Measuring and understanding progress in U.S. endangered species conservation

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Abstract

Since passage of the Endangered Species Act in 1973, over 1,300 endangered and threatened species have been protected in the United States and its territories. Most species continue to face a significant risk of extinction, but the status of many species is improving. Here we present analyses of Reports to the United States Congress (1988 – 2002) that describe differences in species status and show which variables are correlated with improving or declining status. We found that 52 percent of species showed repeated improvements or were not declining over this time. Species status improves over time, with only 35 percent still declining 13 years or more after protection. Taxonomy, funding by U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA), and agency assessment of risk of extinction and potential to recover were significantly correlated with status.

Introduction

Claiming that the United States “Endangered Species Act (ESA) is broken,” leaders in the U.S. Congress have signaled that in 2005 they will attempt to amend this law that regulates actions affecting more than 1,200 endangered and threatened species (Pombo 2004, Thomas 2004). Is the law broken? Have the law and its implementers failed to achieve significant results with available resources?

The ESA sets forth the goal of protecting U.S. biodiversity by preventing species extinctions and promoting their “recovery.” Through 1999, the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) had designated (listed) 1,216 species (inc. subspecies and distinct populations) as threatened or endangered in the U.S. and trust territories. Of these species, 1172 (96 percent) had not gone extinct by 2004; nine species were declared extinct and removed from the endangered species list (www.fws.gov) and another 35 species were categorized as “extinct” in the USFWS 2002 Recovery Report to Congress (USFWS 2002a). Up to 192 of these species might have gone extinct but for the ESA’s protections (Schwartz 1999). Critics of the law, however, declare it a “failure” because only thirteen species, subspecies, or populations have been recovered and removed from the endangered species list since the law’s passage in 1973 (Pombo 2004). Measuring effectiveness of the ESA using only these endpoints is overly simplistic because it hides all results short of full recovery or extinction. It also ignores the fact that recovery for many species may require decades because most species are extremely imperiled when listed and face multiple and pervasive threats (Abbitt & Scott 2001). We used data from Recovery Reports to Congress covering 1988-2002 to evaluate species status across this period and to determine whether status improves over time.

The question of “why” species are improving or declining once protected by the ESA is even more important to inform debate over how to conserve biodiversity (Abbitt & Scott 2001). Previous analyses have examined subsets of the available data and variables. For example, progress in recovering species has been correlated with variation in ESA implementation through funding, designation of critical habitat, taxonomy, island versus mainland species’ range, and degree of threat (Simon *et al.* 1995, Rachlinski 1997, Restani & Marzluff 2001, Clark *et al.* 2002, Miller *et al.* 2002, Restani & Marzluff 2002, Simmons &

Frost 2004, Taylor *et al.* 2005). Recovery progress is likely influenced by (1) many aspects of species' biology, distribution, and threats; (2) strengths and weaknesses of the ESA; and (3) ESA implementation. We analyzed thousands of data points provided by many separate reports by the USFWS and NOAA on species status, expenditures and other biological and ESA-implementation variables for more than 1,000 listed species covering a 14-year period to assess the ESA and agencies' effectiveness in stabilizing and recovering endangered species populations.

Materials and Methods

Data Sources

We used data from Recovery Reports to Congress covering 1988-2002 to analyze the relationship between each species' status and years since listing under the ESA (USFWS 1990a – 2002a). Each Recovery Report provides information on whether species are "declining," "stable," "improving," or "unknown," however, this designation is made relative to the species status two years prior. USFWS assigns species to categories based on changes in numerical or population abundance or threats over a two-year period, but reports do not provide information on which of these factors influence the category to which a species is assigned. We excluded species that were listed after 1999 (five years before present), and species that had been taken off the endangered species list or were identified as "extinct" before 1999. Comparable status information is unfortunately not available for most marine mammals and anadromous salmonids under NOAA's jurisdiction. We should note that categories of species status are not assigned using quantitative or objective criteria although the USFWS has made recent efforts to improve this by providing more guidance to its biologists and requesting more information on how biologists decide which category to assign. Other authors have noted that status assignments for many species simply reflect the best judgment of a species expert (Boersma et al. 2001). There is a compelling need for these agencies to provide more and better information on species' recovery progress (Boersma et al. 2001, Scott & Goble 2005), however at present this data is the best that is available.

Recovery Reports also provide the year that species were listed and their taxonomic category (mammal, plant, fish, etc.), and species' "recovery priority rank.". The USFWS assigns one of thirty-six recovery priority ranks to each species (USFWS 1983). We focused analyses on two variables used by the USFWS to determine recovery priority rank – risk of extinction and recovery potential. We created one recovery potential and risk of extinction rank for each species based on the median rank from all reports (> 75 percent of species never changed priority rank). USFWS assigns three categories of risk of extinction: high applies to species requiring immediate action to prevent their immediate extinction. USFWS assigns only two categories to potential for recovery. High recovery potential species have threats that are well understood or easily removed, do not need intensive management or for which management techniques are well-developed and likely to succeed in helping the species. In the case of multiple distinct population segments of the same species or subspecies we combined populations and were conservative in using the highest priority ranking and worst status for any population segment for the whole entity.

Funding data was available from annual Expenditure Reports to Congress between 1989-2002 (USFWS 1990b – 2002b). These reports list expenses by the USFWS, all other federal agencies (including NOAA), and state agencies. We used individual tables of NOAA expenses in the report appendices and combined NOAA expenditures with USFWS expenditures for those species for which NOAA had jurisdiction or shared jurisdiction. This gave us one dataset of combined expenses by the two agencies responsible for implementing the ESA, one dataset for other federal expenses, and one dataset for state wildlife agency expenses. For each agency grouping we calculated mean spending/yr/species. We summed expenditures for multiple "distinct population segments" of the same species.

Information on critical habitat was obtained through the USFWS' "Threatened and Endangered Species Database System" found at the USFWS webpage (www.fws.gov); we coded critical habitat as "present" if critical habitat had been designated for a species or any distinct population of a species or subspecies before 2000.

Analyses

Using a general linear model, we examined the association between recovery progress and taxonomy, funding, distribution on islands, designation of critical habitat, and USFWS priorities. Since status is only reported over a two-year period it is difficult to evaluate long-term trends in whether species are making recovery progress (or are closer to extinction). To assess long-term patterns we transformed the biennial status data from "unknown," "declining," "stable," and "improving" to the numeric values: *(unknown), -1, 0, and +1, respectively. This allowed us to sum individual status from each report to get a composite status for each species that covered up to 14 years reporting. We grouped species into seven taxonomic groups (amphibians, birds, fishes, invertebrates, mammals, plants, reptiles). Tests of significance are added-last tests. NOAA does not provide status information on species on which it is the lead agency (whales and most salmonids) so these species were not included.

We evaluated correlations between USFWS and NOAA funding and taxonomy, risk of extinction, recovery potential, designation of critical habitat, and species' island or mainland distribution using a second general linear model, first transforming expenditures by taking the log (mean expenditure/year + 1) to give data a normal distribution and not exclude species that were unfunded. Skewness in the distribution of funding among species was calculated for each year of USFWS and NOAA, and other federal funding by regressing expenditure skew against years.

Results

Measuring Recovery Progress

Averaging over 14 years of available data, we found that slightly more than half of listed species were not declining or were consistently improving (Figure 1). The USFWS failed to assess status for an average of 40.3 percent of all listed species (SEM = 4.51) per report. Many of these species were assigned a status in at least one report, but 173 species remained "unknown" in every report. If declining species were disproportionately represented among this group our analysis may be overly optimistic.

We found a strong correlation between the length of time since listing and whether species were stable or improving (R^2 = 93.4 percent; Figure 2). Less than two years after listing, 23 percent of species were improving, many of which were plants (69 percent) for which immediate improvement may be an artifact of new population discovery (Wilcove *et al.* 1993). However, by 12 – 13 years after listing, 68 percent of known status species were reported as having stable or improving status. This finding suggests that many species protected by the ESA have made progress toward recovery. Since more than 55 percent of species have been listed for less than 13 years, many more species are likely to stabilize or improve over time (Figure 2). Improvements in status peaked around 13 years after listing and thereafter approximately 35 percent of species remained in decline.

Status differed among taxonomic groupings with birds and mammals having the fewest species in decline (Figure 3). Length of time on the list may have influenced this result; birds had the fewest declining species and > 50 percent were listed before 1970. Conversely, > 50 percent of invertebrates have been listed for fewer than 12 years and this group had the worst status. The unique circumstances and extreme endangerment of freshwater mussels (*16;* n = 60 mussel species, mean status trend = - 4.05)) had a strong influence on results for all invertebrates.

Explaining Recovery Progress

Recovery progress was significantly correlated with taxonomy, funding, USFWS-determined threat of extinction and recovery potential (R^2 = 13.1 %; Table 1). The designation of critical habitat was not correlated with improved status.

The significant association between status and USFWS and NOAA funding was of greatest interest because they administer the ESA and funding is likely to reflect the extent of agency efforts to conserve species. A “recovery plan” for every species describes necessary conservation actions and their associated costs (Clark *et al.* 2002). In these recovery plans, species recovery cost estimates differ, showing at least two orders of magnitude variation across a spectrum from endemic plants with restricted ranges to wide-ranging mammals (Miller *et al.* 2002). We found that greater absolute USFWS and NOAA funding was correlated with more favorable status (Figure 4). Repeatedly improving species (status ≥ 2) had a median annual USFWS expenditure 73 percent greater than repeatedly declining species (status ≤-

2). This same pattern was evident in other federal and state agency expenditures, but those expenditures were highly correlated with USFWS and NOAA spending and failed to explain additional variation among species (Table 1).

By summarizing Expenditure Reports to Congress we found that between 1989 and 2002, $5.196 billion was reported spent on individual endangered species. The USFWS and NOAA spent $1.601 billion, while other federal agencies reported $2.909 billion and state wildlife agencies reported $0.694 billion in expenses. Despite this significant spending, only a fraction of species recovery needs were funded because resource distribution was skewed toward very few species. For example, in each year the USFWS and NOAA reported spending less than $1,000 for an average of 275 species/year (SEM ± 39 species). Conversely, for the USFWS and NOAA, and other federal agencies 20 species received 52 percent ($641 million) and 69 percent ($2.0 billion) of funding, respectively. Four salmon species accounted for $806 million (36 percent) of NOAA and other federal agency expenditures; bald eagle (*Haliaeetus leucocephalus*) conservation consumed $63.1 million (8 percent) of all USFWS spending reported. Despite past criticism of skewed resource allocation (U.S. Government Accountability Office (USGAO) 1988, USGAO 2002), funding distribution has become more positively skewed over time for USFWS and NOAA ($F_{1,13} = 11.07$, $P = 0.006$) and other federal agencies ($F_{1,13} = 5.47$, $P = 0.037$).

The USFWS and NOAA apportioned resources differently among taxonomic groups (Fig. 3; $R^2 = 24.6$ %), and island species received less funding than mainland species ($F_{1, 1184} = 7.15$, $P = 0.008$). Although recovery costs are generally expected to be lower for plants and invertebrates (Miller *et al.* 2002), they make up more than 73 percent of endangered species yet received only 12.5 percent of USFWS and NOAA funding (Figure 3). Designation of critical habitat was not correlated with greater funding ($F_{1, 1184} = 0.80$, $P = 0.372$).

Funding was significantly correlated with both recovery potential ($F_{1, 1184} = 23.16$, $P < 0.0005$) and threat ($F_{2, 1184} = 14.65$, $P < 0.0005$), but these variables explained only an additional 3 % of variation among species once taxonomy and island distribution were incorporated into the model. These differences were likely driven by patterns among the best-funded species; there were no differences apparent in the distribution of funding among recovery potential and threat categories for the 1,057 species that received less than $100,000 in USFWS funding/yr. (Figure 5).

Discussion

Although some species show status improvements immediately after listing, some take many years with the proportion of species that are stable or improving peaking 12 - 13 years after listing (Figure 2). Further analyses and new policies should focus on ways to reduce this period during which many species continue to decline, for example by listing species before they become extremely rare (Wilcove *et al.* 1993), or by speeding the publication and subsequent implementation of recovery plans (Tear *et al.* 1995). Some policy-makers are already suggesting such an emphasis on rapid recovery planning (Owens 2004).

This result also raises the question of why some species improve and not others, even after being protected for more than a decade. No comprehensive data exists on some of the variables that are likely to be the most important in explaining recovery trends, including species dependence on unprotected lands, importance of specific threats, and existence of conservation partnerships. However, other authors have noted agency failures to meet statutory deadlines to list and de-list species (USGAO 1988), designate critical habitat (Taylor *et al*. 2005), publish and revise recovery plans (Clark *et al.* 2002), and develop effective landowner incentives (Bean 1998), implying that these failures influence recovery progress. We found ample evidence that species biology – as reflected through taxonomy – and the way the ESA is being implemented influence conservation progress.

The USFWS and NOAA provide more funding to some taxonomic groups (Simon *et al.* 1995), possibly because agencies fund more "visible," charismatic species (USGAO 1988) or because some groups had more widely distributed and thus more expensive to conserve species (Miller et al. 2002). Unlike Restani & Marzluff 2001, we found no correlation between recovery progress and distribution on islands, but we found they received less funding than mainland species. Among taxonomic groups significant variation exists between the status of island species. For example, all birds with consistently improving status are found on the mainland, whereas island reptiles are generally doing better than mainland ones. Further analyses of differences among species by taxonomic family or habitat type are worthwhile, but sample sizes made it difficult to carry out such analyses here.

The USFWS and NOAA reported more than $1 billion in spending on individual species. Despite this significant spending, only a fraction of species recovery needs were funded because resource distribution was skewed toward very few species (Simon et al. 1995, Restani & Marzluff 2002) and Congressional appropriations have been insufficient to cover all estimated recovery costs (Miller et al. 2002). However, funding levels and allocation among species is within agencies' and Congress' discretion to change. Although available expenditure data provides an imperfect summary of recovery funding (Simmons & Frost 2004, USGAO 2005), our findings suggest that larger Congressional appropriations would likely stimulate more recovery progress. However, recovery progress would also be improved if existing resources were allocated more efficiently toward species most likely to show subsequent recovery progress or a decline in their risk of extinction (Rachlinski 1997, Possingham et al. 2002). In this respect, the success or failures of the ESA are driven as much or more by implementation decisions than by the statute itself.

USFWS and NOAA recovery priority systems were explicitly adopted in 1983 to prioritize how agency resources would be allocated (USGAO 2002). The USGAO (2005) concluded that the USFWS focused resources on its highest priority species – those facing the greatest threats or with moderate threats and high recovery potential. However, 91 percent of the species they examined fit these categories and the USGAO (2005) went further to conclude that the USFWS lacks a consistent or transparent process to decide how to identify priorities and allocate funds among species within these categories. Other authors have found that these priority systems play only a small role in funding decisions (USGAO 1988, Simon *et al.* 1995, Foin *et al.* 1998). The position of individual members of Congress on funding and oversight committees may have greater influence than priority systems over how much funding species received (DeShazo & Freeman 2003).

The cost of recovering all listed species is likely to always exceed the budgets provided by Congress. Thus, in implementing the ESA, agencies responsible for biodiversity conservation should allocate resources to maximize their effectiveness at conserving species and achieving recovery outcomes (Possingham et al. 2002). Indeed, the U.S. Congress amended the ESA in 1982 to require agencies to give priority to species that are most likely to benefit from recovery efforts. In explaining why the USFWS funding allocations do not closely match recovery priorities, the agency cites the significance of Congressional earmarks to specific species (DeShazo & Freeman 2003) and opportunities to pursue partnerships in driving resource allocations (USGAO 2005). It is unclear to us why the agencies could not create a more robust priority system that would allow them to pursue partnerships for recovery while also focusing on species for which funding would have the greatest impact in achieving recovery progress or reducing the likelihood of extinction.

Taylor *et al.* (2005) found a significant correlation between critical habitat and species status, however their analysis did not include government expenditures, detailed taxonomic information or recovery priority variables. In a general linear model with designation of critical habitat as the only independent variable, we found that critical habitat explained a small but significant portion of the variation in species status ($F_{1, 1019} = 6.49$, $P = 0.011$; $R^2 = 0.54$ %). However, because critical habitat was correlated with both USFWS and NOAA expenditures and taxonomy, and these variables had greater significance in the full model, critical habitat was not important in explaining variation in status. Clark *et al*. (2002) also found that critical habitat was not significantly correlated with species status. A Recent court decision (*Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service*, 9th Circuit, 2004) may influence the level of protection that critical habitat affords to species in the future and subsequent analyses should examine future trends between species with and without critical habitat.

Measuring the success or failures of the ESA and its implementation is particularly difficult because so little information is available for many species; 172 species listed before 2000 were reported as "unknown" in every Recovery Report to Congress. Further, the USFWS currently reports status trends over a two-year period without providing information on change in status since listing and NOAA provides little information on status since listing. Both agencies should develop a standardized framework for reporting on the status of species that includes recent trends and whether species are better or worse off since they were listed. In addition, agencies should report which conditions are driving changes in status. More robust data would better inform policy and policy-makers (Schwartz 1999, Pombo 2004, Scott and Goble 2005), but at the very least USFWS and NOAA should expand their current reporting to finally provide data on species whose status has been “unknown” for more than a decade.

The endangered species status assessments we present should provide a far more detailed picture of recovery progress than is currently being used in the debates over Endangered Species Act reauthorization. Moreover, these analyses highlight the importance of identifying and funding priorities in biodiversity conservation because that funding does make a difference in the recovery of endangered and threatened species.

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Figure Captions

Figure 1. Status trends between 1990-2002 for endangered and threatened species (n = 1020 species). Repeated declines (status trend less than or equal to -2) occurred for 47.4 percent of species while 43.1 percent were stable or had no trend (-2<x>2) and 9.5 percent repeatedly improved (equal to or greater than 2).

Figure 2. Cubic regression model of the proportion of species that were stable or improving increased over time (in two year periods), to a peak of 64 % between 13-14 years. Therefore, by 2012 when some 1205 species will have been listed for > 13 years, we predict that approximately 776 species will be stable or improving.

Figure 3. Proportion of species within a taxonomic group in decline (composite status < -1) and mean U.S. Fish and Wildlife Service and NOAA expenditures/species/yr by taxonomic group ($F_{1,1163} = 60.66$, $P < 0.0005$). Funding values shown are means (+ SEM), but statistical analysis was performed on log-transformed data. The mean proportion of species declining in each group (gray line) is significantly correlated with funding (Table 1). Mean funding per bird species was 25-times greater than mean funding per plant species.

Figure 4. Improving status trends are associated with the greatest mean funding/year from the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration ($1,000s). Positive numbers indicate species that were reported as “improving” repeatedly in Reports to Congress; negative numbers indicate repeated “declining” status (n = 992 species).

Figure 5. For species receiving less than $100,000 in funding from the U.S. Fish and Wildlife Service/yr. (n = 1,057 species) there was no association between a species threat category (high, moderate, or low) and recovery potential (high or low) and levels of funding. (Each dot represents four species.)

Tables

Table 1. General linear model showing significant correlations between species' status trends and taxonomy, U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration funding, risk of extinction, and recovery potential.

Source	DF	MS	F	P
Taxonomic group	6	21.60	3.75	0.001
USFWS and NOAA funding/yr.	1	64.88	11.27	0.001
Other federal funding/yr.	1	1.220	0.21	0.645
State funding/yr.	1	17.66	3.07	0.080
Risk of extinction	2	211.4	35.94	<0.0005
Recovery potential	1	34.50	5.99	0.015
Critical habitat	1	19.91	3.46	0.063
Island distribution	1	19.85	3.45	0.064
Error	989	SS = 5691.37		
Total	1003			

Figures

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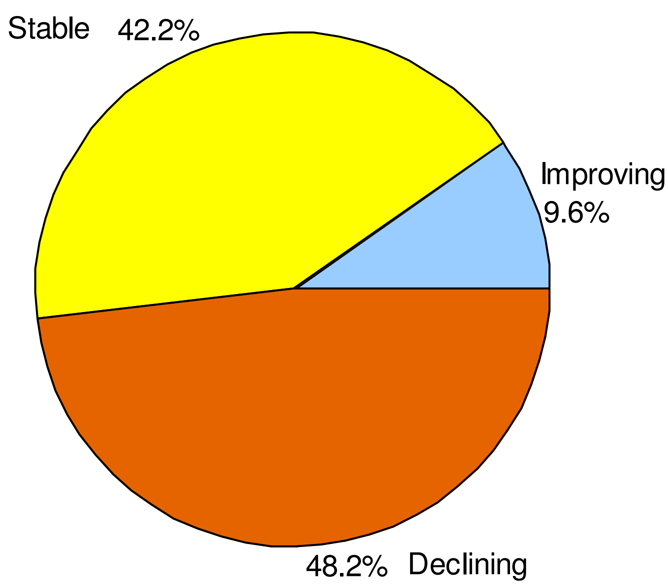

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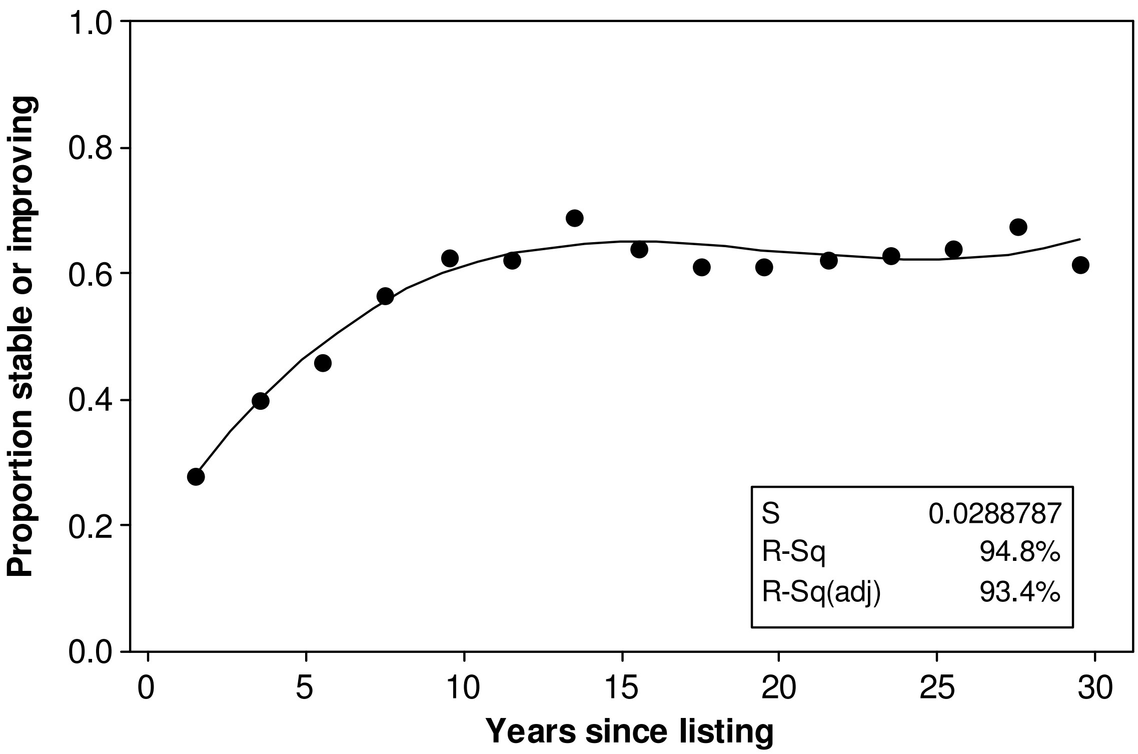

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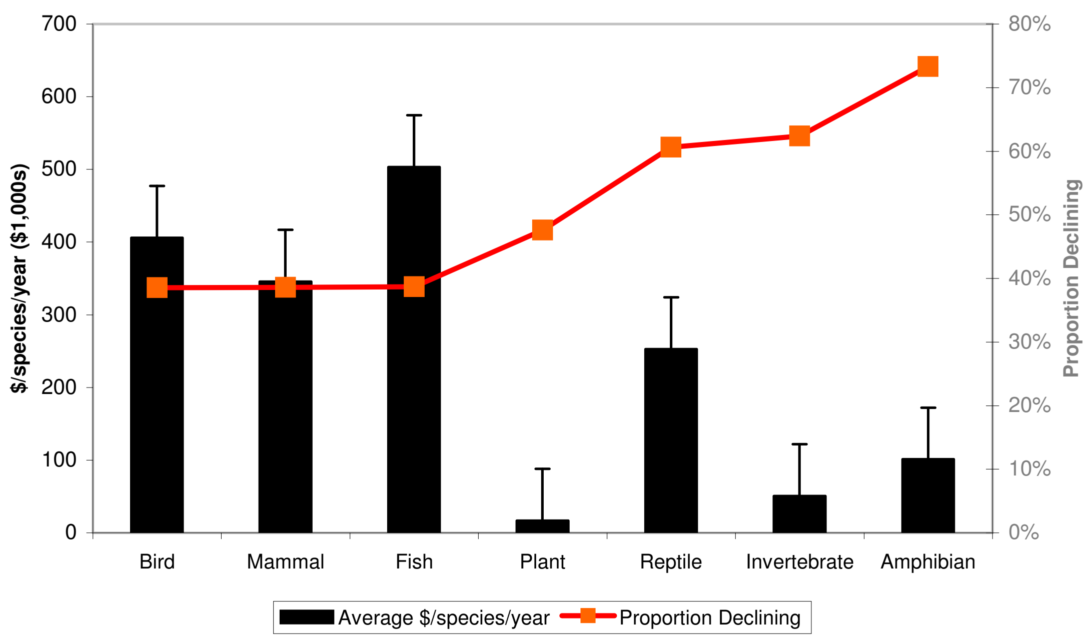

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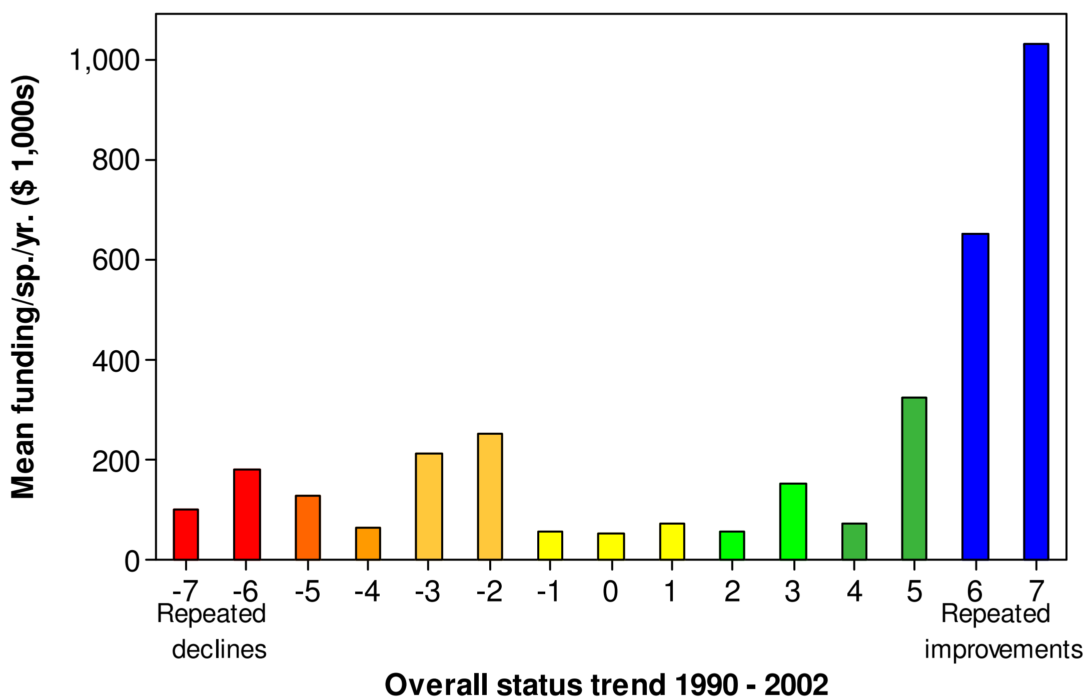

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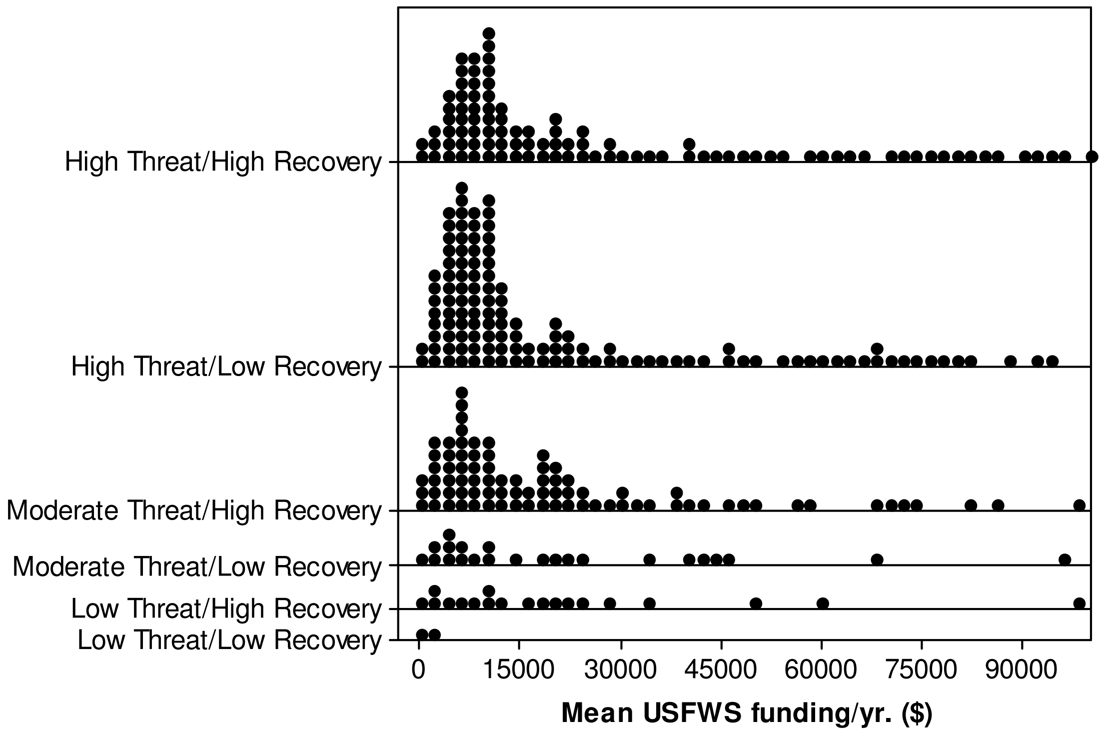

High Threat/High Recovery
High Threat/Low Recovery
Moderate Threat/High Recovery
Moderate Threat/Low Recovery
Low Threat/High Recovery
Low Threat/Low Recovery
0
15000
30000
45000
60000
75000
90000
Mean USFWS funding/yr. ($)