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Berchem, Emily A. ***How Effective is the Endangered Species Act? An Evaluation of Coverage Across Multiple Animal Taxa***

Abstract

The Endangered Species Act (ESA) was passed in 1973 and is the most effective legislation in the United States for the protection of threatened and endangered species. However, even valuable legislation can have faults. This study examines the effectiveness of the ESA across the following animal taxa: mammals, birds, reptiles, amphibians, fish, and invertebrates. Favorable public opinion is heavily skewed towards mammals and birds, which are the groups that receive the most conservation funding and protection under the ESA. Other less popular taxa, such as amphibians, show 80% under recognition on the ESA when compared to species listed on the International Union for Conservation of Nature (IUCN) Red List. There are 307 invertebrate species listed on the ESA, but based on statistical estimates, the actual number of imperiled invertebrates in the United States ranges from 8,600 to 25,000. Even though mammals are the best protected group, there is still 50% under-recognition of mammals on the ESA when compared to the IUCN Red List. Several species listed as endangered on the ESA were used as case studies throughout this paper, showcasing differences in conservation management across species. After an extensive literature search, certain groups appear to be underrepresented on the ESA such as amphibians, invertebrates (especially freshwater invertebrates), and island species. Future management should focus more attention on less publicly charismatic species, as there are many less well-known species that provide an important component to their ecosystem and need increased protection to recover.

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Table of Contents

Chapter I: Introduction

We are currently living through the planet's sixth mass extinction. This latest extinction event is set apart from all previous mass extinctions by its anthropogenic origin. Humans, with all our success, have made the Earth a very difficult place to survive for many species. Some scholars have even argued that we have entered a new geological epoch, the "Anthropocene". According to recent estimates, the Earth could lose half of its biodiversity by the year 2100 if current human impacts continue (George et al., 2016). We create problems for other species primarily through habitat destruction, overexploitation for profit, and climate change (Liordos et al., 2017). Although there are many methods that can be used to offset these issues, one piece of legislature, which protects endangered species is the Endangered Species Act (Knight, 2008).

The Endangered Species Act (ESA) was passed in 1973, and this provided much needed support for threatened and endangered species. The U.S. Fish and Wildlife Service (USFWS) defines a species as endangered if it is, "in danger of extinction throughout all or a significant portion of its range." A species is defined as threatened if it is, "likely to become endangered in the foreseeable future throughout all or a significant portion of its range" (Harris et al., 2012). However, the ESA has been very controversial since its passing, and not all species protected by the ESA have the same amount of public support (Knight, 2008). Public support for the ESA is currently closely tied to species attitudes, wildlife value orientations, and knowledge of what the ESA actually does (Rodgers & Willcox, 2018). Although the ESA provides protection to listed species, these are only a fraction of the imperiled species in the U.S. Part of this issue stems from the fact that it is still not known how many species inhabit the United States, and of the species described, only about 15% have been studied extensively enough to determine whether they are at risk (Wilcove & Master, 2005).

The ESA currently recognizes 1,655 U.S. species as threatened or endangered (ECOS, 2021). However, the International Union for Conservation of Nature (IUCN) Red List includes many species in the threatened and endangered categories, which are not listed on the ESA. The ESA recognizes roughly 36% of imperiled species listed on the IUCN, and there may be more than ten times the number of imperiled species than are listed on the ESA (Wilcove & Master, 2005). Some of the discrepancies are due to listing delays, as it can take years between the concern being raised for a species and its listing under the ESA; although there are strict timelines in place that are intended to stop such delays (Puckett et al., 2016).

There are multiple ways that success of the ESA could be measured, one of which is the rate of extinction of listed species. Less than 1% of listed species have gone extinct, and this could lead to the belief that the ESA is very successful. However, the delisting rate of species is also very low. This points to the ESA successfully preventing species extinction, but not necessarily bringing species to the level that they are no longer threatened. Also, most of the extinctions that have occurred since the ESA's implementation were species that were not listed (Walls et al., 2017).

If the ESA is providing equal support for all taxa, then there should be similar numbers of success stories among less popular taxa such as amphibians and invertebrates and more publicly popular taxa such as mammals and birds. However, if some taxa are receiving less support than others, then the ESA is not performing to the standard that it should be in protecting imperiled species. This paper will critically examine the available literature and data to determine whether the ESA can be considered successful or if there is a need for improvement. If shortcomings of the ESA are found, then it is possible to proceed to address these shortcomings and improve the act to better protect all species in need of support.

Statement of the Problem

Increasingly more species are becoming imperiled due to habitat destruction, overexploitation, climate change, and various other factors. The ESA is the best legislation the U.S. has in protection of imperiled species. However, the ESA is not perfect, and may not be allocating protection and funds appropriately across all taxa. It is important to investigate the extent of protection provided under the ESA to various taxa in order to determine shortcomings that can be resolved to strengthen the protections of all imperiled species.

Purpose of the Study

The purpose of this study is to examine the differences in coverage that the ESA provides to mammals, birds, reptiles, amphibians, fish, and invertebrates. By determining places where the ESA fails to adequately carry out its intended purpose, it will be easier for managers who are making decisions regarding threatened and endangered species to suggest improvements or changes. This study is intended to expose the gaps in ESA coverage, so that taxa, which are being underrecognized and underfunded, can gain more support.

Assumptions of the Study

Regarding this study, the following assumptions exist:

1. The number of listed species changes over time. It is possible that very recently listed species will not appear in the data throughout this study. This could also happen if a species was recently listed but does not yet have information added to the Environmental Conservation Online System (ECOS) database.
2. All literature cited throughout this study has been peer reviewed before publication.

Definition of Terms

This paper includes terms that may not be familiar to all readers. These terms and definitions are listed here.

Caecilian

"Any of an order (Gymnophiona) of chiefly tropical burrowing limbless amphibians resembling worms" (Merriam-Webster, n.d.-a.).

Endemic

"Restricted or peculiar to a locality or region" (Merriam-Webster, n.d.-b.).

Extant

"Currently or actually existing" (Merriam-Webster, n.d.-c.).

Flagship Species

"A species selected to act as an ambassador, icon, or symbol for a defined habitat, issue, campaign, or environmental cause" (World Wide Fund for Nature, 2020).

International Union for the Conservation of Nature (IUCN) Red List

"The world's most comprehensive inventory of the global conservation status of plant and animal species" (IUCN, 2021).

Taxon

"A scientifically classified group or entity: a taxonomic unit (such as a genus or order) of any rank" (Merriam-Webster, n.d.-d.).

Limitations of the Study

The largest limitation of this study is the lack of new data. All data taken for this study is from previously published literature. While this data is valuable, and forms much of this study, it is not always as current as collecting new data would be. However, it was outside of the scope of this study to collect new data due to budgetary, time, and Coronavirus (COVID-19) pandemic related constraints.

This study only focuses on animals listed on the ESA and does not cover plants. The author recognizes the difficulties plant species face in listing and funding support under the ESA but wanted to narrow the focus to just animals for this study.

Methodology

Chapter two of this study is a literature review that explores the effectiveness and coverage of the ESA for the following animal taxa: mammals, birds, reptiles, amphibians, fish, and invertebrates. The chapter begins with background information on the ESA, and then covers each of the forementioned taxa with case studies on selected species. The purpose of this chapter is to discover where there might be gaps in ESA coverage.

Chapter three of this study is the methods section. This chapter explains the methodology that was used throughout the study.

Chapter four of this study is the results section. This section contains Table 1, which includes data taken from the USFWS ECOS page. Species listed on the ESA are broken into taxonomic groups (mammals, birds, reptiles, amphibians, fish, clams, snails, insects, arachnids, and crustaceans). Data for each group includes the number and percentage of listed species that have a completed recovery plan, at least one completed five-year status review, both a completed recovery plan and five-year status review, or has neither a completed recovery plan nor a five-year status review.

Chapter five of this study is the last chapter and provides the discussion of the case studies highlighted in chapter two, as well as the data in chapter four. The conclusion provides recommendations for future processes and areas, which warrant further research.

Chapter II: Literature Review

The focus of this chapter is an examination of the available literature relating to the ESA and its coverage of various animal taxa. First, some historical information about the ESA will be given. The subsequent sections all focus on a specific animal taxon – mammals, birds, reptiles, amphibians, fish, and invertebrates. If the ESA shows an inherent bias towards certain taxa and disregards others, it is important to make it known so that changes can be made. Each animal section includes several case studies of species that are listed on the ESA, which will serve as examples of either good or bad management.

Endangered Species Act Background

The ESA was signed into law by President Richard Nixon in December of 1973. It was created during a time when the public was becoming increasingly concerned about the environment and began to recognize that human activities were having a disastrous impact on the country's biodiversity. Several different versions of the act were drafted before the final version was signed into law. The House worked on 14 versions and the Senate worked on three. Congress clearly wanted an act that would prevent species extinction as the bill passed in both the House of Representatives, and by a vote of 99-to-1 in the Senate (Burgess, 2001).

Since its creation the ESA has been controversial. Some have regarded it as one of the nation's best and most powerful environmental laws and believe that it should be used as a model globally. However, not everyone views the ESA favorably, especially many federal planners and private developers. The ESA requires them to carefully plan their activities and make changes in order to protect any listed species that may be affected. This can slow down and even stop development in certain areas, making it unpopular with many landowners who may feel that the ESA threatens jobs or prevents them from doing what they want on their land (Burgess, 2001; Knight, 2008; Rodgers & Willcox, 2018).

Conversely, there are also those who think that the act is too limited. Many environmentalists claim that the ESA is limited because it does not stop species from becoming endangered. It may offer species protection once they reach threatened or endangered status, but it does nothing to prevent species from going endangered in the first place. It was written to address emergency situations and many environmentalists argue that it would be more effective to change certain activities to prevent species from even needing to be listed on the ESA (Burgess, 2001).

As of February 15th, 2021, there are 1,655 U.S. species listed on the ESA; 713 species of animals and 942 species of plants. There are currently 78 mammal species listed, 105 bird species, 48 reptile species, 36 amphibian species, 139 fish species, and 307 invertebrate species (Environmental Conservation Online System, 2021). It is estimated that as many as 80% of listed species may be conservation reliant, meaning that they will require additional management to persist even after they have met the approved recovery goals (Wiens & Gardali, 2013).

The ESA was revised several times between its implementation in 1973 and 1992, but it has remained unauthorized since then, making it the longest the act has gone without revisions. Congress tried multiple times in the 1990s to push forward reauthorizing bills, but none of those bills survived. The ESA has the potential to be very effective but there are several factors, which impede the act from reaching this potential. Because the act has been subject to shifts in political power throughout its history, its success has been sporadic depending on which political party holds more power at the time. The ESA has been fairly effective at protecting threatened and endangered species on public lands but has been much less effective on private lands.

Another huge limitation of the ESA is a lack of provisions to implement. The ESA protects species and the species habitat but does not consider ecosystems, which contain multiple habitats. It also does not address habitat disturbance or fragmentation as well as it should, potentially because these concepts were not well understood when the act was first written (Burgess, 2001).

Opponents of the ESA tend to frequently focus their attention on section seven of the act because it contains many of the strictest measures of the law. Although it is strict on paper, many conservationists claim that federal agencies are failing to implement the measures outlined in this section because of increasing pressure to minimize the economic impacts that come from protecting wildlife. In the past, section seven made headlines by restricting the logging of old-growth forests or halting the construction of several major dams. It appears that today the prohibitions outlined are not being implemented to the extent that they were in the past. Consultations are conducted with the USFWS before the start of a development project to ensure that the project will not harm any listed species or their habitats. An analysis done on all 88,290 consultations recorded by the USFWS for the years of 2008-2015 was performed and found that none of the consultations led to a project being stopped. These results could indicate three possibilities.

First, creators of projects are increasingly recognizing the importance of protecting listed species and are purposely designing projects, which do not cause harm to listed species. Second, if a project is flagged as putting a listed species in jeopardy, the project leaders are willing to negotiate with the USFWS and alter the project until it is considered acceptable. The final and worst possibility is that section seven is not being implemented to its full extent and projects are being approved that should not be (Malcolm & Li, 2015). It is likely that all three situations are in play, although it is unclear the extent of each.

The ESA also contains skewed treatment towards certain biological groups. Vertebrate animals receive the most protection, especially mammals and birds; amphibians and reptiles receive much less protection than other vertebrates. Furthermore, even the low amount of protection amphibians and reptiles receive compared to other vertebrates is more protection than is received by invertebrate and plant species. In addition, insects that are considered pests are excluded from protection. This lack of protection for various biological groups does is incongruent with the importance these species have to their ecosystems, especially plants, which are vitally important as they support the entire food web (Burgess, 2001). Finally, funding has not been allocated according to level of conservation concern, with the average threatened species listed on the ESA (across all taxa) receiving $5.6 million per year and the average endangered species receiving only $1.3 million (Gratwicke et al., 2012).

While it is true that the ESA has prevented the extinction of several species, and notable success stories such as the bald eagle and peregrine falcon exist, this does not mean that the ESA is doing all that should be done in the quest to save species from extinction. There is a heavy need for improvement, and although mammals and birds should remain a priority, the ESA must do more in increasing protections for other biological groups such as amphibians, reptiles, invertebrates, and plants.

Listing Delays and Slow Implementation

It is true that since the ESA has been enacted less than 1% of listed species have gone extinct and the status of 52% of listed species has been either stable or has improved. It is also estimated that the conservation actions implemented after species have been listed as threatened or endangered under the ESA has protected 227 species from extinction (Luther et al., 2016). However, during the first 21 years (1973-1994) of the ESA's implementation, 108 species of plants and animals went extinct. Of these species 85 were not listed on the ESA prior to their extinctions, and the 23 species that were listed likely went extinct due to listing delays (Walls et al., 2017).

Prior to 1982 there were no set timelines included in the ESA related to the listing process. However, in response to a sharp drop in listings during the first year of the Reagan administration, Congress amended the ESA to include strict timelines addressing the listing process that were designed to prevent further delays. Petitions to list a species on the ESA can either come from USFWS or from a third party. When given a third-party petition, the USFWS has 90 days to decide if further investigation is warranted. Assuming that further investigation is warranted, the USFWS is given one year to determine whether listing is warranted, not warranted, or warranted but precluded (WBP). The WBP category gives the USFWS more time to decide about a particular species (Puckett et al., 2016). Originally, the WBP category was meant to be used in a limited manner to give the USFWS more time on certain lower priority species and allow them to focus on the listing of higher priority species. However, it has been used much more often than was originally intended, and often contributes to the delay of many species being listed (Harris et al., 2012).

Causes in the delay of listing and implementation of recovery plans are largely due to human behavioral actions. Decisions regarding threatened and endangered species management can be quite difficult because they carry with them public scrutiny, threat of litigation, a sense of urgency, and uncertainty. It is unlikely that a single instance of inaction will lead to a failure in species recovery. Rather, repeated inaction to correct the problem may lead to decline and extinction. Doing nothing is a legitimate pathway to take, and in some instances may be best. However, in many conservation situations doing nothing will only cause the species in question to continue to decline. Fear of failure also results in conservation managers sometimes avoiding direct action. Understanding the role human behavior can play in decision making is vitally important to work past our self-destructive tendencies (Walls et al., 2017).

Public Biases in Species Listing

It is no surprise that the public tends to have an affinity for some species over others. Most people have innate biases when it comes to animals. What makes a certain species either appealing or unappealing to humans? There are several factors, which can also vary between cultures. However, when examining the available studies, opinions are remarkably similar throughout the world. In one cross-cultural study, participants from seven countries (i.e., UK, USA, India, Netherlands, Korea, Hong Kong, and Japan) were asked to rate their fear of certain well-known animals. While many of the countries differed in certain categories, the disgust category was almost universal, and every country designated the same species to this category; the species placed here included cockroach, spider, worm, leech, bat, lizard, and rat (Davey et al., 1998). This shows that humans have a high level of consistency in distaste for certain species, even across cultures. It is interesting to note that most of these species are either invertebrates, or in the case of the bat and the rat, are thought to carry disease.

A similar study asked college students to rank ten endangered species based on aesthetics, fear, and support of their conservation. The two striped garter snake (*Thamnophis hammondii*), Ozark big-eared bat (*Corynorhinus townsendii ingens*), and Dolloff cave spider (*Meta dolloff*) emerged as having notably lower support than the other listed species. The level of support was found to correlate positively with aesthetics and negatively with fear (except for the cougar, which respondents rated as dangerous but still showed high levels of support). Again, the most favored animals were mammals with the exception of the bat (Knight, 2008). This suggests that humans generally prefer mammals over other animal groups and prefer vertebrates over invertebrates.

Public support for mammals is also closely tied to body size. A study of Twitter users found that of all the mammal and bird species listed under the ESA, only a fraction had a median tweeting rate of more than 1 tweet h^{-1}. These species were primarily mammals, and in decreasing order of popularity were the polar bear (*Ursus maritimus*), American bison (*Bison bison*), brown bear (*U. arctos*), cougar (*Puma concolor*), killer whale (*Orcinus orca*), black bear (*U. americanus*), and West Indian manatee (*Trichechus manatus*). The polar bear had a much greater tweeting frequency than any other animal, which could be due to its status as a flagship species for climate change. The only ESA listed bird species that had a median tweeting rate of more than 1 tweet h^{-1} were the sandhill crane (*Grus canadensis*), whooping crane (*G. americana*), and spotted owl (*Strix occidentalis*; Roberge, 2014). This highly biased sample of species receiving public concern could in turn create additional stakeholder bias when making conservation decisions. As a result, more public outreach is needed to increase the appeal of the ESA listed and overlooked species.

Researchers are not immune to biases, which impacts the amount of research published on various taxa. A study conducted on the number of papers published on several species of southern African mammals, birds, reptiles, and amphibians showed a large disparity in the number of papers published on certain species. Typically, mammals were the most studied group, especially large mammals, with the chimpanzee (*Pan troglodytes*) having the most published papers (1855). Other well studied mammals included the African elephant (*Loxodonta*

Africana; 1148), western gorillas (*Gorilla gorilla*; 942), lions (*Panthera leo*; 562), and sperm whales (*Physeter macrocephalus*; 518). Small mammals were much less studied, with the meerkat (*Suricata suricatta*) having the greatest representation (110). Reptiles showed a huge discrepancy in the types being studied, with the top five most studied reptiles all being sea turtle species. The most studied reptile was the loggerhead sea turtle (*Caretta caretta*; 1132). Beyond sea turtles, the most studied reptile was the Nile crocodile (*Crocodylus niloticus*; 119). Amphibians were the least well studied vertebrate class overall, with 16 threatened amphibian species having zero papers. The African clawed frog (*Xenopus laevis*) was most well published (435), but due to its extensive use as a laboratory animal, this is an outlier (Trimble & Van Aarde, 2010). It appears that researchers are not free of biases and tend to study mammals more than other taxa. Perhaps this is due to close phylogenetic relatedness to us.

Mammal Coverage Under the ESA

Mammals tend to be the most charismatic and well-liked taxon of animals among the public. Consequently, they tend to receive more conservation funding than other groups such as reptiles, amphibians, and invertebrates. There are currently 78 mammal species listed on the ESA; 53 are endangered and 21 are threatened (ECOS, 2021). Mammals are the costliest taxonomic group in terms of conservation. In general, monetary investment in mammals is 6-26 times that of plants and 13-19 times more than aquatic invertebrates. Despite the majority of imperiled species being either plants or invertebrates, these groups typically receive much less funding than mammals and birds. It is possible that certain charismatic mammal species may be used as flagship species to promote the conservation of their habitat. By conserving the entire habitat (an ecosystem approach), the flagship species is also providing support for less charismatic species that share its range (Gordon et al., 2020).

Even though mammals garner the most public support for their conservation, the ESA still shows 50% under-recognition when compared to the IUCN Red List (Harris et al., 2012). Though other groups face even greater under-recognition, the discrepancy between the ESA and IUCN Red List highlights the fact that there are species across all taxa that should be listed on the ESA yet are not. Although mammals garner the most support, there are still various levels of support given to other groups. A study conducted at the Prague Zoo had participates give aesthetic ranks to several different mammal species as well as how much they support the species' conservation. The main characteristics that caused an animal to be defined as beautiful were complex fur pattern and body shape. The most preferred mammals were carnivores and ungulates, with rodents and afrosoricids (golden moles and tenrecs) being much less popular (Landová et al., 2018).

Case Study – Gray Bat

Although public opinion of bats is higher than it used to be, (likely due to increased understanding of their ecological importance), their likeability is still rated very low when compared to other mammals (Knight, 2008). The gray bat (*Myotis grisescens*) is the largest member of its genus in the eastern portion of its range. It can be distinguished from other bat species within its range by its single-colored dorsal fur. All other bat species within its range have bi or tri colored dorsal fur. True to their name, gray bats have dark gray fur following their summer molt. However, their fur often lightens to brown or russet in between molts, especially in reproductive females. Gray bats are primarily found in the southeastern U.S., mostly in Alabama, Arkansas, Kentucky, Missouri, and Tennessee (U.S. Fish and Wildlife Service, 1982). The gray bat was listed on the ESA in 1976, primarily due to habitat fragmentation and human disturbance at roost sites. Too much human disturbance causes unplanned arousals during hibernation, which depletes the bats' fat reserves and can lead to mortality. Protecting caves began in the 1980s, which allowed some bat populations time to recover. However, in 2006 White Nose Syndrome (WNS) was found in the United States and the gray bat is potentially vulnerable to the disease, especially because 95% of the species population hibernates in only 9-15 caves throughout their range (Moore et al., 2017).

WNS is sweeping through North America with disastrous impacts on our native bat species. It is caused by the fungus *Pseudogymnoascus destructans* (Pd), which has only been shown to affect hibernating bats (Meyer et al., 2016). Pd grows in cool, moist, and dark conditions. Often these conditions correspond with caves and old mines that host large hibernating bat colonies. The high density of bats that a colony contains makes it easier for the disease to spread throughout the population (Langwig et al., 2012).

Currently it is not known whether WNS is having much of an impact across gray bat populations, however, it is causing major declines in a few closely related species. A previous study conducted in Virginia to monitor the effects of WNS on gray bats did not find anything conclusive, though it was found that infection rates are well below documented infection rates of other *Myotis* species. Researchers have not currently observed mass die offs in hibernating gray bats from WNS or observed declines in the summer colony health in Virginia. Although more research is certainly needed, it is possible that WNS is not affecting gray bats nearly as heavily as other *Myotis* species. This might even allow the gray bat to expand its range as there will be less competition from the little brown bat (*Myotis lucifugus*), which has suffered a 95% mortality rate in regions affected by WNS (Powers et al., 2016). Currently, it appears that human disturbance is still the greatest threat to the gray bat's survival, as they have highly specific cave requirements, which leads to them congregating in higher numbers in fewer caves than any other

North American bat species. Although any human disturbance of gray bat caves can be harmful, it is especially detrimental in maternity caves during the period when the flightless young are on the roost. A single disturbance during this period can cause thousands of young to die (USFWS, 1982).

The gray bat presents an example of a species that is endangered primarily due to human disturbance, and in the absence of such disturbance, would likely recover on its own. Of course, this is easier said than done, as it will be difficult to stop human disturbance of gray bat roosts. However, if all gray bat roosts can be identified then it could be possible to put rules in place to prevent people entering the caves during the time when the bats are there. Continued education of the public on why bats are important to the ecosystem may also prevent people from disturbing gray bat roost sites.

Case Study – Pacific Pocket Mouse

The Pacific pocket mouse (*Perognathus longimembris pacificus*) is one of 19 subspecies of the little pocket mouse (*Perognathus longimembris*). It is the smallest subspecies, maxing out at 5.2 inches in length from its nose to the tip of the tail, and weighing between seven to nine grams. The Pacific pocket mouse is endemic to the coastline of southern California, not being found more than 2.5 miles from the ocean. The subspecies went through an emergency listing in 1994, after a single population was rediscovered in 1993 after 20 years with no sightings. In 1995 the Pacific pocket mouse was found at two sites on the Marine Corps Base in San Diego County. It is estimated that the current distribution of the Pacific pocket mouse is less than 1,000 acres across all occupied sites (USFWS, 1998a).

It is unknown how many Pacific pocket mice are left in the wild, though it is likely to be a very small number. Four recovery actions are needed to reclassify the Pacific pocket mouse as threatened rather than endangered. These actions include: ten populations that are independently viable and are stable or increasing; ensuring occupied habitat is at least 4,940 acres and is fully protected through some means of permanent protection; all populations are managed through a program to retain genetic diversity; and all populations and essential habitat are managed in a way that eliminates current and potential threats. If the plan is implemented, it is possible the Pacific pocket mouse could be reclassified by 2023, though that remains unlikely (USFWS, 1998a).

Although extensive surveying has been done, no additional populations of the Pacific pocket mouse have been discovered since 1995, and it is possible that one of the rediscovered populations is extinct. Reintroduction efforts are planned for the subspecies, however there is the potential that reintroduction could fail if the Pacific pocket mouse is outcompeted by other similar species. Interspecific aggression is a major factor that can reduce fitness for the subordinate species through a decrease in resource acquisition, reproduction, and survival. Though interspecific competition can play a major role in whether reintroductions are successful, it is a factor that is not often considered (Chock et al., 2019). A study conducted on pocket mouse communities found that dominance among species was generally correlated to size. Due to the Pacific pocket mouse’s smaller size, this means that it is likely to always be subordinate to larger species. This could have implications for cache pilfering in the rodent community of the Pacific pocket mouse’s range. Pacific pocket mice primarily eat seeds and if they are less dominate than the other seed eating rodents, there is a chance they could be majorly impacted by cache pilfering. However, the extent that cache pilfering would affect reintroduced Pacific pocket mice is unknown. From a management standpoint, it would make sense to be cautious and attempt reintroductions in areas with a lower density of competitor species (Chock et al., 2018, 2019).

Bird Coverage Under the ESA

There are approximately 10,000 species of birds worldwide. They vary in size from the bee hummingbird (*Mellisuga helenae*), which is so small that it is often mistaken for its namesake, to the common ostrich (*Struthio camelus*), which stands taller than a person. There are currently 105 bird species listed on the ESA; 77 are endangered and 23 are threatened (ECOS, 2021). Between 1994 and 2004 the ESA likely prevented at least 16 bird species from going extinct (Luther et al., 2016). Compared to less popular taxa, birds are relatively well supported by the ESA. However, there is still 40% under-recognition of birds under the ESA when compared to the IUCN Red List. As of 2011, there were 62 IUCN listed U.S. birds; 25 of those species were not listed on the ESA, and ten of them are endemic to the U.S. Although bird extinctions have occurred throughout time, two major extinction peaks occurred in the 1890s and the 1980s. Since 1825, 23 U.S. resident bird species have gone extinct and seven more are potentially extinct as last sightings range from 1937 to 2004. Most of the extinct species were endemic to Hawaii, 21 of the 23 species, which points to a conservation issue surrounding island birds (Harris et al., 2012).

Bird species that are endemic to islands are much more at risk than mainland bird species. This is especially true of populations on the Hawaiian Islands. There are known to have been 109 endemic Hawaiian bird species, however, only 37 endemic species remain. Of the 37, 33 are listed under the ESA, though it is possible that nine of the species may already be extinct as they have not been observed recently (Reed et al., 2012). Most avian extinctions within the last two centuries have been island endemics. These species are more susceptible to population decline due to a variety of factors such as having inherently small population sizes, restricted ranges, higher susceptibility to invasive species, and receiving less funding and conservation actions than mainland species (Luther et al., 2016). Mainland species generally received 15 times the funding of Hawaiian birds of similar rank. Between 1996 and 2004, the 31 Hawaiian bird species that were currently listed received roughly $30 million from all available sources. Over this same period, the most well-funded bird species, the Red-cockaded woodpecker (*Picoides borealis*), received roughly $100 million from all available sources. This is more than three times what all Hawaiian bird species received combined, and points to a major discrepancy in the funding allocated to mainland versus island birds. This is partly due to Hawaii ranking 42nd in human population, which limits the amount of conservation funds the state is allocated as states with higher populations receive more funding. Consequently, although Hawaii has the most imperiled species of any state it receives the lowest tier of funding. Also, species with smaller geographic ranges receive less funding and Hawaii's species have much smaller natural ranges than most mainland species (Leonard, 2008).

Habitat loss is the single greatest threat facing most listed bird species. A study done on California birds showed that 97% of the 92 species studied were heavily impacted by habitat loss. Although most listed species face multiple threats, single threat species most commonly suffer from habitat loss. Marine and coastal species do not face as large of a threat from habitat loss as most other species. Their major threat comes from human actions, such as pollution. Due to habitat loss being the most common threat faced by listed bird species, habitat-enhancement actions are a common conservation method. Habitat-enhancement includes restoration, maintenance, protection, and creation of habitat (Wiens & Gardali, 2013).

Case Study – Akikiki & Akekee

The akikiki (*Oreomystis bairdi*) and the akekee (*Loxops caeruleirostris*) are two species of Hawaiian honeycreepers endemic to Kauai Island (Hammond et al., 2015). Each is an example of a failure to provide ESA listing to a species that has long needed it. Both species have been in serious decline for a long time and were listed as endangered by the IUCN in 1994. The akikiki was listed as critically endangered by the IUCN in 2004, and the akekee followed in 2008. However, neither species was listed by the ESA until 2010, and both species populations continued to decline rapidly (Harris et al., 2012).

The akikiki was found throughout the island of Kauai until the early 1960s but is now restricted to the high elevation forests of the Alakai plateau. Its distribution has decreased from 88 km^2 in 1970 to 36 km^2 in 2000. The estimated population also declined during this period, from 6,832 to 1,472 (VanderWerf & Roberts, 2008). Likewise, the akekee's population has also been declining, from an estimate of 5,066 in 1973 to 3,111 in 2008. Both species are now restricted to small areas of undisturbed forest with an elevation of around 1,000 meters. However, no fossil evidence of akekee have been found in lowland areas, suggesting that the species has always had a limited distribution (Hammond et al., 2015).

Neither the akikiki nor the akekee have a finalized recovery plan, though there is a draft of a recovery plan that includes all listed species found on Kauai Island. The most recent 5-year status review of both species was conducted in 2017, where it was determined that neither species would have a change in listing status. Both species share the same four down-listing criteria, which when met, would change their status from endangered to threatened. The criteria are as follows:

1. A total population of 5,000 birds throughout 75% of the recovery area. The species must occur in two or more viable populations that provide genetic diversity to the species.
2. The number of individuals in each isolated population has been stable or increasing for 15 years.
3. Sufficient recovery area is protected and managed to achieve criteria one and two.
4. The mix of threats that were responsible for the decline of the species have been identified and controlled (USFWS, 2017a, 2017b).

Currently none of the four down-listing criteria have been met for either species. Both species are assumed to have decreasing populations, though the akekee is particularly difficult to observe due to spending the majority of their time in the upper forest canopy. Additional demographic monitoring is needed for the akekee to truly assess the current population size and growth rate. The threats, which have caused the decline of the akikiki and the akekee, have been identified but have not yet been controlled. These threats include an increase in avian malaria, impacts from climate change, degradation of habitat due to invasive plants and ungulates, and predation by invasive species (USFWS, 2017a, 2017b).

Both species face significant threats, that while possible to control, will be extremely difficult. Invasive species management will be required on multiple invasive plant species as well as feral ungulates and predators such as rats and cats. Avian malaria mosquito vector control is difficult, but emerging technologies might make it more feasible in the future. Neither the akikiki nor the akekee have captive breeding programs, though this is desired to augment the existing wild populations (USFWS, 2017a, 2017b).

It is encouraging that the threats to the akikiki and the akekee have been identified, as this is the first step to developing a solid conservation plan. However, more research needs to be done for both species in order to provide conservation actions that would lead to their delisting. Endemic bird species throughout Hawaii are often less well funded than mainland species, and their conservation suffers as a result.

Case Study – California Condor

One of the most iconic endangered birds in the United States is the California condor (*Gymnogyps californianus*). It is a highly charismatic bird, due to its large size and distinctive appearance. The California condor is also considered by many people to be a success story, though it is still one of the rarest birds in the United States. Unlike many other species, the condor's decline towards probable extinction sparked much public interest in its conservation. By 1982 there were only 22 condors left in existence. By 1987 all wild condors had been trapped and brought into captivity to attempt a captive breeding program. It was widely expected that it was too late to save the species, and that limited conservation funds should not be spent on a lost cause. However, the captive breeding and release program has since resulted in reintroduced condors in California, Arizona, Utah, and Baja California (Walters et al., 2010). As of 2019, the total population of California condors is 518, with 337 being wild birds (USFWS, 2019c).

The first case of reproduction in captivity of the California condor occurred in 1988 and continued to be successful, with the population growing rapidly. By 1992 reintroductions started and have continued since (Meretsky et al., 2000). Although reintroductions have been much more successful than many people believed back in the 1980s, there are still threats that are facing the wild population that continue to inhibit their growth. The leading cause of death of wild condors from 1992 to 2019 was lead poisoning, with 93 documented deaths. This makes up

50% of wild condor deaths for which the cause of death has been determined (USFWS, 2019c). In addition to deaths, between the years of 1997 and 2010, 48% of captured wild condors in California had blood lead levels that required them to be treated for lead poisoning. However, with the California wide ban of lead ammunition for hunting that went into effect in 2019, it is possible that there will be less condor deaths and presents the chance to expand the species range (West et al., 2017).

California condors once occupied a much larger range than current wild populations and it is possible that future reintroductions could be conducted in new areas of their former range. A study by D'Elia et al. (2015) found that condors currently occupy roughly 30% of modeled nesting habitat and 40% of modeled roosting and feeding habitat within their study area of California, Oregon, and Washington. This suggests that there may be significant opportunities for further introductions in new areas. Due to geographic, biological, and social factors in coastal northern California it provides an ideal new reintroduction area. In addition, the California condor is a species of cultural significance to the Yurok tribe who initiated efforts to reintroduce condors to the Yurok Ancestral Territory in 2003. By reintroducing condors to that region, it is likely that they would be protected by the Yurok tribe, and a northern population could provide a buffer for the southern population in the case of unexpected threats (West et al., 2017).

The California condor provides an example of a species where extensive conservation efforts and public support have resulted in what is commonly thought of as a success story. Although the condor still has a very small population, captive breeding efforts and reintroductions have gone well, and new condors are being born both in captivity and in the wild. The condor will likely remain on the ESA for a long time, until the wild population reaches a much higher level. However, if conservation efforts continue to move in a positive direction, it is possible that the species could eventually be delisted. The condor’s success likely comes from its charisma and the support the public has shown toward its conservation. The condor is fortunate in that regard. This is not the case for many other endangered species. The California condor is proof that if enough people are willing to provide conservation actions and funding, the species can be brought back from the brink.

Reptile Coverage Under the ESA

Reptiles are a diverse group of vertebrates that include lizards, snakes, crocodilians, turtles, tortoises, and the tuatara. In general, reptiles do not get nearly as much public support as mammals or birds (Gardner et al., 2007). The exception is turtles and tortoises, which are popular groups among the public (Trimble & Van Aarde, 2010). Although sea turtles are among the group of reptiles with the best image among the public, they still face significant conservation concerns as six of the seven sea turtle species are endangered in all or part of their range. Nesting threats are a concern for many sea turtle populations, though multiple programs have been implemented to mitigate these threats. In recent years, fisheries bycatch has been a major threat to many sea turtle populations. It likely has been a major threat for some time, but has only been recognized recently (Donlan et al., 2010).

Snakes tend to be the most unpopular reptile group among the public, and it translates to their conservation support. A recent analysis showed that around 33% of snake species worldwide may be imperiled. A major issue facing snake conservation is that for many species data on population trends is limited. However, an analysis done on 17 snake populations across Europe, Australia, and Nigeria found that 65% have declined significantly in the last 20 years. The most common threat facing snakes worldwide is habitat loss due to human development (Tucker et al., 2020).

One of the major issues facing the conservation of reptiles is lack of funds and lack of research. Even species that have finished recovery plans often do not have much information to work with. Without adequate knowledge of a listed species, it is very difficult to design and implement an effective recovery plan. Due to this lack of knowledge many reptile species go through a long period of stagnation, where they are placed on the ESA but make no measurable progress towards delisting. There are currently 48 reptile species listed on the ESA; 17 are endangered and 32 are threatened (ECOS, 2021). However, due to the lack of knowledge on population trends of many reptile species, it is highly probable that there are several other reptile species that should qualify for listing but that currently remain unrecognized.

Case Study – Leatherback Sea Turtle

The leatherback sea turtle (*Dermochelys coriacea*) is the largest turtle species and is found in all the world's oceans but has suffered steep population declines in the past three decades and may be facing extirpation in certain areas (James et al., 2005). Worldwide, the population has decreased roughly 67% due to habitat degradation, poaching, and fisheries bycatch. It is difficult for the leatherback to rebound from steep population declines because they mature slowly and have low rates of hatching success. Even young that successfully survive hatching have a high mortality rate during early life stages. Hatching success can be further hampered by elevated levels of mercury (Hg) present in adult females. Females with high enough concentrations of Hg and other compounds can pass these along to their young via egg components such as the yolk and albumen (Perrault et al., 2011).

Mercury is the most toxic of heavy metals and has no known biological function. Ocean surface concentrations of Hg have tripled in the past century, and most worrisome is the ability of Hg to travel thousands of miles from the original point source. Leatherback sea turtles have the lowest nesting success rate of the seven sea turtle species, and high concentrations of Hg in the breeding females may play a pivotal role in this decline. Leatherback hatchlings from Florida were shown to exhibit muscular pathologies resulting from selenium (Se) deficiency. High Hg concentrations in the body have been shown to cause Se deficiency in other animal species, and it is likely that this is also the case for leatherbacks (Perrault et al., 2013).

Part of the difficulty in creating conservation plans for the leatherback comes from their highly migratory nature. Besides breeding females, which return to the same beaches, observations of leatherbacks in the open ocean are rare, and their foraging behavior is mostly still unknown. This may be a reason that it was not known initially the extent of the danger posed to the species by fishing bycatch. Because of the leatherback's migratory behavior, its conservation is reliant on cooperation between multiple countries. However, the recovery plan for the species focuses on the U.S. population of the leatherback and provides five recovery actions. The first, is to provide long-term habitat protection for nesting beaches. Next, is to ensure at least 60% hatching success on major nesting beaches. The third is to determine distribution and seasonal movement for all life stages. The fourth action is to reduce the threat from marine pollution. Finally, the fifth involves reducing incidental capture from marine fisheries (USFWS, 1992). The recovery plan listed 2015 as the possible delisting year if all actions are implemented, though this has not happened. Thus, the leatherback will continue to be listed for years to come.

The leatherback sea turtle provides an example of a species that has high public visibility and charisma, but still needs much more conservation support than has been received thus far. Protection of sea turtle nesting beaches is a high-profile conservation issue, and volunteers around the world aid in these efforts. However, as mentioned previously, knowledge of leatherback behavior while at sea is still lacking and more conservation efforts are required to protect leatherbacks during migration and throughout the open ocean. Because heavy metal pollution has been shown to negatively affect nesting success, a vital component of leatherback conservation needs to be the drastic reduction of ocean pollution. This might be the hardest conservation action to implement as multiple countries around the world contribute to the heavy metal pollution that ends up in the ocean.

Case Study – Puerto Rican Boa

The Puerto Rican boa (*Chilabothrus inornatus,* formerly *Epicrates inornatus*) is a snake endemic to the island of Puerto Rico. It is the largest snake found on the island, with a length between 1.8 – 2.2 meters; females are larger than males (Moreno, 1986). The Puerto Rican boa has been classified as endangered since 1970 and was listed on the ESA from its beginning. However, during all this time, there are still no estimates of historic or current population sizes and there have been limited studies on the species population status, trends, or demographics. This makes it very difficult to conduct status reviews of the species (as recommended every five years by the ESA) because not much more is known than when the recovery plan was written in 1986 (Tucker et al., 2020).

There were amendments made to the original recovery plan in 2019 to account for new knowledge that the Puerto Rican boa is likely to be more numerous than first thought. Much of the snake's apparent rarity might be explained by observer difficulties in detecting individuals, due to their cryptic coloration and elusive habits. Because it is very difficult to observe the boa, field studies, which have reported sightings, are likely underestimating the number of individuals residing there. Observations of the Puerto Rican boa have occurred in 97% of the municipalities of Puerto Rico. Also, it is predicted that 46.3% of the island is potential habitat for the boa. Although this is encouraging and may mean that the Puerto Rican boa is not as imperiled as was originally thought, this does not mean that the species is secure. The amended delisting criteria of the Puerto Rican boa includes these requirements: at least three populations occupy at least 50% of its suitable habitat and are distributed island wide, populations show a stable or increasing population trend, and threat reduction and management activities have been implemented to the extent that the species will remain viable for the foreseeable future (USFWS, 2019a).

Studies on the genetic diversity of the Puerto Rican boa have begun in recent years and are an important aspect to understanding the conservation needs of the species. The first genetic study was conducted using two cave dwelling populations and two surface dwelling populations. Because some populations of the Puerto Rican boa live in caves, preying on bats and using caves as shelter, there was concern that these populations may show genetic differences from the populations that live in other parts of the island. If this was the case, it would have implications for how conservation should be carried out for the species. However, no distinct genetic differences were found between boas that live in caves and those that don't (Puente-Rolón et al., 2013).

In addition to the genetic study of wild boas, there is a single study that examined the genetic diversity of *ex situ* populations of the species. Although the Puerto Rican boa has been protected for over 40 years and has been illegal to collect from the wild, there is still a sizable captive population that is descended from individuals that were collected before the ban. *Ex situ* conservation is an important conservation tool for many endangered species. Captive breeding is often carefully planned to maintain genetic diversity. However, there is currently no studbook for the Puerto Rican boa. Nevertheless, it was found through genetic testing of boas in public and private collections that the genetic diversity of the *ex situ* population is higher than would be expected. This is an ideal situation from a captive breeding standpoint, and if breeding starts to be monitored more carefully, it is likely that the genetic diversity will remain high (Aungst et al., 2020).

Although the population of the Puerto Rican boa is likely much greater than originally thought, urbanization and habitat destruction are still major concerns. A population projection model indicated that the population is very likely to decline over the next 30 years given the continued rate of urbanization. Lower rates of urbanization increased the probability of a stable population, but even in the best-case scenario in which there is no further urbanization (which is unlikely) the probability of growth is only 50.2%. This indicates that the species will continue to need conservation support (Tucker et al., 2020). The Puerto Rican boa presents an example of a species that has been listed on the ESA since the beginning but has made little measurable progress towards recovery. It is not enough to simply list a species. Studies must be conducted to understand the population trends and demographics. It seems that these studies are finally starting for the Puerto Rican boa, and hopefully in a few years more will be known about this elusive snake.

Case Study – Blunt-Nosed Leopard Lizard

The blunt-nosed leopard lizard (*Gambelia sila*) is the largest lizard species in the San Joaquin Desert, California, where it is endemic. Males are slightly larger than females ranging in size from 3.4 to 4.7 inches, snout to vent length. Females range from 3.4 to 4.4 inches. For a while, taxonomy of the blunt-nosed leopard lizard was contested, with some believing it to be a subspecies of the long-nosed leopard lizard. However, in 1970 a solid argument was presented, which confirmed the blunt-nosed leopard lizard as a separate species (USFWS, 1998b).

The San Joaquin Desert covers an area of about 28,500 km^2 and blunt-nosed leopard lizards can be found throughout the desert. However, populations have become very fragmented due to land conversion of the desert into agricultural, urban, and industrial uses, which now take up 59% of the area (Germano & Rathbun, 2016), and this has resulted in the species currently occupying 15% of its original range (Germano & Williams, 2005). There is some evidence that blunt-nosed leopard lizards prefer more open areas as dense plant cover can impede their ability to forage for food and to escape predators. They have been observed using old mammal burrows for shelter, and when escaping predators, they sprint across open ground and avoid dense vegetation (Warrick et al., 1998). Habitat loss is the primary reason the lizards were listed as endangered federally in 1967, and by the state of California in 1971. Although the species has been listed for a long time, there is still little ecological information available, which makes developing and implementing meaningful management actions difficult (Germano & Rathbun, 2016).

A study done by Germano (2018) found that 22.3% of radio collared blunt-nosed leopard lizards were killed or presumed killed by predators annually. This is a lower rate of predation mortality than is seen in many other southwestern lizard species and could be attributed to the smaller sizes of other lizard species. Although the blunt-nosed leopard lizard is larger than other lizards in its range and preys on smaller lizards (USFWS, 1998b), it is still vulnerable to predation by snakes and birds. Predators of the blunt-nosed leopard lizard include Cooper's hawks, red-tailed hawks, gopher snakes, western rattlesnakes, California kingsnakes, and striped racers (Germano, 2018). Whether predation is a conservation concern for the blunt-nosed leopard lizard is not yet clear, but considering that the species is rare, annual mortality due to predation could be hindering the growth of the population.

The recovery plan for the blunt-nosed leopard lizard lists three factors that are deemed the most important for recovering the species. These factors are determining appropriate habitat management and compatible land uses, protecting additional habitat in key portions of their range, and gathering additional data on population responses to environmental variation throughout their extant geographic range (USFWS, 1998b). Primarily, it appears that more research is needed to really understand the conservation needs of this species. Even though the blunt-nosed leopard lizard has been listed as endangered since before the ESA was passed, there is still little information about the species. Most recent papers published about the blunt-nosed leopard lizard are from the same author. This points to a need for more researchers to conduct studies on this species. The lack of information about the species, even though it has been listed for decades, also points to a common issue faced by reptiles, which is a large lag time in research when compared to other vertebrate groups such as mammals and birds. This makes the management of endangered reptiles more difficult and could easily lead to reptile species being listed on the ESA for extended periods of time simply because not enough research is being conducted to know how to effectively manage species.

Amphibian Coverage Under the ESA

Amphibians are a taxon of vertebrates that are distinguished by having an aquatic gill-breathing larval stage followed in most instances by a terrestrial lung-breathing adult form. Amphibians are comprised of frogs, toads, salamanders, newts, and caecilians. Concerns about the world-wide decline of amphibians were first voiced during the First World Congress of Herpetology in 1989 (Harding et al., 2016). Amphibians have the highest threat status of the terrestrial vertebrates, with significantly more species (by percentage) at risk than either mammals or birds. Amphibians face numerous of threats that are pushing them toward extinction. These include direct factors such as habitat change, over-exploitation, and the introduction of invasive species. Indirect factors affecting amphibians include climate change, acidification, pollution, and infectious disease (Gardner, 2007). Amphibians have value for many reasons including medical research, control of agricultural pests, and ecological value in the food chain. Their permeable skin makes them extremely sensitive to environmental pollution, which makes them useful as indicator species (West, 2018).

Across the globe over 40% of all amphibian species are in decline, though this is likely to be an underestimate since 24% of species do not, yet, have enough population or range data to know their true status. At least 122 species have gone extinct since 1980, and this trend is likely to continue without protective measures. It is also estimated that there are still many amphibian species, which are not yet known to scientists, especially in the tropics. Lack of funding is a major issue faced by amphibians in the U.S. From 2004-2007, the average amphibian listed on the ESA received only 25% of the funding that was allocated to the average mammal, bird, and reptile, and received only 10% of the funding that was allocated to the average fish (Gratwicke et al., 2012). This is a major discrepancy in the funding allocated to other vertebrates.

Although tropical frogs tend to get the most publicity due to their imperiled statuses, many amphibian species in the U.S. are equally threatened. At least 36 of the 300 amphibian species in the U.S. are classified as endangered or presumed extinct (Gratwicke et al., 2012). Some of these species are extinct in the wild and only survive due to captive breeding, such as the Wyoming toad (*Anaxyrus baxteri*), which was placed on the ESA in 1984 and declared extinct in the wild in 1991. As a result of captive breeding efforts, there are now three small populations at the Mortenson Lake National Wildlife Refuge in Wyoming (Gleason, 2013). Some people may see this example as a success since the Wyoming toad has been reintroduced.

Others will say that because the Wyoming toad is still endangered with a small population, the conservation efforts have not had a substantial impact. This raises the important question of how success is quantified. Unless there are strict guidelines of success there will always be disagreement on this.

There are currently 36 listed amphibian species from the U.S.; 21 are listed as endangered and 15 are listed as threatened. However, only 24 of the 36 listed species have active recovery plans (ECOS, 2021). It is also possible that the ESA does not list all amphibian species that should be listed. A previous study by Harris et al. (2012) compared species listed on the ESA to the species listed on the IUCN Red List and found that the ESA shows 80% under-recognition of amphibian species. This may indicate that the ESA is failing to list species that should be listed; thereby leaving them vulnerable.

The listing delay among amphibians is a problem, with the average amphibian species waiting 9.9 years from initiation to full listing. An example of an extreme case of listing delay is the dusky gopher frog (*Lithobates sevosus*). This frog species is considered one of the top 100 most critically endangered species in the world by the IUCN, and concerns over its status were raised in 1982, but it was not formally listed as endangered until 2001. Compounding the problem, even species that are listed often experience a delay in the formation of a recovery plan and the designation of critical habitat. For the 18 taxa that have completed recovery plans, the delay between listing and completion of those plans was 2-29 years. Finally, the completion of a recovery plan does not guarantee its implementation. The desert slender salamander (*Batrachoseps aridus*) has had a recovery plan since 1982, but very few actions have been taken since then. The recovery plan for the Puerto Rican golden coquí (*Eleutherodactylus jasperi*) was completed in 1984, which was seven years after its listing. However, none have been seen since 1981 and it is possible that the species is now extinct (Walls et al., 2017).

Case Study – Wyoming Toad

The Wyoming toad (*Anaxyrus baxteri*, formerly *Bufo baxteri*) is the most endangered amphibian in North America and is classified as extinct in the wild. The Wyoming toad was first described by George Baxter in 1946. It was first thought to be a subspecies of the Canadian toad but is now recognized as a distinct species. It is endemic to the Laramie Plain and was once found in wetlands across southeastern Wyoming. Although its range has always been small, the Wyoming toad was considered common from the time it was discovered until the early 1970s. However, by the 1980s it was in serious decline, and was listed as endangered on the ESA in 1984. A single population of toads was discovered at Mortenson Lake in 1987. Reproduction was observed in 1988 but the number of eggs continuously declined and by 1991 no further reproduction was observed in the wild. In 1993 the Mortenson Lake National Refuge was established in Wyoming as a place to reintroduce a population of toads and any remaining toads that could be located were collected for captive breeding (Dreitz, 2006; Gleason, 2013). Today, there are wild Wyoming toads living in the Mortenson Lake National Refuge. However, this population is not self-sustaining as no successful breeding has occurred, and the population must be continually supplemented with captive born individuals (Polasik et al., 2016).

Fortunately, the effort to breed Wyoming toads in captivity has been quite successful, with over 40,000 tadpoles and toadlets having been released into the wild (Gleason, 2013). However, they are not establishing breeding populations in the wild. It is important to understand the factors that are causing this lack of reestablishment because continuing to release thousands of captive-born individuals is counterproductive if they are not surviving. If the wild population is not increasing it will never make it to the point of delisting from the ESA, which is the goal.

Research undertaken on the Wyoming toad includes captive breeding, field studies, and disease identification. The most successful research has been conducted by the Association of Zoos and Aquariums (AZA) institutions, eight of which have captive breeding programs. The captive breeding program is currently the most successful aspect of the Wyoming toad's recovery plan. However, this does not mean that it is without its issues. Most captive individuals do not live longer than three years, but it has been shown that breeding success is highest in toads that are more than three years old. It is not clear why most captive animals are not living to their natural lifespans. Likely, there is an underlying husbandry reason that has not yet been found (Dreitz, 2006).

Field research on Wyoming toads has unfortunately been relatively unsuccessful. This is mostly due to the limited number of wild individuals and flawed research methods. Two master's theses form the backbone of most of the field research done. This data suggested that Wyoming toads mature faster than many other amphibians in the region, with males maturing at two years and females at three years. However, very few toads were observed to survive more than two years after reaching adult size; this mortality is likely due to chytrid fungus, which is another major threat to successful reintroduction efforts (Dreitz, 2006).

Batrachochytrium dendrobatidis (Bd) is a fungal pathogen, which is responsible for the chytridiomycosis (chytrid) disease in amphibians and has resulted in amphibian declines worldwide. Chytrid is an infection of the epidermis, which can result in death for the amphibian (Russel et al., 2019). Bd has been identified on Wyoming toads at Mortenson Lake National Refuge, and it is certainly possible that Bd could have contributed to the major population crash in the 1970s, though this is not known conclusively. It is also possible that Bd could more negatively affect early life stages and contribute to the declining number of toads, which are making it to adulthood (Polasik et al., 2016).

The original recovery plan for the Wyoming toad was completed in 1991 but was revised in 2015. The recovery plan provides an overview of what is known about Wyoming toads as well as strategies to increase the population. Currently, the Wyoming toad’s range is very small and amounts to the population at Mortenson Lake and two other sites protected under the Wyoming Toad Safe Harbor Agreement. Breeding has not been seen at any of the three sites in recent years, which means that none of the wild populations are self-sustaining. This requires the continual supplementation of captive born individuals. The plan states that the limited distribution of the Wyoming toad constitutes a severe threat in the ability of the species to recover (Vincent & Abbott, 2015).

The recovery plan outlines both short and long-term strategies that will hopefully lead to the highest goal of delisting the Wyoming toad. That goal is still far from reach, but with continued flexible management plans and further research it could be possible in the future. The captive breeding program is currently working on maximizing the genetic diversity of all offspring produced and is focused on continued improvements in husbandry of captive animals to maximize health. A major goal is increasing the knowledge of the needs of wild toads to determine why reintroductions have failed to establish breeding populations. Management is also being driven by an increased understanding of disease dynamics and how certain diseases such as chytrid are affecting both wild and captive Wyoming toads. The plan estimates a cost of $4,260,000 plus any unforeseen costs for the actions necessary to delist the Wyoming toad. The estimated timeline for delisting is at least 15 years but could be potentially longer (Vincent & Abbott, 2015).

Case Study – Puerto Rican Golden Coquí

Very little is known about the Puerto Rican golden coquí (*Eleutherodactylus jasperi*), and although it is commonly believed to be extinct some say that this is not certain and that more surveys of historic and new locations are still needed. It is a very small (i.e., 0.75 inch) golden-yellow frog, which was discovered in the Sierra de Cayey and the Carite forests of Puerto Rico in 1973. There have never been many sightings of the golden coquí, and it was listed on the ESA in 1977, only one year after being described to the scientific world. It has not been seen since 1981 (Diaz, 1984; Walls et al., 2017).

The golden coquí is the only frog species in the Americas that is ovoviviparous; meaning that during embryo development the female keeps the eggs inside her body instead of laying them. Then the mother 'gives birth' to live offspring. It is not the same process mammals go through, but it appears as if the frog is giving live birth. Another extremely rare trait in the development of the golden coquí is the lack of a tadpole stage. The young are born as mini replicas of the adult frogs; this is known as direct development and is found in only a few species of amphibians (Diaz, 1984).

It is believed that habitat destruction was the main factor in the golden coquí's extinction. The areas where the species was discovered have been deforested, developed, and were impacted by fires. All that is known about the preferred habitat of this species is that it was found living in bromeliads growing on trees and on cliff faces at elevations of 700 to 850 meters. The only population estimates come from field work conducted between May 1973 and August 1974 when three populations were identified. Estimates of these populations were less than 10, 500-

1,000, and 1,000-2,000. Surveys searching for the golden coquí were conducted in 1986 and 1994, but none were found. It is possible that the species always had a very small distribution, which would leave it vulnerable to any changes in its habitat. It is also possible that the chytrid fungus played a factor in the golden coquí's demise (Diaz, 1984; Russel et al., 2019). Of course, neither of these predictions can be known with any certainty, as the golden coquí went extinct before the species could be studied in depth.

A recovery plan for this species was created in 1984, three years after the last individual was seen. The plan states that the golden coquí's range occurs primarily on private lands, which makes conservation more administratively complex and restricts the potential management that can be taken. The highest goal of the recovery plan is delisting, but since there is no data on the historical population the temporary recovery goal is that each of the three populations be either stable or expanding, each containing at least 1,000 individuals. Long-term habitat protection for each of the three populations was also listed as a goal, with plans for negotiations with private landowners to make habitat protection possible (Diaz, 1984).

The recovery plan was well-written but came too late. No one has seen any golden coquís since the plan was written. The unfortunate case of the Puerto Rican golden coquí highlights what could be a major issue concerning species with limited distributions. It is very possible that humans have caused the extinctions of several species, which we never knew existed, because they were found in small geographic areas that were developed before being surveyed. The other major issue in this example is the delay in crafting a recovery plan. If the plan had been completed only a year or two after the listing, it is possible the species might still be extant.

Case Study – Desert Slender Salamander

The desert slender salamander (*Batrachoseps major aridus*) is endemic to the state of California and has been found in only two canyons of the eastern Santa Rosa Mountains in Riverside, California. It is a small salamander, only around four inches long, and is a blackish-maroon color. The desert slender salamander is from the Plethodontidae family, which are a group of lungless salamanders that breathe entirely through their skin. This species is sexually dimorphic, with the female being slightly larger than the male (USFWS, 2014a).

The desert slender salamander was listed on the ESA in 1973, the first year of the act's implementation, but did not have a recovery plan until 1982. Even with the recovery plan, not many conservation actions have been taken (Walls et al., 2017), though it is important to mention that both known populations of the species are located on protected land (USFWS, 2014a). Due to the protected location, it is possible that further actions may not be necessary at this time.

The known habitat of this species includes two locations at Hidden Palm and Guadalupe Canyons and spans an elevation from 760 to 1,170 meters. Due to the desert slender salamander's lack of lungs, it is vital that it keep its skin moist. It does this by living primarily in cracks and crevices inside the limestone canyon walls. While this provides an ideal habitat, it is quite restricted as much of the area surrounding these canyons is dry desert. In essence, it is an island endemic. Due to its habitat specificity, it is likely that the desert slender salamander has always had a very restricted range. Population surveys have not been performed at Hidden Palm Canyon since 1978, at which time 343 salamanders were sighted. A large percentage of these sightings were juveniles, which indicates reproduction was occurring at the time. Unfortunately, individuals have not been sighted at Hidden Palm Canyon since 1997. It is presumed that the population is still extant based on the difficulty in finding the salamanders and the area being protected. The last population survey at Guadalupe Canyon was conducted in 1985 and 30 salamanders were sighted. Population sizes are likely to be higher than what was observed because searches were only conducted above ground in order to preserve the delicate substrate inside the canyon walls (USFWS, 2014a).

Current recommended actions include surveys at both population locations to determine habitat suitability and attempt to find more individuals. It is also recommended to determine whether invasive species are negatively impacting the desert slender salamander, and to remove invasive species if necessary. If a population still exists at Hidden Palm Canyon, habitat restoration efforts are to be considered as well as monitoring of groundwater levels. If individuals can be found, non-lethal DNA collection may be considered to further understand the desert slender salamander's taxonomic placement. Lastly, surveys of other sites with suitable habitat conditions are recommended to determine whether there are additional populations, which not currently known (USFWS, 2014a).

The desert slender salamander provides an example of a species, which does not appear to have been negatively impacted directly by humans. However, it suffers from a very restrictive range and is vulnerable to environmental changes such as years of heavy flooding or sustained droughts. Some of these environmental changes could be explained by human caused climate change. This means that we may have indirectly made it harder for the species to survive even though the area the salamanders live is not impacted by human development.

Fish Coverage Under the ESA

There are currently 139 fish species listed on the ESA; 76 are endangered and 46 are threatened (ECOS, 2021). Fish are not typically valued by the public to the same extent as mammals and birds, primarily being seen simply as a food source. As a society, we tend to value the commercial production of seafood and the recreational experiences provided by wild stocks. However, we are starting to recognize the effects of overfishing and realize that how fishing is conducted has environmental consequences (Takahashi, 2011). Our views toward fish can be seen in how the fish species that get the most conservation support and funding are typically species that humans like to eat, such as salmon. Of course, this does not mean that salmon species do not need conservation support, as they also provide an important food source to other animals and serve an important ecological function overall.

Highly migratory marine fish are currently excluded from the protections of the ESA even though the act has the necessary framework to list these species. Since overexploitation is rampant among migratory pelagic fish species it follows that there are several species that should be considered for listing under the ESA. For example, the bluefin tuna is a highly sought commercial fish species in many parts of the world that faces significant threat from the overexploitation of direct harvesting. In the case of the Atlantic bluefin tuna, populations are at an unprecedented low point and continue to decline. If this trend persists, the population is likely facing collapse. Ultimately, it seems unlikely that any highly migratory fish will be listed on the ESA unless there is a significant societal shift that sees fish as more than just a commercial commodity. Barring a societal shift, a significant collapse of fisheries may be the only event that would precipitate such listings. Either of these possibilities would likely need to include an international context, as conservation of most marine species requires cooperation from multiple countries (Takahashi, 2011).

Another prevalent issue in the conservation of certain fish species is the use of hatcheries. Salmon and steelhead population declines were noted as far back as the 1800s. Hatcheries were soon constructed to boost population sizes, mostly for human consumption. Continued habitat destruction due to dams and urbanization have further reduced salmon and steelhead populations. Currently, approximately 70-80% of wild coastal salmon and steelhead originate in hatcheries (Lum, 2010). In the case of Pacific salmon, the two goals of hatcheries are to increase the number of salmon for fishing and to prevent natural salmon from becoming extinct. Although hatcheries may seem like an effective way to boost wild populations there are some issues with mixing wild-born and hatchery-born fish. Hatchery fish can exhibit behavioral differences from wild fish, and when interbreeding with wild fish, can cause a decrease in the genetic diversity of the wild population. They can also spread diseases and oftentimes outcompete the wild-born fish for food resources (Stein, 2010).

Since the creation of the ESA nine fish species have been delisted, but only four of them were delisted due to recovery. Four other species were delisted due to extinction and one due to taxonomic revision. In addition, the four species that have been delisted due to recovery (Oregon chub, Modoc sucker, Foskett speckled dace, and Borax Lake chub) have all been delisted in the last six years. The most recent delisting is the Borax Lake chub (ECOS, 2021). This species is endemic to Borax Lake in Oregon and to adjacent wetlands. The species exists as a single population, which makes it vulnerable to habitat destruction and invasive species. Endemic fish species throughout the U.S. present conservation questions. Although they may be common throughout their specific range, it is this restriction that makes the species extremely vulnerable to environmental changes. In the case of the Borax Lake chub, it was decided that their habitat is adequately protected for their recovery. However, there are several endemic fish species that are still listed on the ESA (Williams et al., 2005).

Case Study – Comanche Springs Pupfish

The Comanche Springs pupfish (*Cyprinodon elegans*) is a small fish, which is endemic to a small area of Texas. Very little is currently known about its behavioral ecology. Its historical range included Comanche Springs in Pecos County, Texas, but these springs have since dried up. Currently, the Comanche Springs pupfish is restricted to San Solomon Spring pool, a man-made refugium in Balmorhea State Park, and spring-fed irrigation canals. The Comanche Springs pupfish was federally listed as endangered in 1967, prior to the completed ESA (Brannan et al., 2003). A recovery plan was completed for the species in 1981 (USFWS, 1981) and in 2019 a supplemental finding for the original recovery plan stated that developing quantifiable delisting criteria is not practical at this time (USFWS, 2019d).

The Comanche Springs pupfish is more distinctive than most other pupfish species due to the male's speckled color pattern (USFWS, 1981). The females are a rustic olive brown with a blotchy pattern. The species ranges in size from about 30-60 mm. The males at the larger end of the range tend to be territorial and defend all females within their territory during breeding season. The intermediate sized males usually employ the tactic of mating with females when a larger male is occupied elsewhere in his territory, and they do not hold their own breeding territories. The smallest males often breed by mimicking the females. They retain a female coloration and will breed with females within a larger male's territory, often with the larger male unaware (Gumm, 2012).

The primary threat to the Comanche Springs pupfish is habitat loss due to loss of spring flow, which is being caused by a decline in groundwater levels. Other threats include hybridization with bait bucket released fish into Comanche Springs pupfish habitat, and competition with the invasive sheepshead minnow (*Cyprinodon variegatus*) for resource needs.

Since the 1981 recovery plan, Phantom Lake Spring has gone dry and is now being maintained with an artificial pump system. The specific population that lives in Phantom Lake Spring is considered genetically unique. Although the population is currently stable, it is extremely vulnerable to any event that could damage the pump system that is enabling its survival. There are currently two facilities that maintain captive bred populations of the Comanche Springs pupfish. While this is an important aspect for the conservation of the species, these facilities are useless for reestablishing wild populations if there is no suitable habitat. At the moment, this appears to be the case (USFWS, 2019d).

The original recovery plan lists three main objectives, none of which have been met. The first objective is to assure perpetuation of the species in its natural habitat. The second is to assure genetic diversity of the species by improving the quality of currently occupied habitats, increasing the quantity of suitable habitat, and establishing a continuing program of management and public information. The third is to down-list the Comanche Springs pupfish from endangered to threatened. Due to none of the criteria being met, the Comanche Springs pupfish will not be delisted for quite some time. In fact, it is likely that the Comanche Springs pupfish represents an example of a species that will never be delisted. If the limited habitat on which the species relies continues to be threatened, there is no way that delisting will be possible (USFWS, 2019d).

Case Study – Pallid Sturgeon

Sturgeons are a group of fish sometimes called living fossils. This term applies to a species, which has been in existence for a very long time, often without many evolutionary changes. Fossilized remains of the ancestor of modern sturgeon species date back to 75-80 million years ago. There are currently eight sturgeon species, seven of which are listed on the ESA as either threatened or endangered. The pallid sturgeon (*Scaphirhynchus albus*) is one of the endangered sturgeon species, having been listed on the ESA since 1990 (Guy et al., 2015; USFWS, 2014b).

There is not much data on the historic population numbers of pallid sturgeon, since it wasn't recognized as a separate species from the shovelnose sturgeon until 1905. Forbs and Richardson, who first described the species, speculated that it might be due to rarity that the pallid sturgeon had not been recognized earlier (USFWS, 2014b). The pallid sturgeon is endemic to the Missouri and Mississippi rivers and has the unfortunate luck to be living in an area where rivers are highly regulated and broken up by multiple dams. Dams change the natural river flow and break rivers into segments that fish cannot always move between. The upper and middle Missouri river is now broken up by six large dams, which have had the effect of reducing the pallid sturgeon population due to lack of cyclical spawning habitat and recruitment. When embryos hatch, they drift long distances of 200-500 km along the riverbed, but the blockage by dams does not allow them to do this anymore. This leads to the embryos reaching a reservoir before they have had time to mature, making them easy prey for other species (Guy et al., 2015).

Due to recruitment being very low or potentially nonexistent in some areas, hatchery born fish are being used to augment wild populations. Stocking of hatchery born fish has been a major conservation action taken to stop pallid sturgeon populations from becoming extirpated until wild populations are self-sustaining. Since 1994, more than 1.1 million fish aged less than a year and 375,000 aged one year or older have been stocked throughout the Missouri river (Pierce et al., 2019). However, many of these stocked fish may not be reproducing yet. The pallid sturgeon is a long-lived fish, and females often don't reach sexual maturity for 15-20 years; males reach sexual maturity much earlier, often around 5 years (USFWS, 2014b). Fish stocking is an effective way to keep populations stable, but in the case of the pallid sturgeon, it seems unlikely that natural recruitment will increase anytime soon.

The greatest threat to the pallid sturgeon currently comes from the impacts of habitat destruction and modification. Impoundment has caused the extirpation of the pallid sturgeon from roughly 28% of its historic range. The remaining portion of their range is either affected by upstream impoundments, which alter water flow, turbidity, and temperature, or the area has been modified by channelization and bank stabilization. The six main-stem Missouri river dams have blocked normal migration routes, altered habitat characteristics, reduced the possible drift distance of embryo Pallid sturgeon, and caused changes in river function, which impact the size and diversity of aquatic habitats. The effects of dams primarily affect the population in the upper Missouri river basin. In the middle and lower Missouri river and the middle Mississippi river water quality and impacts caused by the maintenance of the channel are considered high threats. Though habitat threats are not the only possible threats that the pallid sturgeon faces, they are the most urgent, and receive the most attention on the revised recovery plan (USFWS, 2014b).

The pallid sturgeon is a species that is highly impacted by habitat modifications that are not likely to change. Management should focus on trying to restore as much habitat as possible, although the impact of dams may significantly hinder efforts to address fragmentation of the species. If habitat restoration is not possible to the extent necessary for stable natural recruitment, then the pallid sturgeon might be a conservation reliant species indefinitely.

Case Study – Razorback Sucker

The razorback sucker (*Xyrauchen texanus*) is a large fish endemic to the Colorado River Basin. The species has gone through a substantial population decline due to dams disrupting the stream flow and predation by invasive fish species. The razorback sucker’s distribution is currently limited to the upper Colorado River Basin and a few lower Colorado River Basin reservoirs. Historically, the species ranged from Mexico to Wyoming and was widespread throughout its range. The razorback sucker was listed as endangered on the ESA in 1991 (Kegerries et al., 2017; Webber & Haines, 2014). The first recovery plan was completed in 1998, and another recovery plan was completed in 2002, which amends and supplements the original (USFWS, 2002).

The Upper Colorado River Endangered Fish Recovery Program began a stocking plan in 1995 to try to boost population numbers. Since it began, the program has stocked more than 200,000 razorback suckers. Reproduction among stocked hatchery fish has occurred every year, though the level has not been significant in boosting the razorback sucker population. From 1995-2005 fish of all sizes were stocked, but it was found that fish less than 300 mm in length did not survive well. Currently hatcheries try to stock fish greater than 300 mm in length to increase the percentage of survival (Webber & Haines, 2014). However, even large razorback suckers are vulnerable to predation by large striped bass (*Morone saxatilis*), which has been confirmed by observations of anglers finding razorback suckers, as well as radio transmitters from razorback suckers, in the stomachs of striped bass in Lake Mohave (Karam & Marsh, 2010). Lake Mohave currently has the largest population of razorback suckers in the entire Colorado Basin. Razorback suckers were abundant there in the 1950s but have been declining due to the drop in recruitment. Population estimates were 60,000 in 1991, down to 25,000 in 1993, and 9,000 in 2000 (USFWS, 2002).

There is currently no projected timeline for when the razorback sucker can be expected to be delisted because first populations must be identified as self-sustaining. Once self-sustaining populations are reached it will be more practical to develop a delisting timeline. Management goals include providing adequate habitat and range for recovered populations, protection from overutilization, protection from diseases and predation, and ensuring existing regulatory mechanisms are adequate. For a self-sustaining population, reproduction must be occurring, and recruitment of young fish must be maintained at a rate to keep the population at 5,800 adults or more (USFWS, 2002). Currently, there are populations of greater than 5,800 adults in the Green and Colorado River subbasins. However, they are not considered self-sustaining because recruitment is low and populations are maintained through stocking. The Lake Mead population is a stable and recruiting population but does not, yet, meet the criteria of 5,800 adults (USFWS, 2018a). Continued stocking will be important to the recovery of the razorback sucker until populations are able to produce adequate recruitment on their own. The razorback sucker provides an example of a species that has greatly benefitted from stocking as a conservation measure. It is possible that the razorback sucker would be very near extinction if stocking efforts had not been a major part of the conservation management plan. Now, it seems the most important factors to ensure that recruitment continues to increase are habitat management and restoration, and predator control.

Invertebrate Coverage Under the ESA

Invertebrates make up 96% of all described species, yet much less is generally known about them than about vertebrates. This can be explained in part to their lack of charisma when compared to larger bodied vertebrates, particularly mammals. In general, there is not much public concern over imperiled invertebrates, with a notable exception being butterflies (Moir et al., 2011). There are currently 307 invertebrate species listed on the ESA (ECOS, 2021), though based on statistical estimates, the actual number of imperiled invertebrates could be as high as 8,600 – 25,000 species (Wilcove & Master, 2005). This is way more imperiled species than the

ESA is equipped to handle, and it is likely that there will continue to be great under-recognition of invertebrates for the foreseeable future.

The ESA does not provide as much protection to invertebrates as it does for vertebrates. Any vertebrate can qualify for listing at the species, subspecies, or distinct population segment level. However, invertebrates can only qualify at the species and subspecies level. This is the result of a compromise between the House of Representatives and the Senate in 1978, when the House had voted to eliminate all protections for invertebrates (Black, 2008). Though this compromise was necessary to keep most protections for invertebrates in place, it still leaves invertebrates lagging when compared to vertebrates in regard to conservation.

There are many invertebrate groups that have not been studied sufficiently to determine their percentage of imperiled species. These are studies that should be conducted in the future. Of the invertebrate groups that have been evaluated, the percentage of imperiled species varies significantly. Butterflies and skippers are at the low end, with 6% of described species imperiled. At the high end, with 61% and 70%, respectively, are the freshwater snails and freshwater mussels. In the U.S., invertebrate groups typically associated with freshwater such as mussels, snails, crayfish, and shrimps have a higher percentage of imperiled species than terrestrial groups. However, there are a few exceptions. Dragonflies and damselflies have a lower percentage of imperiled species than other freshwater invertebrates, though this could be explained by these insects being strong fliers and not necessarily being restricted to a small area or single watershed. For terrestrial groups, the percentage of terrestrial snails and grasshoppers is much higher than that of butterflies and moths. Again, this could be explained by the ease of movement butterflies and moths have compared to snails and grasshoppers, which often have restricted ranges, making them more vulnerable to habitat destruction and environmental changes (Schwalb et al., 2011; Wilcove & Master, 2005).

The ocean is an environment that is full of invertebrate species. However, these species are only very rarely protected under the ESA. This could be mainly due to not having the necessary demographic and life history information to determine whether certain marine invertebrates warrant listing on the ESA. Corals are particularly vulnerable to climate change as has been seen in bleaching events throughout the planet's oceans. The three largest threats that are likely to cause the extinction of corals by 2100 are ocean warming, disease, and ocean acidification. Coral species should be listed on the ESA if they are imperiled, however, the threats to their extinction are not going to improve unless wider action is taken to combat climate change worldwide. Coral reefs are the rainforests of the ocean as they contain the majority of the ocean's biodiversity. If most coral species were to go extinct, this would have a major impact on the biodiversity of the world's oceans. This makes the conservation of corals a significant and difficult undertaking (Brainard et al., 2013).

There are some invertebrates that even most conservationists do not consider protecting, namely, parasitic insects. Among recorded arthropod extinctions, a large number are of parasitic insects. During the conservation efforts to save the California condor, the Californian condor louse (*Colpocephalum californici*) was deliberately eradicated. This was done for the protection of the California condor, though was potentially unnecessary, as there was no evidence that the louse had negative effects on the health of its California condor hosts. Although most people are used to only thinking of parasitic insects such as fleas in negative terms, if there is no real reason that they pose a threat then there is no reason they must be eradicated either. It could be possible to conserve the host species as well as their parasite (Kwak, 2018).

Insects are also the only group singled out under the ESA as not being afforded protection if the species in question is claimed to be an agricultural pest by the Secretary of Agriculture. An example of an insect species that is potentially imperiled but does not qualify for listing under the ESA is the Ashton cuckoo bumblebee (*Bombus ashtoni*). There is evidence that the Ashton cuckoo bumblebee is disappearing across its range, however, cuckoo bumblebees are parasites of other bumblebee species. Due to the Ashton cuckoo bumblebee's status as a 'pest' of agriculturally important bumblebee species it cannot be listed, even if it continues to decline (Black, 2008).

Overall, invertebrates as a whole need increased research and conservation protection. The only groups that tend to generate public concern are usually pollinators such as bees and butterflies, and although these groups are very important, other invertebrate groups should also be prioritized.

Case Study – Oahu Tree Snails

Hawaiian tree snails were historically abundant across their range, occurring from sea level to at least 1,500 m. However, due to habitat destruction, extensive shell collecting, and invasive predators, populations are now fragmented and only occur in high-elevation forests (Price et al., 2015). The genus *Achatinella* contains 41 species, all of which are endemic to one of the two mountain ranges on the island of Oahu (henceforth referred to as Oahu tree snails). Although 41 species of Oahu tree snails have been classified, there are now believed to be only ten remaining (O'Rorke et al., 2016). Extinctions of the Oahu tree snails began to increase following the introduction of a species of predatory snail in 1958, *Euglandina rosea*, which was introduced to control the population of the giant African snail (*Achatina fulica*). The giant African snail is a garden pest but introducing *E. rosea* to control it was not a good idea as it also preys on the native Oahu tree snails. Invasive ungulates also pose a threat by degrading the remaining habitat of the Oahu tree snails by destroying native vegetation and facilitating the spread of invasive plants (Hadfield et al., 1993).

All the Oahu tree snail species have been listed on the ESA since 1981. Extinction rate estimates range from 75-90% and habitat destruction has reached 90%. This is a major decline, and recovery is made more difficult by certain life history traits that are common to the Oahu tree snails. The genus generally shows late reproductive maturity as well as low fecundity, which make recovery of populations a very slow process. They also have a limited dispersal ability so any threat to their habitat is serious (Holland & Hadfield, 2004). To conserve the remaining Oahu tree snail species, an *ex-situ* breeding facility maintains populations of each species. However, despite the absence of predators, these captive populations have not been very successful and are prone to high mortality events. More studies are needed to understand how to maintain Oahu tree snails in captivity (O'Rorke et al., 2016).

The recovery plan for the Oahu tree snails was originally completed in 1992 and covers all 41 species, though many of them are now extinct. The recovery plan was amended in 2019. The amended plan contains new down-listing and delisting criteria, though it is unlikely that any of the criteria measures will be met anytime soon. For any of the Oahu tree snail species to be considered for down-listing there must be at least six to ten stable populations which are distributed across the known historical range of the species. Evolutionary significant units (ESU) are identified for some species, in which case each ESU of a species must be represented by one stable population. A population is considered stable if it contains at least 300 individuals distributed across all size classes, and the population must have a growth curve that is stable or positive for at least four of the next five years. To be considered for delisting, there must be at least 12 to 20 stable populations and each ESU must be represented by two populations. All the populations must have a population growth curve that is stable or positive for seven of the next ten years. In addition, there must be habitat suited for natural dispersal, expansion of the occupied range, and positive population growth (USFWS, 2019b).

The Oahu tree snails face an uncertain future that is shared with many other endemic island species. Unless habitat restoration and intensive invasive species management is successful it is unlikely that these snails will be able to make a full recovery in the wild. *Ex-situ* breeding efforts have the potential to help maintain populations, but more research is required to understand the exact husbandry needs for each species.

Case Study – Karner Blue Butterfly

The Karner blue butterfly (*Lycaeides melissa samuelis*) is a small butterfly with a wingspan of one inch. Males and females differ in color. The dorsal side of the males' wing is violet blue with a black margin and white around the edge. The dorsal side of the females' wing ranges from a light violet to a bright purple blue near the body and the central portion of the wing. The rest of the wing ranges from a light to dark gray or brown. Both males and females are grayish fawn on the ventral side of the wing with orange crescents along the border. There are a few butterfly species with overlapping ranges that can sometimes be confused with the Karner blue, though there are distinguishing characteristics used to tell them apart (USFWS, 2003).

The Karner blue was listed as endangered on the ESA in 1992. The Karner blue has gone through a dramatic population decline with numbers only 1% of what they were a century ago (Nice et al., 2009). Changes in canopy cover is a major factor in declining populations. The Karner blue lives in savanna and barren habitat. The majority of individuals are currently found in the Great Lakes region of the Midwest, though they are also found in New York. Historically, the habitat was much more heterogeneous, with many patches of canopy cover and openings. Today, the habitat is more densely forested, primarily due to the suppression of wildfires over the last 150 years. This loss of canopy openings can have very serious consequences for the Karner blue butterfly. The Karner blue is also restricted by its reliance on wild blue lupine (*Lupinus perennis*), the only larval host plant (Grundel et al., 1998). Climate change is likely to have negative impacts on the Karner blue. It has been observed in recent years that an earlier spring leads to the Karner blue laying eggs earlier in the year, often before there is sufficient wild blue lupine to sustain the larvae. In drought years, the lupine senesces earlier, often by late July. Lupine, which are water stressed, leads to poor nutritional quality for the Karner blue larvae. This can slow the larva growth rate, reduce size at pupation, and causes a decrease in fitness (Patterson et al., 2020).

Conservation efforts include three reintroduction programs, one each in Ohio, New Hampshire, and Indiana. There is also an accelerated colonization project in Minnesota. All projects also include habitat restoration and management activities in addition to the reintroductions (USFWS, 2003). An important component to current Karner blue conservation is the efforts of private landowners. Although the species is protected on some state-owned lands, funding and resources are limited, and the protection of the Karner blue on private lands has been beneficial (Neff et al., 2017). Some of the landowners have simply agreed to not negatively impact the butterfly or its habitat on their property. Some take it a step further and actively plant lupine and nectar plants as well as restoring savanna and barren habitats on their land (USFWS, 2003). It is likely that part of the reason private landowners are more willing to aid in the conservation of the Karner blue is because it is a charismatic species, which represents the worldwide decline of pollinator species (Neff et al., 2017).

The Karner blue butterfly represents a species of invertebrate that seems to have an effective recovery plan. The plan is 293 pages, which is longer than most single species recovery plans. Management efforts have been ongoing since before the final draft of the recovery plan in 2003 (USFWS, 2003). Butterflies are widely appreciated among the public, which is something that is not the case for many other invertebrate species. This may give the Karner blue an advantage when it comes to conservation management, as more people may be willing to contribute to Karner blue conservation on their private lands.

Case Study – Snuffbox Mussel

Freshwater unionid mussels are one of the most imperiled groups worldwide as well as in North America, where 70% of species are in decline. Field studies have found skewed age classes toward older individuals in many populations of unionid mussels, indicating either failed reproduction or high juvenile mortality. Declines in freshwater mussels are caused by loss of habitat, decline in fish host populations, predation, over-harvesting, invasive species, and exposure to environmental pollution. Environmental pollution is the factor that is likely causing lack of recruitment, as early life stages are more sensitive than adults (Gillis et al., 2008).

The snuffbox mussel (*Epioblasma triquetra*) currently has the largest distribution of all species in its genus. However, the snuffbox is absent from more than 60% of its historic range, and without management is likely to continue to decline (Beaver et al., 2019). At the time of the snuffbox's listing on the ESA in 2012, it was known to inhabit 79 streams in 14 states and one Canadian province. Since then, snuffbox have been observed in a few more streams, bringing the total to 82. Only seven snuffbox populations are described as having sizable numbers, and with recent evidence of recruitment. Most known populations are small and restricted to a limited area of stream (USFWS, 2018b).

Snuffbox mussels, like other unionid species, use fish as a larval dispersal agent. Survival of local populations is highly dependent on the prevalence and dispersal ability of their host fish. Snuffbox primarily use logperch (*Percina caprodes*) as their host fish, so any conservation management of the snuffbox should also consider the conservation of logperch. Mussels in the genus *Epioblasma* infest host fish with their glochidia by capturing the host between the mussel's valves. The logperch has a sturdy enough skull to not be crushed when captured by the snuffbox, which makes it an ideal host species. However, the dispersal ability of the logperch requires further study to determine effective management for the snuffbox (Schwalb et al., 2011).

There is currently no completed recovery plan for the snuffbox mussel. As this species has been listed since 2012, creating a recovery plan should be a priority. Although there is not currently a recovery plan, management actions are being taken. Successful propagation techniques are ongoing in Indiana, Kentucky, Minnesota, Tennessee, Wisconsin, and Virginia. Some methods being used involve host fish inoculation while some employ *in vitro* culture of glochidia without using host fish. Eight streams currently have ongoing propagation and/or reintroduction efforts. Of the 82 extant populations, only 17 have a high enough recruitment to be considered viable populations. Since its listing in 2012, the status of the snuffbox has not improved, and its threats have not been mitigated. Only 6% of the snuffbox populations are stable or improving. More management for the snuffbox is required to ensure the survival of the species. The first step should be the development of a recovery plan as that would provide guidance for future management actions (USFWS, 2018b).

Chapter III: Methodology

This chapter explains the methods that were used throughout the research involved in this paper. Due to the literature review forming the bulk of the research, the methods used no scientific equipment.

Subject Selection and Description

Representative species case studies were chosen within the following categories: mammals, birds, reptiles, amphibians, fish, and invertebrates. All case studies were chosen from species listed as endangered on the ESA. With the exception of the Puerto Rican golden coquí all species are extant. The mammal category had two case studies: the gray bat and the pacific pocket mouse. The pacific pocket mouse was the only case study that featured a subspecies rather than a species. Small mammals were intentionally chosen as case studies rather than larger ones to showcase less popular mammals. The bird category had two case studies but three species – the akikiki and the akekee were combined into one case study, as they are both endemic Hawaiian birds. The California condor was the subject of the second case study. The reptile, amphibian, fish, and invertebrate category all had three case studies. More case studies were chosen for these groups to illuminate needs (and current situation) of the broader group since they have less coverage under the ESA than either mammals or birds. The invertebrate category had one case study that included all species of the Oahu tree snails. All Oahu tree snails were included because there was not enough information available to focus on a single species of the genus.

The species included in each category were intentionally diverse to gather information across a wide range of species. For example, the reptile category contains case studies on one turtle, one snake, and one lizard species. This provides a more diverse overview of the reptile taxon than would have been given if all three case studies would have focused on closely related species.

Data Collection Procedures

Information and data for this study were collected through an extensive literature search. Searches focused on papers that mentioned the ESA and were divided into categories for ease of reference. Categories were as follows: general ESA background, mammal coverage, bird coverage, reptile coverage, amphibian coverage, fish coverage, and invertebrate coverage. The literature search was conducted through the University of Wisconsin-Stout library database, using search terms including endangered species act, endangered species conservation, endangered species act coverage, endangered mammal conservation, endangered bird conservation, endangered reptile conservation, endangered amphibian conservation, endangered fish conservation, and endangered invertebrate conservation. Once species were selected for case studies, searches also included species specific information.

The USFWS site was used extensively to obtain information on the selected listed species. Recovery plans were used to collect information on the conservation efforts of selected species. It should be noted that not all selected species have completed recovery plans. In these cases, five-year status reviews or other USFWS information was used to determine conservation management efforts for the selected species. A few of the selected species have more recent recovery plan amendments than the original plan. In these cases, information was taken both from the original recovery plan and the amendment. One species (i.e., leatherback sea turtle) has two recovery plans based on different geographic areas. In this case, information was taken from both recovery plans. The ECOS list was used to find species listed as endangered on the ESA.

Data Analysis

Due to this study being primarily a literature review, data analysis was limited. All data comes from previously published literature or from the USFWS website. Data taken from the USFWS was used to create a table showcasing coverage across taxa, such as the percentage of each taxon that is listed but does not have a completed recovery plan, at least one five-year status review, or both.

Limitations

The greatest limitation of this study is the lack of information gathered through primary research. All information came from pre-existing literature. Although many publications were used here, it was not feasible to find every relevant paper that exists, and it is possible that there are gaps in the information either due to lack of research or of failure to find relevant research.

Summary

This chapter overviews the methods used to conduct this study. Since this study is a literature review, the methods are simple. Research into the primary literature was conducted through the UW Stout library database and through the USFWS website. The literature review was broken into sections focusing on ESA background, mammal coverage, bird coverage, reptile coverage, amphibian coverage, fish coverage, and invertebrate coverage. Each section was broken into subsections, which contained case studies. Case studies focusing on selected species were chosen based on species listed as endangered on the ESA, with the additional goal of choosing a diverse selection of species. Analyzed data was taken from the primary literature search and from the USFWS website.

Chapter IV: Results

This chapter provides the results of this study. Due to the study being comprised primarily of a literature review, there is very little numerical data included. Recovery plan and five-year status review data was taken from the USFWS Environmental Conservation Online System (ECOS) in order to determine which animal taxa have a high percentage of completed recovery plans and five-year status reviews and which taxa could benefit from an increase in completion of recovery documents.

Demographic

The groups included in Table 1 are all animals, with more extensive inclusion of traditional vertebrate classes (i.e., mammals, birds, reptiles, amphibians, fish). Invertebrates, while much more speciose, are limited in coverage by the ESA; thus, limited here as well. Select groups included species that are listed on the ESA (i.e., clams, snails, insects, arachnids, crustaceans).

Item Analysis

Table 1 shows the number of listed species by taxa that have a completed recovery plan, at least one completed five-year status review, both a recovery plan and a five-year status review, and the number of species that do not have a completed recovery plan or five-year status review. Percentages are also given for each item.

Arachnids are the taxon that has the highest completion of recovery plans and five-year status reviews, with 100% of listed species having both documents completed. However, it is important to note that there are only 12 listed arachnid species, which is far fewer than any other taxon.

Aside from arachnids, birds have the highest percentage of listed species, which have both a completed recovery plan and at least one five-year status review. Seventy bird species (82.4% of listed birds) have both documents. Birds are also the taxon with the lowest number of listed species that have neither a recovery plan nor a five-year status review; only one listed bird species (1.2%) has neither document completed.

In contrast, amphibians are the taxon with the highest percentage of listed species with neither a recovery plan nor five-year status review. Ten species (28.6% of listed amphibians) have neither a completed recovery plan nor a five-year status review. Insects have the next highest percentage of listed species with neither recovery documents completed, with twenty species (22%) falling into that category. Insects are also the taxon that has the lowest percentage of listed species with both recovery documents completed (49.5%).

All other taxa fall somewhere between arachnids and birds at the high end, and amphibians and insects at the low end. Although mammals are a favorite animal group among the public, there are still 10.8% of listed mammal species that do not have a completed recovery plan or five-year status review. Fish have the greatest number of species listed on the ESA (122) and have the greatest number of species with a completed recovery plan and a five-year status review (98). This puts fish only slightly behind birds for the percentage of listed species with both recovery documents (80.3%). Discounting arachnids, the invertebrate taxon with the highest percentage of listed species with both recovery documents is clams, of which 70 listed species (76.9%) have both recovery documents. Again, discounting arachnids, the invertebrate taxon with the lowest percentage of listed species with neither recovery document completed is snails. The ESA has 50 listed snail species, three of which (6%) do not have a completed recovery plan or five-year status review.

Table 1

Status of Recovery Document Coverage Across Listed Taxa

Taxa	Recovery plan	Five-year status review	Both	Neither
Mammals	2 (2.7%)	8 (10.8%)	56 (75.7%)	8 (10.8%)
Birds	11 (12.9%)	3 (3.5%)	70 (82.4%)	1 (1.2%)
Reptiles	6 (15.0%)	1 (2.5%)	27 (67.5%)	6 (15.0%)
Amphibians	3 (8.5%)	2 (5.7%)	20 (57.1%)	10 (28.6%)
Fish	8 (6.6%)	7 (5.7%)	98 (80.3%)	9 (7.4%)
Clams	4 (4.4%)	6 (6.6%)	70 (76.9%)	11 (12.1%)
Snails	3 (6.0%)	11 (22.0%)	33 (66.0%)	3 (6.0%)
Insects	5 (5.5%)	21 (23.1%)	45 (49.5%)	20 (22.0%)
Arachnids	0 (0.0%)	0 (0.0%)	12 (100%)	0 (0.0%)
Crustaceans	2 (7.1%)	5 (17.9%)	18 (64.3%)	3 (10.7%)

Research Questions

There are several research questions that could be explored regarding the data above. It is clear, which animal taxa are more highly prioritized (i.e., a higher number and higher percentage of listed species with completed recovery plans and five-year status reviews) and which are not (i.e., listed species that do not have completed recovery plans or five-year status reviews). Based on the data, some questions can be asked that would be excellent lines of future inquiry.

Research Question 1: Do Taxa With a Higher Percentage of Listed Species Without Recovery Plans and Five-Year Reviews Face More Threats Than Other Taxa?

Even though certain taxa have more species without completed recovery plans or five-year status reviews does not necessarily mean that they are more imperiled than taxa, which have a higher percentage of listed species with the documents completed. Conversely, it is possible that species of lower priority take longer to receive recovery documents. However, the underlying issue is that a species without a recovery plan also lacks documentation that states all known threats to the species. Thus, no recovery actions can be recommended for completion to improve the situation for the species. This will ultimately allow for delisting once the species has made a recovery. Similarly, a species that has been listed for several years but does not have a five-year status review is at a disadvantage when it comes to status improvement. Five-year status reviews include a recommendation for the current status of the species. A species may be up-listed (threatened to endangered), down-listed (endangered to threatened), delisted, or stay the same. Without having frequent status reviews of listed species, it can be unclear how the species is doing; thus, status reviews should be undertaken with urgency when funding is available.

Research Question 2: Are Taxa With a Higher Percentage of Listed Species, but Without Completed Recovery Plans and Five-Year Status Reviews, More Difficult to Study?

Some species are simply more difficult to study and, as a consequence, lesser known than others. This has the potential to impact which listed species are receiving quicker turnaround times from date of listing to the completion of a recovery plan. Often times, these are categorized as data deficient. These may represent a special category that could – or should – be prioritized for immediate baseline study, whether it involves life history, habitat, or other lines of relevant research. If there is a limited amount of information on a species, it may take longer to create a recovery plan and this, in turn, could lead to a rapid demise of.

Research Question 3: What Could Be Done to Ensure All Taxa Are Receiving an Adequate or Commensurate Amount of Recovery Implementation?

This question is a very important one, but it would require substantial effort to place it in the proper frame. At its foundation, here we are asking why a species or group should be prioritized or valued. This is the root of conservation biology. Do we prioritize and preserve only those for which we find immediate, applied value? Do we consider potential future applications and, if so, what is our measure? Phylogenetic relatedness to other species of high utility?

Taxonomic or phylogenetic distinctiveness? Other factors? These are the broader questions and challenges faced in management of biodiversity. In any case, we must continue to evaluate why and how we prioritize our efforts, especially when conservation funds are limited.

Chapter V: Discussion, Conclusion and Recommendations

This chapter concludes the research paper with a discussion of the findings, conclusions, and recommendations for next steps and future research. Ultimately, the ESA is an effective piece of legislation that provides many protection and conservation measures for listed species. There are multiple factors that determine the ability of managers to provide conservation support to endangered species. Unfortunately, as aforementioned, lack of funding is a major reason that not all species are able to get the amount of conservation management they should. Currently, certain taxa are receiving more protection than others. Thus, future management recommendations include increased conservation concern for less popular taxa.

Discussion

As can be seen by the data showcased in the previous chapter, there is a great deal of variance in the percentage of listed species with completed recovery documents across various taxa. It also appears that taxa which have a higher percentage of listed species without either recovery document correspond to groups that are less popular or emblematic among the public, such as amphibians and insects. This is not entirely surprising because funding decisions are often biased towards public opinion. It is easier to obtain public support for conservation when highly charismatic species are profiled. Unfortunately, this often leaves less popular taxa at a disadvantage.

Amphibians are the taxon of vertebrates that has the highest percentage of listed species that have neither a recovery plan nor at least one five-year status review (28.6%). This could be due to a variety of factors such as less funding, less available research on certain species, difficulties in the field, or being bypassed for more popular species. Whatever the cause, it is important to point out this percentage of listed amphibians without recovery documents to draw attention to the issue.

It is clear based on numerous data analyses that roughly 80% of amphibians listed on the IUCN Red List remain unlisted on the ESA (Harris et al., 2012). This is a major problem that arises due to lack of funding, amphibians being less stereotypically charismatic, and the usual delays involved in listing species (Walls et al., 2017). Being listed on the ESA does not necessarily lead to quick results. Although the ESA has prevented the Wyoming toad from becoming extinct, reintroductions that lead to self-sustaining populations have not yet occurred (USFWS, 2015). The delay in the recovery plan of the golden coquí could well have contributed to its extinction, and although the desert slender salamander has been listed since 1973, no observable progress has been made (Walls et al., 2017).

This same issue prevails in some of the reptiles examined here, such as the Puerto Rican boa and blunt-nosed leopard lizard, which have both been federally listed since before the ESA was implemented but have not made much measurable progress towards being delisted (Germano & Rathbun, 2016; Tucker et al., 2020). Importantly, this is likely a result of insufficient baseline knowledge, and could be remedied with on-the-ground research.

Moving forward, it is important to recognize the role that amphibians and reptiles play in the ecosystem and designate a commensurate share of conservation funds relative to other vertebrates. Amphibians are the most threatened vertebrate group, and it is well past time to recognize this. Lawmakers must implement legislative funding mechanisms designed to grow in relation to increasing threat levels (Gratwicke et al., 2012). Though it is likely to be difficult and take time, it is vitally important to be able to direct funds as appropriate related to the level of threats that certain taxa face.

Similar to amphibians, insects have the highest percentage (22%) of listed species without either a completed recovery plan or at least one five-year status review among invertebrate taxa represented under the ESA. In addition to the less popular vertebrate groups, invertebrates receive much less attention and conservation support. The ESA allows the protection of species, subspecies, and distinct population segments of vertebrates, but does not allow the same for invertebrates. Additionally, insects are excluded from protection under the ESA if a particular species is deemed to be a 'pest' (Black, 2008). While most insect species deemed 'pests' have robust populations, that is not the case for all. This type of designation is also plastic, depending on human activities (e.g., shifts in crops, livestock choices, etc.) over a given time frame.

Birds currently have the greatest percentage of listed species that have both a completed recovery plan and at least one five-year status review. However, this does not necessarily mean that all species are receiving adequate conservation support. A recovery plan provides recommendations for conservation actions but does not guarantee those actions will be carried out. Island birds, and in particular, endemic Hawaiian birds, face a multitude of threats due to habitat destruction, invasive species, and disease. Having naturally restricted ranges also exacerbates most threats to their habitat (Luther et al., 2016). Island birds have been prone to high extinction rates throughout history when nonnative species are introduced, and Hawaii does not receive the funding that it needs to address the conservation concerns of all its listed bird species. Currently, funding is given to states based on the state's population, with states such as California, New York, and Texas receiving the most funding. It seems counterintuitive to base conservation funding on the abundance of humans in a region, especially when biotic diversity is inversely proportional to human density. In Hawaii's case, due to its low human population, it receives the lowest tier of funding. However, Hawaii is the state with the most listed species (Leonard, 2008). To provide optimum conservation support to all listed species, it would seem more prudent to allocate funds based on the number of listed species found in a state and not by human population.

Fish currently have the most species listed under the ESA (122) of any taxon included. The primary threat is to freshwater species with habitat modification the primary culprit, especially rivers. Dams have fragmented the habitat of many freshwater fish species such as the pallid sturgeon and razorback sucker. Although hatcheries have been successful in boosting fish populations, natural recruitment is very low due to the impediment of multiple dams (USFWS, 2014; USFWS, 2018). If rivers and streams have been modified to the point where natural recruitment will always be low, then hatcheries will continue to be necessary indefinitely. This, too, raises questions about ultimate aims for delisting from the ESA. If a species is no longer viable in the wild, should we continue to support it?

Conclusions

Not all taxa listed under the ESA are receiving the same level of conservation support. There is a divide between vertebrates and invertebrates (Black, 2008). There is also a divide among vertebrates, with mammals and birds being the most popular groups among the public (Knight, 2008).

While these limitations and the need for improvement are recognized, it is important to note that the ESA is the most effective species conservation act on record. Success stories such as the bald eagle and the peregrine falcon were possible only due to the ESA. In addition, it is estimated that the ESA has protected 227 species from extinction following listing. Indeed, less than 1% of species listed on the ESA have gone extinct, and the status of 52% of listed species has either stabilized or improved (Luther et al., 2016). Most species extinctions that have occurred since the implementation of the ESA have been species that were unlisted, which lends credence to the ESA's effectiveness (Walls et al., 2017).

Due to the increasing numbers of imperiled species in modern times, it is important that more species are listed under the ESA and that taxa, which currently receive less protection, gain more conservation support. Biodiversity loss is a major issue, and according to recent estimates, the Earth could lose half of its biodiversity by the year 2100 unless humans reduce our impacts (George et al., 2016). Biodiversity loss at that scale would be detrimental for all the planet's ecosystems, and ultimately, for humans as well. There are many steps that need to be taken to reduce this loss, but in the U.S., improving protections under the ESA is a good place to start.

Recommendations

Further research that delves into the effectiveness of ESA protection across taxa should be conducted and should cover all major biota, including plants, which were not covered in this study. Plants also suffer from lower public concern and awareness, and likely receive less protection as a result. Plants were not included in this study due to the limited time frame and scope. However, plant coverage would be an excellent topic for subsequent studies.

Due to limited funding, it is not likely that every listed species (or non-listed species that should be listed) will receive adequate conservation management. However, it is important to scrutinize allocation of funding, and when possible, employ an ecosystem approach. This would maximize impact on species that share the same ranges and threats. For example, if two or more listed species share the same range and are both imperiled by habitat destruction and invasive species then allocating funding to habitat protection/restoration and invasive species removal will benefit all listed species in that region. Ideally, every listed species would have enough funding provided to receive individual conservation management. Lacking that option, the most effective management strategy is to determine which species conservation needs overlap.

It is also recommended that groups which do not receive as much favorable public attention, such as reptiles, amphibians, and invertebrates receive a comparable portion of conservation effort relative to mammals and birds. These species bear ecological importance, just as the more charismatic species do. It is possible that more education initiatives focused on the importance of less popular species could improve public perception and concern.

Finally, at the federal level, and especially in these times, we should always seek responsible and appropriate funding for conservation. Failure to do so could yield drastic consequences for future generations.

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