, threatened, warranted but precluded, and not warranted were candidates was 271, 153, 20, and 103 months, respectively. Plants were candidates for listing for longer than other taxa, and birds for shorter periods of time (Table 2).

The most common threats identified in the Rules were land conversion, population isolation, and exotic or invasive species (Table 3). The most common threat to aquatic species was water diversion, while climate change was cited as a threat to 63% of species that utilize both aquatic and terrestrial habitat (Table 3). The mean (±SD) number of threats listed for a species by Rule or NatureServe was 4.6 ± 1.9. Herpetofauna had the greatest number of threats (6 ± 2) (Table 2). Most (57%) of the species evaluated had the highest NatureServe conservation ranks, G1 and G2 (Table 4).

The Service presented a current population range size estimate for 44 (~31%) decisions and a population size estimate for 47 (~33%) decisions (Table 5). Among taxonomic groups, the largest percentage of population and range size estimates was associated with plants (Table 5). Range size estimates were not provided for any of the aquatic invertebrates evaluated ($n = 23$) and were provided for one species of bird (Table 5). Population sizes were provided for <15% of the herpetofauna, fishes, and mammals (Table 5). We did not include population and range size estimates when looking at factors correlated with ESA listing decisions because of the low sample size.

Factors Correlated with ESA Listing Decisions

Some taxonomic identities were correlated with ESA listing decisions: terrestrial invertebrates were less likely to be listed as threatened, aquatic invertebrates were less likely to be listed as not warranted for listing, and herpetofauna were more likely to be listed as threatened when compared to other taxonomic groups (Table 4). ESA decision also correlated with primary ownership of the species' habitat, with species occurring on federal land less likely to be protected than those on non-federal land (Table 4). Other variables that correlated with ESA decisions included use pf both aquatic and terrestrial areas and inclusion in a multiple-species decision (Table 4). Whether a species was an island or mainland species was not correlated with ESA decision, and there was no correlation between ESA decision and

Table 4 Count and summary of Pearson's Chi-square analysis for categorical variables' associations with Endangered Species Act listing decisions from 2011 to 2014

Characteristic	Total	Endangered	Threatened	Warranted but precluded	Not warranted	Chi square tests of independence
Taxonomic Group						χ^2 (18) = 43.20
Mammal	9	2	1	2	4	$p < 0.001$
Terrestrial Invertebrate	30	8	0[a]	6	16	$V = 0.32$
Aquatic Invertebrate	23	14	3	5	1[a]	
Avian	9	0	3	0	6	
Plant	40	16	7	2	15	
Fish	14	5	1	1	7	
Herp	18	6	7[a]	1	4	
Habitat						χ^2 (6) = 6.12
Mainland U.S.	124	42	21	13	48	$p = 0.41$
Island	11	5	1	3	2	$V = 0.15$
Both	8	4	0	1	3	
Aquatic	52	26[a]	9	8	9[a]	χ^2 (3) = 14.35
Terrestrial	83	25[a]	13	7	38[a]	$p = 0.002$
Both	8	0	0	2	6	$V = 0.32$
Primary Ownership						χ^2 (3) = 23.66
Federal	65	15[a]	6	6	38[a]	$p < 0.001$
Non-federal	78	36[a]	16	11	15[a]	$V = 0.41$
Range						
U.S. only	120	47	18	13	42	χ^2 (3) = 4.19
Overlap Mexico	8	1	2	1	4	$p = 0.24$
Overlap Canada	14	3	1	3	7	$V = 0.17$
U.S., Mexico and Canada	1	0	1	0	0	
NatureServe Rank						
No Rank	7	3	1	3	0	χ^2 (12) = 13.00
G1	46	18	8	4	16	$p = 0.37$
G2	36	14	3	6	13	$V = 0.18$
G3	17	6	3	0	8	
G4	16	5	5	2	4	
G5	20	5	2	1	12	
GH	1	0	0	1	0	
No. Species in Decision						
Single	61	15[a]	30[a]	10	6[a]	χ^2 (3) = 11.82
Multiple	82	36[a]	16	7	23[a]	$p = 0.008$ $V = 0.29$

[a]Denotes >10% contribution to Chi square score

whether a species' range overlapped with Canada or Mexico (Table 4). In addition, none of the NatureServe conservation ranks correlated with ESA listing decisions (Table 4).

Number of threats correlated was correlated with whether a species was listed as endangered, warranted but precluded, and not warranted, but not as threatened (Table 6, Fig. 1). Every threat that was added to the listing decision was associated with a 43% and 44% increase in the odds of an endangered or warranted but precluded determination, respectively, but a 41% lower likelihood of a not-warranted determination (Table 6). Time as candidate was also correlated with designation as endangered or warranted but precluded; however, there was no correlation between time as a candidate and a not warranted or threatened determination (Table 6; Fig. 2). For every year a species was a candidate, there was 6% increase in the odds of being listed as endangered, and a 39% lower likelihood of a warranted but precluded determination.

Discussion

Ownership of habitat correlated strongly with being listed as endangered under the ESA. Furthermore, species whose habitat occurs on federal land and were listed as endangered had more threats than endangered species on non-federal land. These results may be an artifact of higher threat intensity on non-federal lands, such as more development or lower water quality, which are common drivers of species declines. It is also possible that these differences are influenced by political variation or various views about land ownership within the states or regions where the species occur. There is the potential that listing decisions are influenced by bounded rationality (Lindblom 1959, Jones 1999) and institutionalized agency norms within the Service (Gerlach et al. 2013, Smith 2016), which infers that decision makers within the Service could be bound by goal-oriented behavior and their ability to process large amounts of information under high workload situations. However, it is also possible that many species occurring primarily on federal land are deemed not warranted for listing because regulatory mechanisms for their protection are considered adequate (ESA, Section 4(a)(D)). *Existing regulatory mechanisms* is not clearly defined under the ESA, and its application in the context of listing decisions under the ESA is unclear.

Our results indicated that species included in multi-species Rules were more likely to be protected under the ESA than those evaluated on their own; therefore, it is important to determine if multi-species evaluations are serving their originally intended purpose. In the Interagency Policy for the Ecosystem Approach to the ESA, released by the Department of Interior and Department of Commerce (59 FR 34274, 1 July 1994), the stated purpose of multi-species Rules was to "provide a means whereby the

Table 5 Count and percentage of species per taxonomic group and Rules containing population and range estimates by the U.S. Fish and Wildlife Service for Endangered Species Act listing decisions from 2011 to 2014

		Estimated by service	
Taxonomic group	# of species	Population	Range
Plant	40 (28.0%)	26 (65%)	20 (50.0%)
Terrestrial invertebrates	30 (21.0%)	5 (16.7%)	12 (40.0%)
Aquatic invertebrates	23 (16.1%)	5 (21.7%)	0 (0.0%)
Herpetofauna	18 (12.6%)	1 (5.6%)	4 (22.2%)
Fishes	14 (9.8%)	2 (14.3%)	4 (28.6%)
Mammals	9 (6.3%)	1 (11.1%)	3 (33.3%)
Birds	9 (6.3%)	7 (77.8%)	1 (11.1%)
Total	143	47 (32.9%)	44 (30.8%)

Table 6 Summary of logistic regression analysis for continuous variables predicting Endangered Species Act listing decision controlling for background variables

Outcome	Predictor	β	*SE* β	Wald's χ^2	*df*	*p*	Odds ratio	Overall model evaluation
Endangered								
	Intercept	−3.2799	0.6874	22.8	1	<0.001	NA	χ^2 (2) = 25.47
	Threats	0.3599	0.1091	10.9	1	0.001	1.43	$p < 0.001$
	Time As Candidate	0.0587	0.016	13.5	1	<0.001	1.06	
Threatened								
	Intercept	−2.6714	0.7542	12.5	1	<0.001	NA	χ^2 (2) = 2.24
	Threats	0.1346	0.1251	1.2	1	0.28	1.14	$p = 0.33$
	Time As Candidate	0.0199	0.0186	1.1	1	0.29	1.02	
Warranted but precluded								
	Intercept	−1.206	0.809	2.2	1	0.14	NA	χ^2 (2) = 43.27
	Threats	0.3651	0.1661	4.8	1	0.03	1.44	$p < 0.001$
	Time As Candidate	−0.4953	0.1632	9.2	1	0.002	0.61	
Not warranted								
	Intercept	2.0248	0.5779	12.3	1	<0.001	NA	χ^2 (2) = 26.52
	Threats	−0.5212	0.1182	19.4	1	<0.001	0.59	$p < 0.001$
	Time As Candidate	−0.0178	0.0153	1.4	1	0.24	0.98	

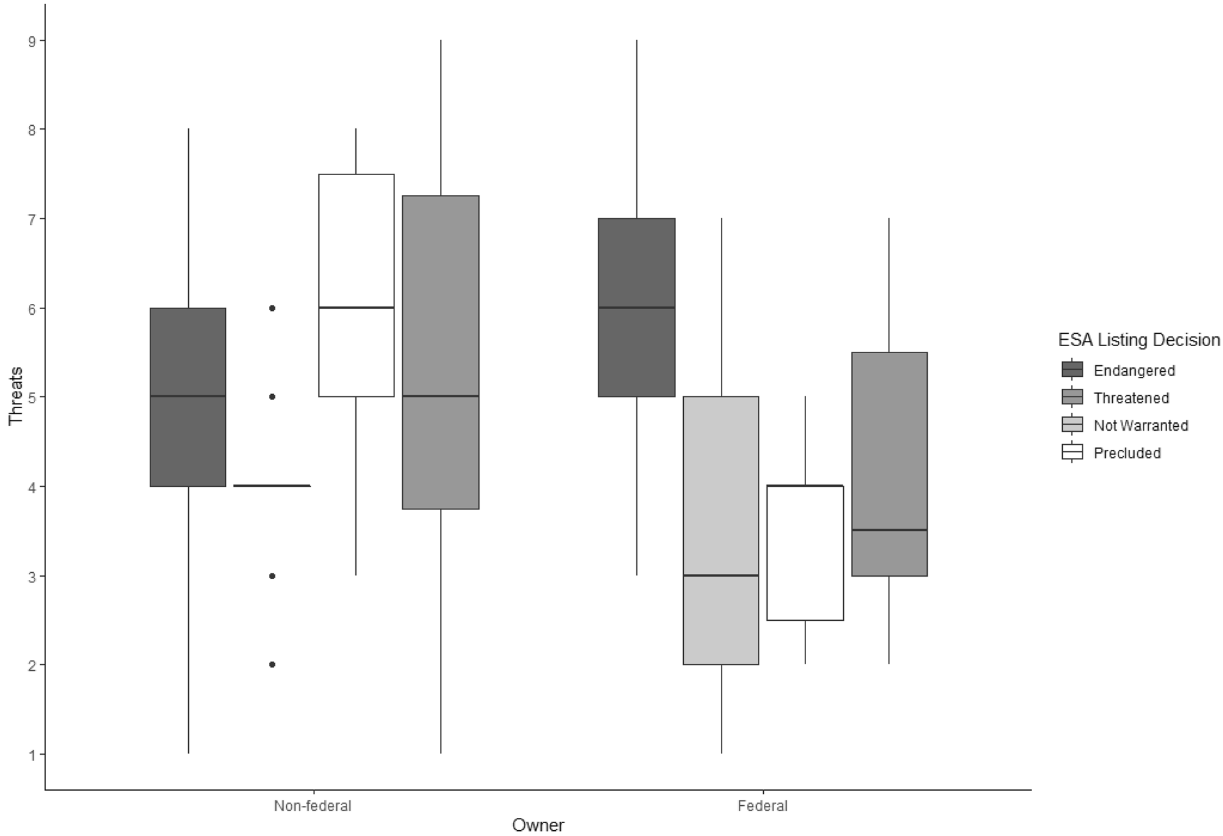

Fig. 1 Number of threats cited for each species by Endangered Species Act (ESA) listing decision and ownership of habitat

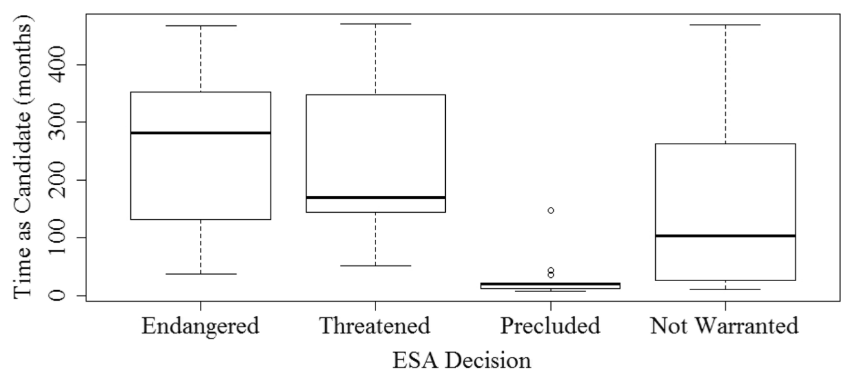

Fig. 2 Time spent as a candidate (i.e., number of months from the time a species was considered a candidate species by U.S. Fish and Wildlife Service (Service) to the time the Proposed Rule was published in the Federal Register) for each decision category for Endangered Species Act (ESA) decisions made from 2011 to 2014

ecosystems upon which endangered and threatened species depend may be conserved" (ESA, Section 2(b)). This was to be done partially by "grouping listing decisions based on a geographic, taxonomic, or ecosystem basis where possible". The Service rarely applied this policy until a 2011 court decisions mandating the large number of listing decisions be made by 2016, which mandated initial petition findings for over 600 species and proposed listing rules for 251 species (WildEarth Guardians v. Salazar 2011). More research is needed into how the Service is currently using multi-species rules and the advantages and disadvantages of utilizing this policy.

There are potential benefits to listing several species in one listing decision, including conservation and efficiency. Species occurring within the same ecosystem or geographic area likely face similar threats (e.g., water quality and non-point source pollution, coastal marshes and sea level rise) that the Service can identify and evaluate concurrently. This would decrease their workload and likely increase overall decision quality (Smith 2016). In addition, if multiple species in the same geographic area are protected at the same time, then overall costs could potentially decrease overall due to simultaneous recovery and management actions if the species needs are similar. Because many of the ESA's costs are indirect, they are difficult to quantify and, therefore, no explicit data exist to assess cost savings for integrative approaches to conservation (Ando 2001). Ando (2001) concluded that the Service benefits from listing several species in one Rule because it decreases the overall interest group opposition. They found that at the county level, above 14.3 previous listed species/100 km^2, the likelihood of opposition to new listings begins to rise (Ando 2001). In addition, the amount of opposition did not increase as the number of species in the decision increased (Ando 2001). Therefore, multi-species decisions may be a constructive avenue to list species from a time and effort perspective.

Our results indicated that relatively large body size (e.g., mammals and birds) was not a significant predictor of protection under the ESA. In contrast, previous research suggested that large body size and charisma increases likelihood of support for conservation (Table 1; Gunnthorsdottir 2001; Metrick and Weitzman 1996). This may be because many of the larger mammals with expansive ranges in the United States were already protected under the ESA (e.g., gray wolf (*Canis lupus*), grizzly bear (*Ursus arctos horribilis*), Florida panther (*Puma concolor coryi*)). Aquatic invertebrates were more likely to receive protection under the ESA than all other taxa. Only one of the twenty-three species, which occurred on public land, was determined not to be warranted for protection. Unlike the results of previous research (Gratwicke et al. 2012, Harllee et al. 2009), our results did not suggest that reptiles, fishes, or plants had a lower likelihood of protection than other taxa. However, three of the seven NatureServe "at risk" fish species were determine to be not warranted for listing while two species classified as having lower risk by NatureServe were given ESA protection. We acknowledge that our study only includes species that the Service determined in their initial 90-day finding to deserve a full evaluation. Further research is needed to determine if certain taxonomic groups are more or less likely to be petitioned for listing or considered warranted for further review during the early evaluation phases under the ESA.

Increasing number of threats and increasing time as a candidate were positively correlated with being listed as endangered, which was consistent with our prediction (Table 1) and potentially indicated that species protected under the ESA are in greater need of protection than those designated as not warranted for protection. It also is possible that this correlation is the result of the Service listing more threats in the Final Rules to justify their decision to protect species under the ESA. Another cause of this correlation may be discovery bias, which Heard et al. (2013) described as the accumulation of knowledge as an artifact of amassed resources for species at increasing risk of extinction. Our data showed that the likelihood of being listed as endangered was much higher for species that were on the candidate list for >10 years. We suspect that the longer a species is designated as warranted but precluded from protection, the more likely that research dollars and time may be channeled in its direction, which could increase awareness of threats. There is also the possibility that more threats accrue to species that are not protected (e.g., more population fragmentation, loss of genetic diversity) and, therefore, chances of recovery decrease (Ando 1999). In our study, however, species deemed warranted but precluded from listing were associated with greater numbers of threats and short duration as a candidate species.

We did not find a correlation between NatureServe conservation rank, which does not reflect protection or existing regulatory mechanisms, and ESA listing decision. This result is consistent with previous research indicating that species of high conservation concern are no more likely to be protected under the ESA than species of lower concern (Gratwicke et al. 2012; Laband and Nieswiadomy 2006; Wilcove and Master 2005). We found a high level of uncertainty in estimated population and range sizes, which were presented in only one-third of listing decisions. Previous research suggested that uncertainty allows for increasing variation in agency interpretation (Schultz 2008). According to Doremus (1997), uncertainty and the ESA "science only" mandate makes the basis for decisions difficult to understand, and ultimately may undermine political support by declaring science is the ultimate foundation for their decisions. This is especially challenging because scientific questions and science policy questions may vary for the same species, especially when uncertainty is high.

The largest threats to species on the brink of extinction around the world include direct habitat loss through land-use changes and invasive species (WWF 2020). Similarly, human land use and invasive species threatened more than half of all species evaluated under the ESA during our study period. Indeed, we conclude common threats to species in peril are the shared denominator among them, and policies that attempt to mitigate common threats, rather than threats to a single species, may be the key to addressing cascading losses in biodiversity. Furthermore, current recovery tools (e.g., wildlife refuges, reintroductions, conservation banking) may not fully address species' needs such that they can be delisted (Gibbs and Currie 2012). Therefore, a more broad ecosystem-based approach that focuses on threats to systems may be more effective. The current structure of the ESA, as well as the configuration and content of listing Rules, are not conducive to making decisions based on threats to ecosystems.

We identified the potential role that extrinsic factors appear to play in listing decisions and limited data available to inform ESA listing decisions for most species under evaluation. Since these data were collected, the Service has shifted its procedures for evaluating candidate and listed species from focusing solely on the traditional five-factor analysis, which was used for all listings evaluated during this research, to SSA. The purpose of SSAs is to more clearly evaluate current and future conditions of the target species assessing causal relationships between factors influencing the species and the species' response over time. While SSAs are providing more biological justifications for ESA listing decision, some of the extrinsic factors presented in this research could still be correlated with listing potential and funding given that SSAs are only part of the decision process within the Service.

Acknowledgements Graduate study contributing to this paper was supported by a dissertation research fellowship from Tom Slick Foundation and the J.H. Benedict Memorial Scholarship. We thank Dr. R. Neal Wilkins, Dr. Manuel P. Teodoro, and Dr. Forrest D. Fleishmann for their support and guidance as well as Dr. Roel Lopez and several anonymous reviewers for their helpful reviews.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

Abbitt RJ, Scott JM (2001) Examining differences between recovered and declining endangered species. Conserv Biol 15:1274–1284

Ando AW (1999) Waiting to be protected under the Endangered Species Act: the political economy of regulatory delay. J Law Econ 42:29–60

Ando AW (2001) Economies of scope in endangered-species protection: evidence from interest-group behavior. J Environ Econ Manag 41:312–332

Bates D, Maechler M (2009) Ime4: linear mixed-effects models using S4 classes. R Foundation for Statistical Computing, Vienna, Austria, R package version 0.999375-31

Bean MJ (2009) The endangered species act. Ann N Y Acad Sci 1162:369–391

Bechtold T (1999) Listing the bull trout under the Endangered Species Act: the passive-aggressive strategy of the United States Fish and Wildlife Service to prevent protecting warranted species. Public Land Resour Law Rev 20:99–129

Beissinger SR, Perrine JD (2001) Extinction, recovery, and the endangered species act. Cambridge University Press, New York

Benscoter AM, Reece JS, Noss RF, Brandt LA, Mazzotti FJ, Romañach SS, Watling JI (2013) Threatened and endangered subspecies with vulnerable ecological traits also have high susceptibility to sea level rise and habitat fragmentation. PloS ONE 8:e70647

Cohen J (1988) Statistical power analysis for the behavioral sciences, 2nd ed. Lawrence Erlbaum Associates, New Jersey

Doremus H (1997) Listing decisions under the Endangered Species Act: why better science isn't always better policy. Washington Univer Law Rev 75:1029–1153

Gerlach JD, Williams LK, Forcina CE (2013) Data selection for making biodiversity management decisions: best available science and institutionalized agency norms. Adm Soc 45:213–241

Gibbs KE, Currie DJ (2012) Protecting endangered species: do the main legislative tools work? PloS ONE 7:e35730

Gonzalez-Suarez M, Revilla E (2014) Generalized drivers in the mammalian endangerment process. PloS ONE 9:e90292

Gratwicke B, Lovejoy TE, Wildt DE (2012) Will amphibians croak under the Endangered Species Act? BioScience 62:197–202

Greenwald N, Ando AW, Butchart SHM, Tschirhart J (2013) Conservation: the Endangered Species Act at 40. Nature 504:369–370

Gunnthorsdottir A (2001) Physical attractiveness of an animal species as a decision factor for its preservation. Anthrozoös 14:204–215

Harllee B, Kim M, Nieswiadomy M (2009) Political influence on historical ESA listings by state: a count data analysis. Public Choice 140:21–42

Heard MJ, Smith KF, Ripp KJ, Berger M, Chen J, Dittmeier J, Goter M, Mcgarvey ST, Ryan E (2013) The threat of disease increases as species move toward extinction. Conserv Biol 27:1378–1388

Henle K, Davies KF, Kleyer M, Margules C, Settele J (2004) Predictors of species sensitivity to fragmentation. Biodiver Conserv 13:207–251

Jenkins CN, Pimm SL, Joppa LN (2013) Global patterns of terrestrial vertebrate diversity and conservation. Proceed Natl Acad Sci 110: E2602–E2610

Jones BD (1999) Bounded rationality. Annu Rev Political Sci 2:297–321

Koh LP, Dunn RR, Sodhi NS, Colwell RK, Proctor HC, Smith VC (2004) Species coextinctions and the biodiversity crisis. Science 305:1632–1634

Laband DN, Nieswiadomy M (2006) Factors affecting species' risk of extinction: an empirical anaylysis of ESA and NatureServe listings. Contemp Econ Policy 24:160–171

Lindblom CE (1959) The science of "muddling through". Public Adm Rev 19:79–88

Manne LL, Brooks TM, Pimm SL (1999) Relative risk of extinction of passerine birds on continents and islands. Nature 399:258–261

McKinney ML (1997) Extinction vulnerability and selectivity: combining ecological and paleontological views. Annu Rev Ecol Syst 28:495–516

Metrick A, Weitzman ML (1996) Patterns of behavior in endangered species preservation. Land Econ 72:1–16

Pimm SL, Jenkins CN, Abell R, Brooks TM, Gittleman JL, Joppa LN, Raven PH, Roberts CM, Sexton JO (2014) The biodiversity of species and their rates of extinction, distribution, and protection. Science 344:1246752

Purvis A, Gittleman JL, Cowlishaw G, Mace GM (2000) Predicting extinction risk in declining species. Proceed Royal Soc Londn B: Biol Sci 267:1947–1952

R Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Schultz C (2008) Responding to scientific uncertainty in US forest policy. Environ Sci Policy 11:253–271

Schwartz MW (2008) The performance of the Endangered Species Act. Annu Rev Ecol, Evol, Syst 39:279–299

Smith DR, Allan NL, McGowan CP, Szymanski JA, Oetker SR, Bell HM (2018) Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act. J Fish Wildlife Manag 9:302–320

Smith KN (2016) Salience, special interest, and science: an emperical assessment of ESA listing decisions. Dissertation, Texas A&M University

Stefanaki A, Kantsa A, Tscheulin T, Charitonidou M, Petanidou T (2015) Lessons from red data books: Plant vulnerability increases with floral complexity. Plos ONE 10:e0138414

U.S. Fish and Wildlife Service (Service) and National Marine Fisheries Service (NMFS) (1994) Interagency policy on information standards under Endangered Species Act. Federal Register 94-16022

WWF (2020) Living planet report 2020 -bending the curve of biodiversity loss. Almond, REA, Grooten M, Peterson T (Eds). WWWF, Gland Switzerland

Waples RS, Nammack M, Cochrane JF, Hutchings JA (2013) A tale of two acts: endangered species listing practices in Canada and the United States. Bioscience 63:723–734

Wilcove DS, Master LL (2005) How many endangered species are there in the United States? Front Ecol Environ 3:414–420

WildEarth Guardians v. Salazar, 30F. Supp. 3d 1126 (D.N.M. 2011)