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Protect or perish: Quantitative analysis of state-level species protection supports preservation of the Endangered Species Act

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Abstract

To combat biodiversity loss in the United States, imperiled species are protected under the federal Endangered Species Act (ESA), which is currently threatened by political initiatives seeking to weaken it and potentially transfer substantial authority to the states. To assess the conservation capacity of current state laws, we conducted a quantitative analysis of imperiled species protection within all 50 states by compiling data on all state-listed species, ESA-listed species, and IUCN Red List species in each state. We found that currently 16% of ESA-listed species and 52% of IUCN imperiled species are not protected by any state law, and if the ESA were repealed these numbers could increase to 73% of ESA-listed species and 81% of IUCN imperiled species unprotected. Although protection varies widely among states, our results suggest that revoking the ESA would be highly detrimental to imperiled species conservation and recovery in the United States.

KEYWORDS
biodiversity law, imperiled species, IUCN Red List, listing, species recovery, U.S. Endangered Species Act

1 | INTRODUCTION

In the United States, imperiled species are legally protected under the federal Endangered Species Act (ESA), which is arguably the world's strongest biodiversity protection law (Bean & Rowland, 1997). Since the ESA was enacted nearly 50 years ago, almost all 1,747 species (including subspecies and distinct population segments) protected by the Act are still around today, and it is estimated that the ESA has prevented the extinction of 291 species (Greenwald, Suckling, Hartl, & Mehrhoff, 2019).

While the ESA has much documented success (Greenwald et al., 2019; Schwartz, 2008; Taylor, Suckling, & Rachlinski, 2005), recent political initiatives have sought to weaken the ESA's protective provisions and even dismantle it entirely to transfer imperiled species authority to state governments (Camacho, Robinson-Dorn, Yildiz, & Teegarden, 2017; Center for Biological Diversity, 2020; Rehm, 2018). Given these initiatives, it is important to empirically investigate the degree to which state laws protect imperiled species within their borders and assess the consequences if the ESA was further weakened or repealed.

Various reviews have assessed the protective provisions of state imperiled species acts (Camacho et al., 2017; Fischman, Meretsky, Drews, & Teson, 2018; George & Snape III, 2010), but there has yet to be a quantitative analysis of species-level coverage. We therefore provide a quantitative review to analyze: (1) How well do state laws, independently and in combination with the ESA, currently protect imperiled species within their borders? and (2) Without the ESA, which species could lose protection and what is the geographic distribution of this risk across the United States?

2 | METHODS

2.1 | Data collection

First, we compiled three datasets: (1) all species protected by state imperiled species laws in all 50 U.S. states, (2) all federally listed (ESA) species in each state, and (3) all IUCN Red List species that occur in each state. To build a dataset of imperiled species protected by each state, we first searched the code and administrative rules for each state to record which listing categories (e.g., Endangered or Threatened) are defined as protected imperiled species. When creating this dataset, we only considered state laws specific to imperiled species (i.e., did not include species only protected by game/hunting laws) and defined "protected" as a species whose protection from harm is legally binding. We then identified lists of protected species in each state by searching the websites of state departments in charge of administering the imperiled species laws and the state's administrative rules. We also recorded whether each state automatically includes federally listed species on their state list and whether or not plants are protected. For federally listed species, we compiled a dataset of all ESA species in each state using information from the U.S. Fish and Wildlife Service website (https://ecos.fws.gov/ecp0/reports/species-listed-by-state-totals-report).

To create a dataset of all imperiled species that occur in each state, we retrieved IUCN Red List data using the R package "rredlist" (Chamberlain, 2018) in R version 3.5.1 (R Core Team, 2019). We downloaded all IUCN Red List species native to the United States and then subsetted just the imperiled species (categories "Vulnerable," "Endangered," or "Critically Endangered"). We then used the R package "natserv" (Chamberlain, 2019) to get a list of all U.S. states in which each imperiled species is believed to occur from the NatureServe database. For any species not found in this database, we manually searched for distribution information in other databases such as IUCN (2020) and GBIF (https://www.gbif.org).

Once all three datasets were complete, we resolved any taxonomy issues between them using the "traitdataform" package in R (Schneider, 2018). When doing so, we assessed each listing to species level (i.e., removed the subspecies or subpopulation name) and did not include listings that were only defined to genus. For cases in which the IUCN categorized a subspecies or subpopulation as imperiled but not the species, we revised the distribution information to only reflect the range of the imperiled entity.

2.2 | Analysis

We first assessed the total number of species protected by each state, and analyzed which factors best predict the number of state-listed species. Our set of predictor variables were modeled after those used in a study assessing similar relationships with ESA listings in each state (Harllee, Kim, & Nieswiadomy, 2009) and include state area, state biodiversity (i.e., total known species), percent of species in various taxonomic groups (vertebrate classes, invertebrates, plants; Stein, 2002), total imperiled species (from our IUCN dataset), whether or not the state is coastal, population density (U.S. Department of Commerce, 2010), percent of state residents over the age of 16 that participate in hunting or fishing (U.S. Department of the Interior, U.S. Fish and Wildlife Service, U.S. Department of Commerce, & U.S. Census Bureau, 2011), percent of state area allocated to agriculture (U.S. Department of Agriculture, 2017), percent of state land owned by the federal government (Congressional Research Service, 2020), per capita personal income (U.S. Department of Commerce, 2019), and state political party affiliation. The variable for state political party affiliation originated from a study by The Hill (Sullivan, Caldwell, Doerflein, & Hill, 2014) that examined the past seven presidential elections, congressional delegations, control of state legislatures, and parties of the past three governors to create a continuous ranking of state party affiliation on a spectrum of most Democratic to most Republican states. After removing any variables with high collinearity ($r > 0.7$), we created all possible models, conducted model averaging up to an Akaike weight of 0.95, removed any uninformative parameters (Arnold, 2010), and repeated the model averaging process.

We next analyzed how well state governments, the federal government (ESA), and state and federal laws combined currently protect imperiled species by comparing the state and ESA datasets to the IUCN imperiled species dataset. First, we filtered all species from the IUCN list that were not on any state list to get the total number of imperiled species not protected by any state law, and did
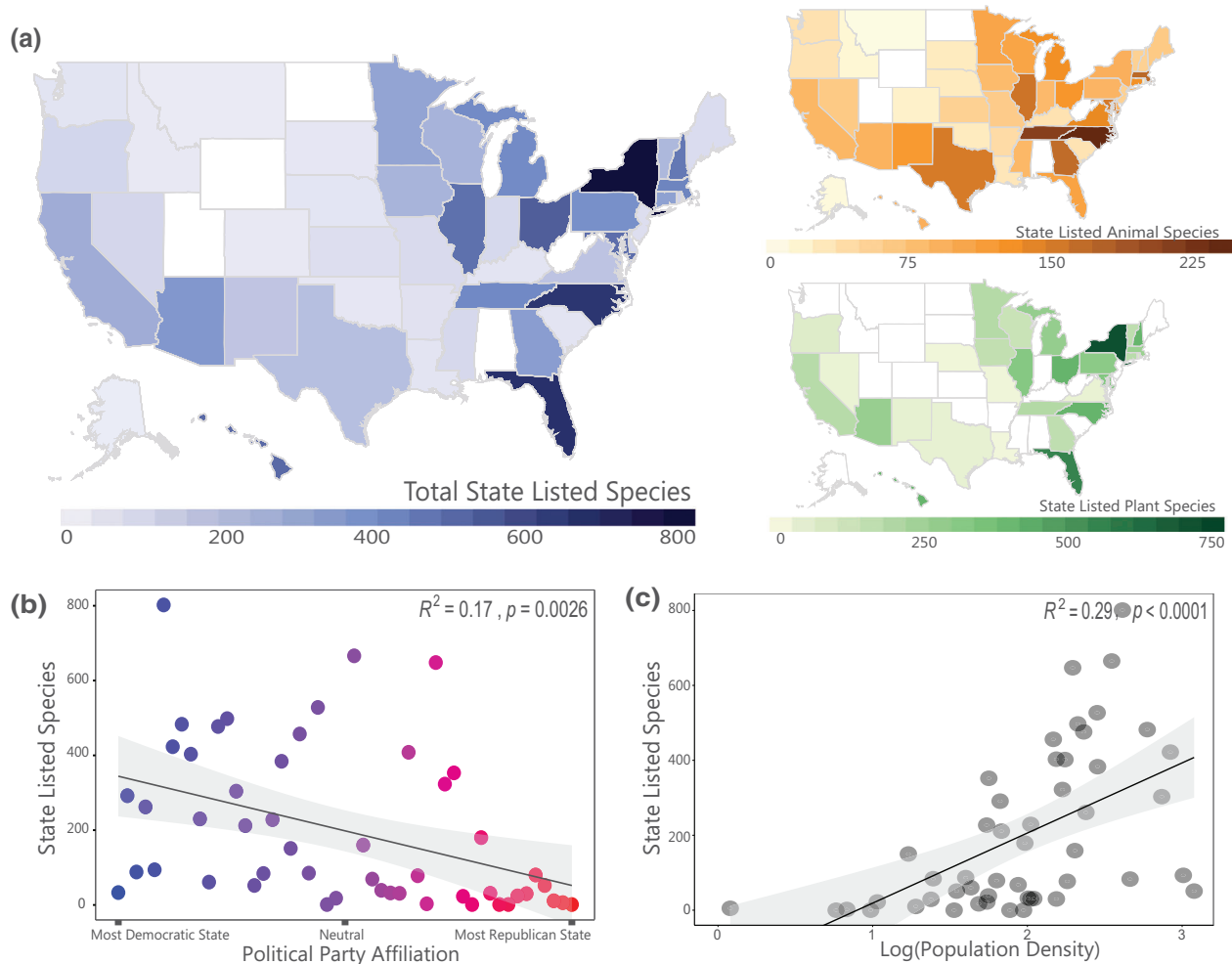
FIGURE 1 (a) Geographic distribution of state-listed species including total, animal, and plant species counts. Based on model selection, two of the most important predictors of this geographic variation are (b) state political party affiliation and (c) human population density. Shaded regions represent 95% confidence intervals

the same for the ESA dataset (an update and extension of Harris et al., 2011) and the combined state and ESA datasets. Second, we assessed imperiled species coverage at the state level by partitioning all datasets by state and calculating the proportion of imperiled species in each state that are unprotected by state laws, the ESA, and state and federal laws combined. To test for differences in the protection afforded to different taxonomic groups, we then divided each list of unprotected imperiled species by phylum (kingdom for plants and fungi) and by class for chordates, and conducted G-tests with post-hoc pairwise comparisons using the "DescTools" package (Signorell et al., 2020). We removed any animal phyla that had less than ten imperiled species.

After assessing the current state of imperiled species protection in the United States, we assessed the consequences of losing federal ESA protections. To analyze the repercussions of repealing the ESA entirely, for each state that automatically includes federally listed species on their

state list, we removed those species from the dataset and assessed how many ESA-listed species and IUCN imperiled species become unprotected without the ESA. This accounts for the immediate consequence of revoking the ESA, since at that point there would no longer be any federally listed species to automatically receive listing by the states.

3 | RESULTS

3.1 | State-listed species

We found non-federal legal provisions for imperiled species that met our definition for "protection" in 45 states. There are a total of 5,614 unique species found on at least one of the 45 state lists, of which 1,831 are animal species and 3,783 are plant species (Figure 1a). Of these, 1,167 are also found on the ESA list and 775 are also on the IUCN

TABLE 1 Summary of phyla/kingdoms with at least 10 IUCN imperiled species (Critically Endangered, Endangered, and Vulnerable species) in the U.S. Data include total number of imperiled species, total imperiled species unprotected by state laws, total unprotected by the ESA, and total unprotected when state and federal laws are combined. The final column shows how many species would be unprotected without the ESA. Percentages are provided in parentheses and significant letter groupings for each column are in brackets

| | | Current protections | | | Protection if the ESA were repealed |
Taxonomic group	Total IUCN imperiled species	Total imperiled species *unprotected* by state laws	Total imperiled species *unprotected* by the ESA	Total imperiled species *unprotected* by combined state and federal laws	Total imperiled species *unprotected* without the ESA
Fungi	24	22 (92% [A])	22 (92% [A])	22 (92% [A])	24 (100% [A])
Arthropods	251	209 (83% [A])	215 (86% [A])	199 (79% [A])	227 (90% [B])
Mollusks	310	194 (63% [B])	212 (68% [B])	179 (58% [B])	244 (79% [C])
Cnidarians	14	7 (50% [BCD])	12 (86% [AB])	7 (50% [BC])	9 (64% [CD])
Vertebrates	488	216 (44% [C])	300 (62% [C])	191 (39% [C])	310 (64% [D])
Plants	530	194 (37% [D])	221 (42% [D])	190 (36% [C])	488 (92% [B])

imperiled species list. Model selection identified political party affiliation (−0.036; 95% CI: [−0.066−0.006]), population density (0.93; 95% CI: [0.52–1.35]) and state area (0.54; 95% CI: [0.08–1.01]) as the best predictors of the total number of species protected by each state (Table S1, Supporting Information). Republican-leaning states protected significantly fewer species than Democratic-leaning states (Figure 1b), and states with higher population densities protected more species (Figure 1c). When running model selection on animal and plant species separately, population density is the best predictor for state-listed animal species and political party affiliation is the best predictor for state-listed plants (Table S1, Supporting Information).

3.2 | State and federal coverage of imperiled species

Assessing state-level coverage independently, 52% (849 of 1,624) of IUCN imperiled species found within the United States (Figure 2a) are not protected by any state. Of the remaining species that are on at least one state list, approximately one-third (248 of 775) are not protected by all states they occur in, as they generally would be under the ESA. This brings the percentage of imperiled species not state protected across their entire U.S. range to 68%. Of the species that are protected throughout their entire range, 92% are state endemics (i.e., they only occur in one state). Separating the analyses by state, the average proportion of imperiled species within each state that do not receive state protection is 76%, with 94% of states protecting less than half of the imperiled species in their state (Figure 2b).

When assessing ESA coverage independently, we found that 61% (989 of 1,624) of IUCN imperiled species are not

listed by the ESA. On a state-level basis, the average proportion of imperiled species unprotected by the ESA in each state is 82% (Figure 2c). When combining the state and ESA lists, the total number of unprotected IUCN imperiled species is reduced to 49% (795 of 1,624). Of the imperiled species that are found in the combined state and ESA lists, 22% (183 of 829) are not listed by all the states they occur in, making the percent of imperiled species not protected in their entire U.S. range, by either state or federal governments, 60%. When the state and ESA datasets are combined, the average percent of unprotected imperiled species per state decreases to 71% (Figure 2d).

When we partition these species by phylum/kingdom, there is significant variation in the protection afforded to different taxonomic groups for state, ESA, and combined state and ESA lists ($p < 0.0001$ for all G-tests). In general, fungi and arthropods receive the least protection and plants receive the most protection (Table 1). There is also significant variation in the proportion of species protected among vertebrate classes for all lists considered ($p < 0.0001$ for all G-tests), with Chondrichthyes (cartilaginous fish) being the least protected group (Table 2).

3.3 | Consequences of losing ESA protection

There are currently 219 federally listed species (16% of all ESA species) that are not protected by any state law. On average, 37% of federally listed species within a state are not protected by that state and 16 states protect 50% or less of their federally listed species (Figure 3a). There are 32 state imperiled species acts that automatically include some species listed under the ESA on their state lists. If the ESA were revoked and therefore there were
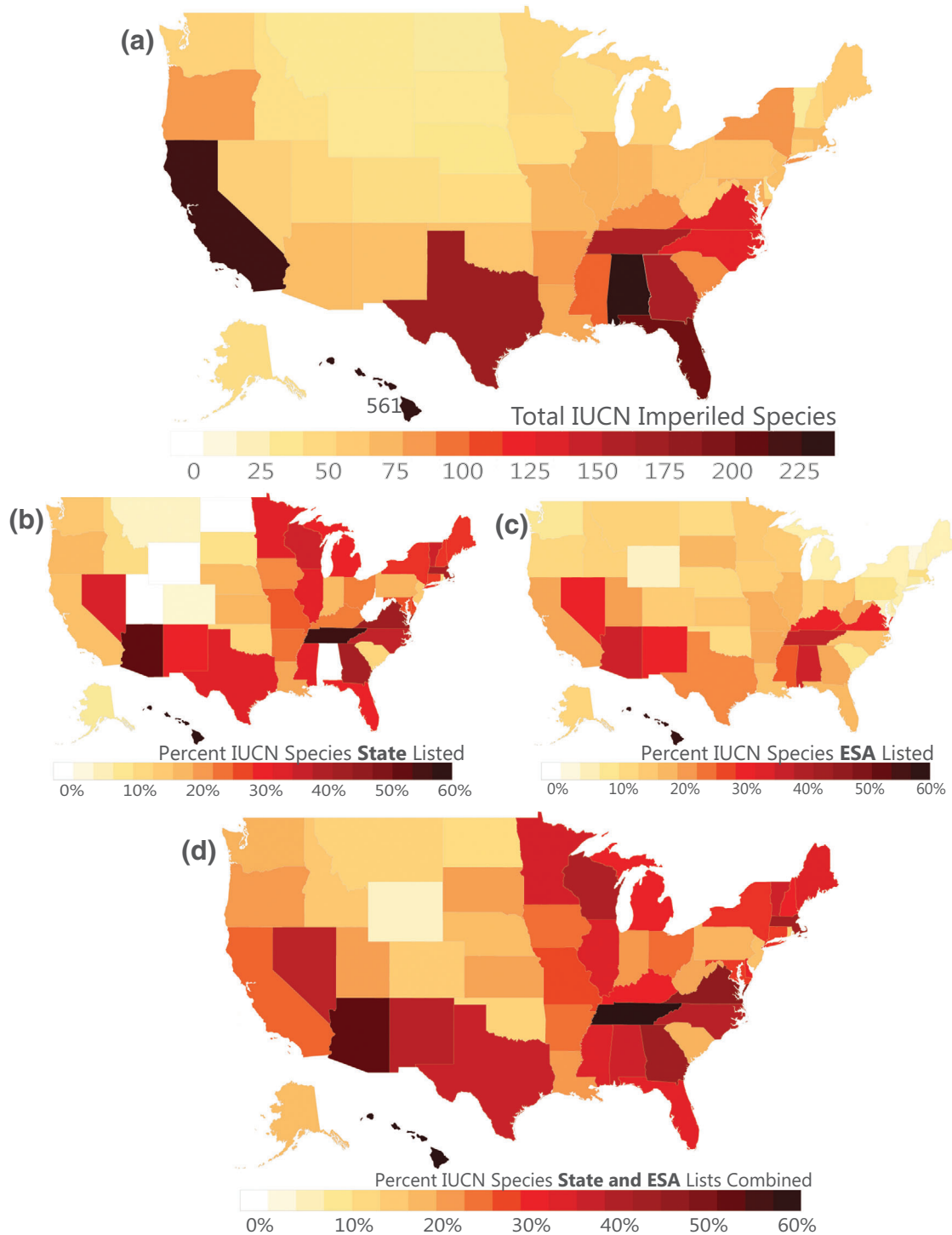
FIGURE 2 (a) Total number of IUCN imperiled species that occur in each state, (b) percent of IUCN imperiled species protected by each state's imperiled species law, (c) percent of IUCN imperiled species protected by the ESA in each state, and (d) percent of IUCN imperiled species that are protected in each state when state and ESA lists are combined, showing that imperiled species are best protected by the combination of state and federal laws

no more ESA-listed species, the immediate consequence would be that those ESA species would lose protection in these 32 states, and the percent of ESA species no longer protected by any state would increase from 16% to 73% (Figure 3b). This could lead to a total of 1,017 ESA species losing protection (Figure 4a), an average of 84% of ESA species in each state (Figure 4b). When re-assessing the level of imperiled species protection in the United States without the ESA, the number of unprotected IUCN imperiled species would increase from 49% to 81%, and the

TABLE 2 For each vertebrate class of IUCN imperiled species in the United States, total number of imperiled species, total unprotected by state laws, total unprotected by the ESA, and total unprotected when considering state and ESA lists combined. The final column shows how many species would be unprotected without the ESA. Percentages are provided in parentheses and significant letter groupings for each column are in brackets

| Vertebrate class | Total IUCN imperiled species | Current protections | | Protection if the ESA were repealed |
		Total imperiled species *unprotected* by state laws	Total imperiled species *unprotected* by the ESA	Total imperiled species *unprotected* by combined state and federal laws	Total imperiled species *unprotected* without the ESA
Cartilaginous Fishes	36	35 (97% [A])	35 (97% [A])	35 (97% [A])	35 (97% [A])
Birds	93	45 (48% [B])	56 (60% [BC])	43 (46% [B])	72 (77% [B])
Bony Fishes	214	85 (40% [B])	122 (57% [BC])	73 (34% [C])	139 (65% [C])
Amphibians	56	22 (39% [BC])	34 (61% [BC])	14 (25% [CD])	28 (50% [D])
Mammals	47	18 (38% [BC])	31 (66% [B])	16 (34% [BCD])	20 (43% [D])
Reptiles	40	9 (23% [C])	20 (50% [C])	8 (20% [D])	14 (35% [D])
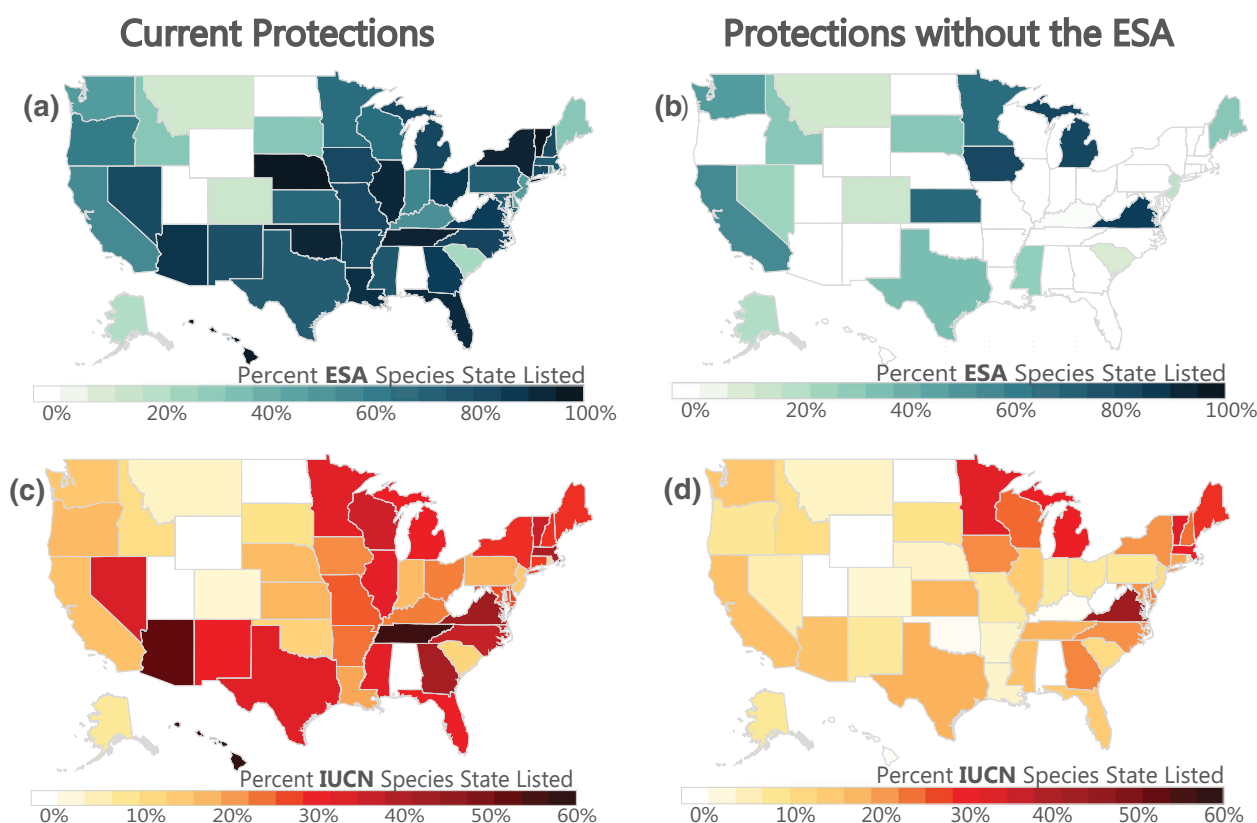
FIGURE 3 (a) Percent of ESA species currently included on state imperiled species lists and (b) the percent that would be protected by each state without the ESA (i.e., any automatically listed ESA species would be removed from state lists), and (c,d) Similar numbers for IUCN imperiled species in each state

average proportion of imperiled species unprotected in each state would increase from 75% (Figure 3c) to 85% (Figure 3d). This could lead to a total of 514 imperiled species losing protection (Figure 4c), an average of 52% of imperiled species in each state (Figure 4d).

4 | DISCUSSION

While previous studies have analyzed the strength of protective provisions in state imperiled species acts (Camacho et al., 2017; Fischman et al., 2018; George & Snape

Total Species Losing Protection

Percent of Species Losing Protection
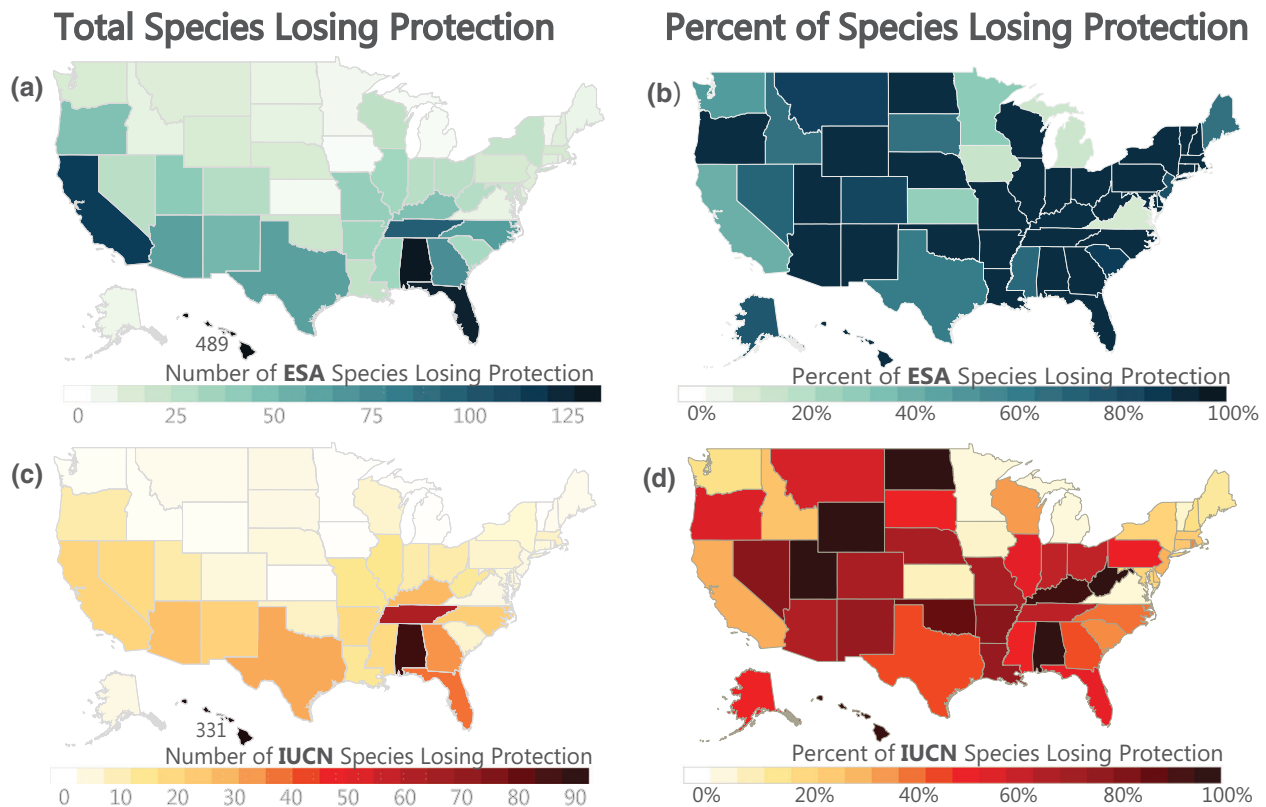
FIGURE 4 (a) Total and (b) percent of ESA species and (c) total, and (d) percent of IUCN imperiled species that could lose protection in each state if the ESA was removed

III, 2010), here we provide the first quantitative review of which species are protected by state legislation. Our results show that state level protection is inconsistent and overall inadequate, and an alarming number of imperiled species could lose protection without the ESA.

We found a high level of inter-state variation among imperiled species acts. One of the best predictors of this variation among the variables assessed was human population density, such that states with larger population densities list more species. This is likely a result of states with higher human impact having more negative environmental effects (McKee, Sciulli, Fooce, & Waite, 2003; Thompson & Jones, 1999), leading to a higher number of species being imperiled and needing protection. Additionally, we found that Republican-leaning states list significantly fewer species than Democratic-leaning states. This bolsters previous findings that states with Republican representation on congressional committees with U.S. Fish and Wildlife Service oversight are less likely to have species in their state listed under the ESA (Harllee et al., 2009).

Along with the total number of species protected by each state, the amount of protection provided by states is also highly variable, and important provisions would be lost without the ESA. While a few states have statutes on par

with ESA provisions, state acts generally provide much weaker provisions compared to the ESA (Arha & Thompson, 2011; Camacho et al., 2017; Fischman et al., 2018; Snape & George III, 2010). For most states, protection provided by state imperiled species acts is limited to preventing the take and transport of listed species, and very few states have provisions mandating habitat preservation or conservation plans for species recovery. For example, there are 40 states in which prohibited "take" does not consider habitat modification, 38 states with no provisions for the protection of critical habitat, and 48 states where provisions for mandating recovery plans are weak or non-existent (Camacho et al., 2017). Meanwhile, the ESA is written to provide these protections to all listed species, although carrying out such provisions is limited due to complications such as chronic funding shortages (Gerber, 2016; Malcom et al., 2019). Thus, protecting habitat for imperiled species in the United States is largely reliant on federal provisions, such that over the past 30 years habitat for ESA-listed species has remained the most intact on federal lands, but showed high and increasing losses on state lands (Eichenwald, Evans, & Malcom, 2020). Therefore, in addition to the ~1,000 ESA species and ~500 IUCN imperiled species that could lose total protection without the ESA, the vast majority of the remaining species protected by state

governments would no longer have any legal provisions supporting habitat preservation and recovery.

Protective provisions afforded by state governments are also variable between listed plant and animal species. In some states, plants form a very large percentage of the total number of listed species (Figure 1a), however the protections are often minimal compared to those afforded to animals. For example, protective provisions for plants usually only apply on public lands, and some state acts explicitly state that the presence of listed plants should not deter any development plans or other uses of public lands (e.g., Ky. Rev. Stat. §146.615). These disparities are also true at the federal level, such that ESA-listed plant species are only protected on federal lands, whereas animal species are usually protected wherever they are found. Despite these disparities, plant species would lose a significant amount of protection without the ESA, given that 20 states do not have *any* protective provisions for plants.

The appropriate role of state governments in imperiled species protection has been a source of long-standing argument since the ESA was enacted in 1973 (Arha & Thompson, 2011; Stoellinger, 2017). While states have the advantage of local resources, closer relationships with stakeholders, and the ability to provide more efficient on-the-ground action, there are concerns that economic interests could take priority if the ESA was no longer holding states accountable for imperiled species protection. In addition, state governments lack public reporting of their endangered species programs, which is critical to evaluate their imperiled species conservation and hold them accountable for assuming the responsibilities of the ESA (Bennet & Schwartz, 2019). Given the current variation among state imperiled species acts, how states would prioritize protection without the ESA would likely be equally variable. Our finding that 73% of ESA species could lose protection if the ESA were dissolved is the worst-case scenario, as most states automatically include some ESA species on their state list. If the ESA were repealed, legislators from many states would likely amend their acts to keep these species on their state lists, but there is no guarantee that state governments would make this decision. Further, amendments to state acts would likely take time, and imperiled species might experience losses during the interim. In addition, there are proposals to remove ESA protections for all listed species that only occur in one state (U.S. Senate Bill 1768, 2019). According to our dataset, this would entail removing 1,064 species (77%) from the ESA, making them totally reliant on state protections. Of these

species, 862 are state-listed, but 660 of these 862 are among those that receive automatic state listing due to their ESA status, and thus their removal from the ESA would again require action of state legislators to keep them on state lists. Overall, state acts are highly inconsistent, and without a consistent federal imperiled species law, biodiversity conservation and recovery would vary drastically across the country.

While many unknowns remain, our quantitative analysis, along with previous reviews of state protective provisions (Camacho et al., 2017; Fischman et al., 2018; George & Snape III, 2010), indicate that the weakening or removal of the ESA would be highly detrimental to imperiled species protection and recovery in the United States. If conservation was left entirely to the states, a drastic number of imperiled species would lose protection. To simply maintain the current level of species protection provided by the ESA, state imperiled species acts would require significant reforms and huge budget increases (Camacho et al., 2017). However, even the current level of species protection is insufficient due to underfunding of the ESA (Gerber, 2016; Malcom et al., 2019). Even with federal and state imperiled species lists combined, nearly half (49%) of IUCN imperiled species currently remain unprotected. As we are in the midst of a global biodiversity crisis, protecting the unique biodiversity of the United States is of utmost importance. We argue that this can be most efficiently accomplished through continued federal oversight of the ESA complemented by improved state imperiled species acts.

AUTHOR'S CONTRIBUTIONS
CCM conceived and designed the study with intellectual contributions from all coauthors. CCM, LRS, TNF, SLC, HJH collected data. CCM conducted data analysis with contributions from CAS. CCM led the writing of the manuscript. All coauthors contributed substantially to the writing and gave final approval.

ETHICS STATEMENT

The authors adhered to all laws, regulations and protocols in conducting this research. Authors also adhered to Wiley's "Publishing Ethics Guidelines,"

DATA AVAILABILITY STATEMENT

All data and code used for this study are available as Supporting Information and online at https://github.com/ccmothes/stateListedSpecies.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of the article.

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