

The Effectiveness of the Endangered Species Act: A Quantitative Analysis

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Population trends for 1095 species listed as threatened and endangered under the Endangered Species Act were correlated with the length of time the species were listed and the presence or absence of critical habitat and recovery plans. Species with critical habitat for two or more years were more than twice as likely to have an improving population trend in the late 1990s, and less than half as likely to be declining in the early 1990s, as species without. Species with dedicated recovery plans for two or more years were significantly more likely to be improving and less likely to be declining than species without. The proportion of species improving increased, and the proportion declining decreased, with increasing time listed throughout the 1990s, irrespective of critical habitat and recovery plans. On the basis of these results, we recommend increased funding for earlier listing of imperiled species and prompt provision of critical habitat and recovery plans.

Keywords: biodiversity, population biology, endangered species, environmental policy

Critics of the US Endangered Species Act (ESA; 16 U.S.C. §§ 1531–1540 [1988]) argue that the recovery of only 13 of some 1300 endangered species is an indication of failure (Mann and Plummer 1995, Pombo 2004). Others contend this is a poor measure of success, because few species have been protected under the ESA long enough to reach full recovery (Doremus and Pagel 2001). The prevention of hundreds of extinctions (NRC 1995, Schwartz 1999) is an important accomplishment, but it does not indicate whether the ESA is effectively moving imperiled species toward recovery. As the ESA enters its 31st year, a comprehensive assessment of its role in species recovery is needed.

Data for such an analysis are available in biennial reports of the US Fish and Wildlife Service, or USFWS (1990, 1992, 1994, 1999, 2003, 2004a), and the National Marine Fisheries Service, or NMFS (1994, 1996, 2002). These reports score species as improving, stable, declining, or unknown for successive two-year periods. Previous studies used single reports to determine whether funding (Miller et al. 2002, Restani and Marzluff 2002), recovery plans (Schultz and Gerber 2002), critical habitat (Clark et al. 2002), and multiple factors (Rachlinski 1997) were correlated with recovery trends. However, these two-year “snapshots” may not reliably reflect long-term population trends.

In this article, we combine trend data to examine correlations with the length of time that species were listed, their critical habitat, recovery plans, kingdom (plant or animal), and listing status (endangered or threatened). In a related paper (Suckling and Taylor 2005), we review the statutory framework and present case studies to illustrate the mechanisms through which critical habitat designation affects species recovery.

The data from biennial reports were augmented and corrected to account for extinctions, delistings, and recovery. After correction, 1095 species were scored as declining, stable, or improving in at least one report. The data set is available from the authors on request. The agencies’ trend scores are imprecise and subjective (NRC 1995, IG/USDOJ 2003), but there is no reason to expect systematic, agency-wide bias. We assumed that the scores reflected actual population trends and that they were not influenced by knowledge of the presumed independent variables.

Preliminary analysis showed strong correlations between trends and the variables of interest in each biennial report; however, there were clear differences in the patterns of correlations between the early 1990s and later reports. Thus, we divided the data into an early period from 1990 to 1994 and a late period from 1997 to 2002, combining scores for these periods. We rejected conventional repeated-measures regression as a score-combining method, because a single unknown or missing score in any report removed a species from analysis. We also rejected simple score averaging, because it does not account for time directionality. For example, it gives the same trend score of “stable” to a species whose trend

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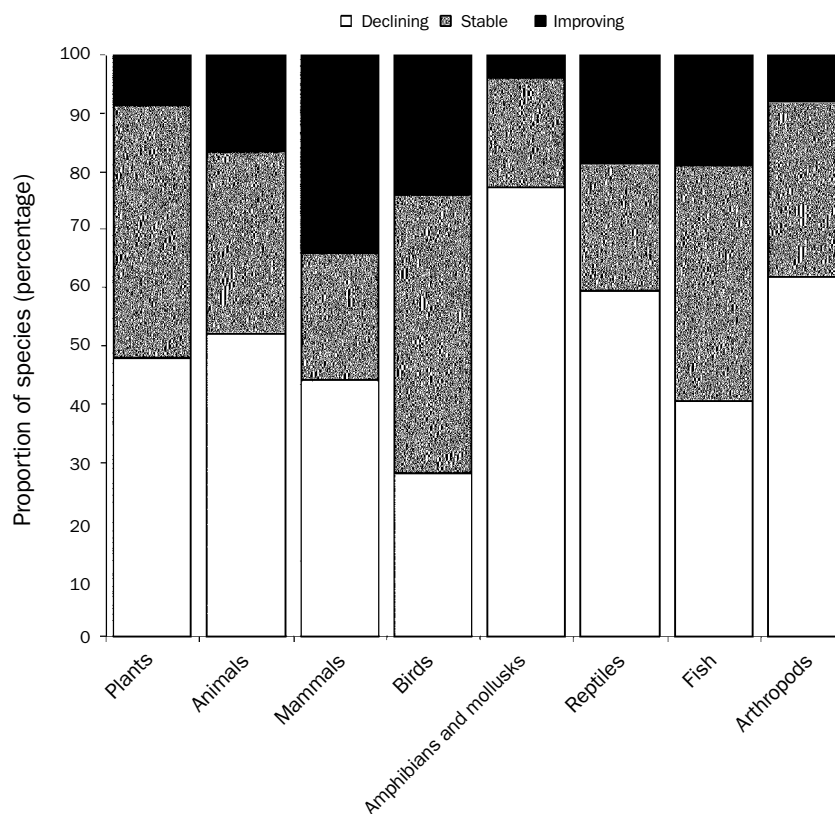


Figure 1. Proportions of species in major taxonomic groups that were declining, stable, or improving in the late period of this study (1997–2002).

changes from declining to stable to improving in successive biennial reports as to a species moving in the other direction. Thus, we used time-weighted score averages. Numerical scores of 1 for improving, 0 for stable, and –1 for declining were assigned to each species. We then multiplied the most recent score by 1.5, the middle score by 1.0, and the oldest score by 0.5. A final score of “improving,” “declining,” or “stable” was assigned to each species if the weighted average was, respectively, 0.5 or greater, –0.5 or less, or between –0.5 and 0.5.

To deal with confoundments among the main independent variables, we used partial z statistics in logistic regression (using Intercooled Stata 8.0 software) in a way similar to the use of partial F statistics by Rachlinski (1997). Because of the evident differences among trends for different groups of animals, higher taxonomic groups (as in figure 1) were used as a clustering variable, with robust standard errors.

Finding 1: Listing enhances recovery over time

Listing under the ESA provides species with an array of regulatory and nonregulatory benefits, including recovery plans, protection from unauthorized take, protection of critical habitat, scientific research, captive breeding, public education, and habitat restoration and acquisition. The longer species were listed, the more likely they were to be improving and the less likely to be declining (figure 2), suggesting that ESA conservation measures act cumulatively over time. This correla-

tion included any beneficial effect due to recovery plans and critical habitat, which were also more likely to be present for species listed for a longer time. We used logistic regression to ascertain how much of this effect was due to these distinct protections.

Finding 2: Critical habitat promotes species survival and recovery

With limited exceptions, the ESA requires that critical habitat be designated for all listed species, encompassing all lands and waters “essential to the conservation of the species” (sec. 3[5][A]). “Conservation” is defined as all actions necessary to fully recover and delist species (sec. 3[3]). Federal agencies are prohibited from authorizing, funding, or carrying out actions that are likely to “destroy or adversely modify” critical habitats (sec. 7[a][2]). This prohibition also applies to state or private actions that require federal permits, such as Clean Water Act permits for significant development, mining, logging, or cattle operations and the approval of habitat conservation plans by the USFWS and NMFS.

In 1986, the Reagan administration promulgated regulations that defined “destruction or adverse modification” as an action that “appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species” (Endangered and Threatened Wildlife and Plants: Interagency Cooperation, 50 C.F.R. part 402 [1986]). This defini-

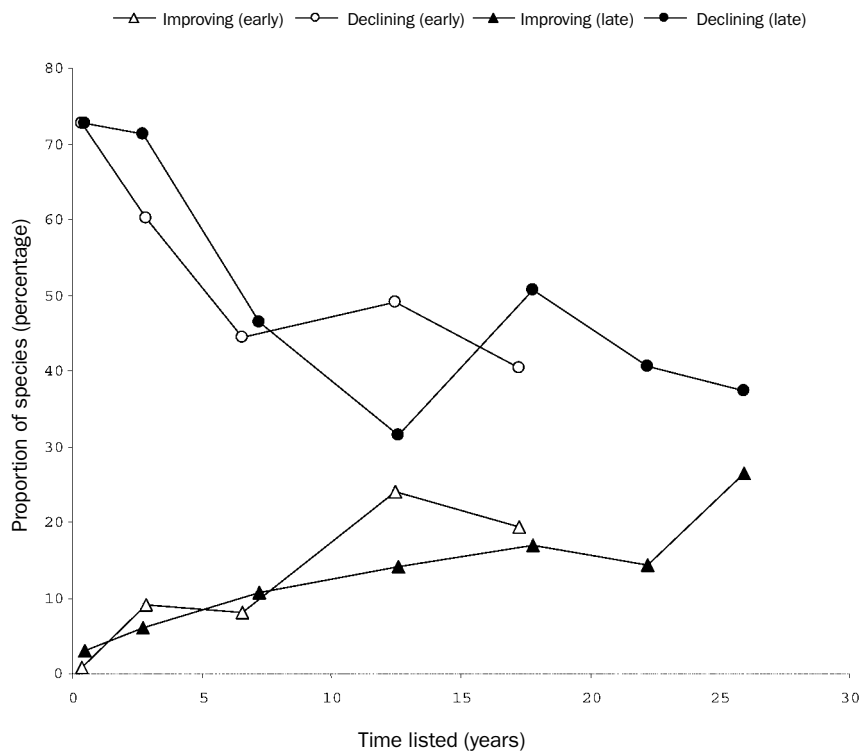


Figure 2. Proportions of species that were declining or improving in the early (1990–1994) and late (1997–2002) periods of this study, in five-year intervals of time listed. Time listed was calculated from the effective date of final or emergency rule to the date of mid-period for extant species listed under the Endangered Species Act, the date of delisting rule for recovered species, or the estimated date of extinction.

tion has been controversial because it permits actions that reduce the potential for recovery as long as they do not also threaten a species' survival. On the basis of this definition, the US Department of the Interior asserts that critical habitat designation is redundant and unnecessary, as other aspects of the ESA more broadly prohibit jeopardizing the survival of a species (USDOI 2003). The USFWS dramatically reduced the number of new critical habitat designations immediately after the regulations were issued (Suckling and Taylor 2005).

In recent years, the 1986 regulations have been invalidated by numerous court rulings affirming that critical habitats must be managed to promote recovery, and not merely to avoid extinction (e.g., *Conservation Council for Hawai'i et al. v. Bruce Babbitt et al.*, Civ. No. 97-00098 ACK [1998], *Sierra Club v. US Fish and Wildlife Service and National Marine Fisheries Service*, Civ. No. 00-30117 [2001], *Gifford Pinchot Task Force et al. v. United States Fish and Wildlife Service*, Civ. No. 03-35279 [2004]). In practice, land managers have often given significant protection to critical habitats despite official policy, as, for example, when the US Department of Energy established a preserve around critical habitat for *Amsinckia grandiflora*; when the USDA Forest Service moved trails away from, and prohibited recreation within, critical habitat for *Potentilla robbinsiana*; when the Forest Service

removed domestic sheep from critical habitat for peninsular bighorn sheep; and when the Bureau of Land Management prohibited mining within critical habitat for *Astragalus yoder-williamsii* (Suckling and Taylor 2005). The courts and USFWS biologists have also focused management decisions around critical habitat; for example, the USFWS required the Bureau of Land Management to remove sheep from critical habitat for the desert tortoise, and federal judges ordered cessation of livestock grazing in critical habitat for the palila, of ground-fish trawling in critical habitat for Steller's sea lion, and of lobster fishing in critical habitat for the monk seal (Suckling and Taylor 2005).

Species with critical habitat for two or more years appeared to be more likely to be improving and less likely to be declining than species without (figure 3). After using logistic regression to correct for the confounding effects of time listed and recovery plans, we found that species with critical habitat for two or more years were less than half as likely to be declining (i.e., more likely to be stable or improving) in the early period, and more than twice as likely to be improving in the late period, as species without such critical habitat (table 1).

These results suggest that critical habitat assists species recovery, independent of the length of time listed and the pres-

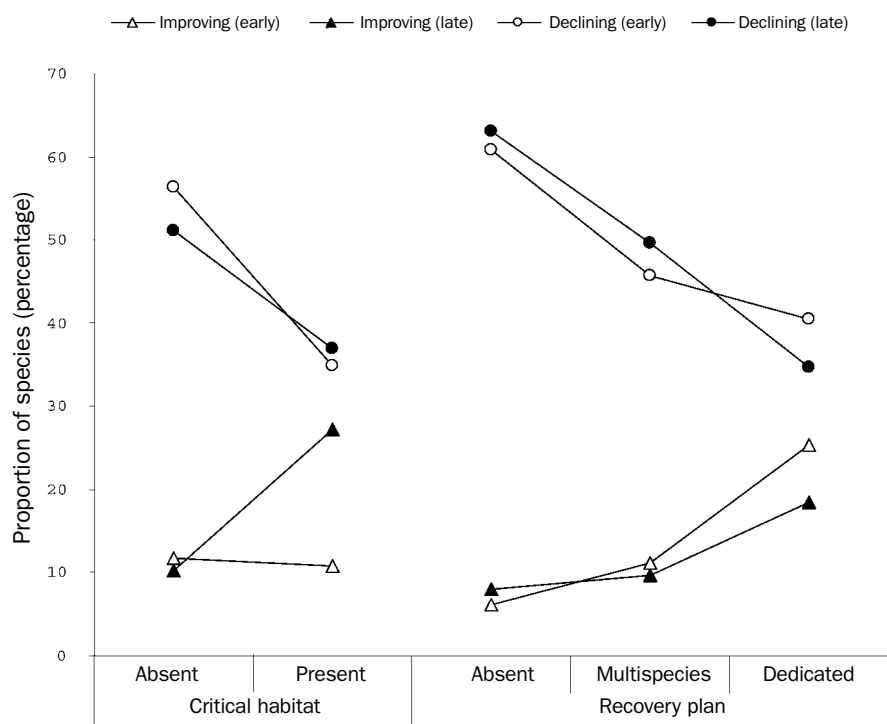


Figure 3. Proportions of species that were improving or declining in the early (1990–1994) and late (1997–2002) periods of this study, with and without designated critical habitat and with and without multispecies or dedicated recovery plans under the Endangered Species Act. Critical habitat or recovery plans were considered absent unless present for two or more years at the mid-period date.

ence of recovery plans. Rachlinski (1997) also found that species with critical habitat were 11 percent less likely to be declining and 14 percent more likely to be stable in the 1994 USFWS report. However, Rachlinski (1997) excluded 96 species (mollusks and species delisted or recovered before 1994), and thus the analyses are not entirely comparable. Another analysis of a small subset of data from the 1996 USFWS report showed a similar but statistically nonsignificant correlation, most likely due to small sample size and lack of control for confounding variables (Clark et al. 2002).

The uneven rates of creation of critical habitats over time may have precluded the detection of negative correlations between critical habitat and declining trends in the late period. Critical habitat appeared to act primarily on a single cohort of species in both periods, moving them from declining to stable status in the early period and from stable to improving in the late period (table 1). However, few critical habitats were designated from 1986 until the late 1990s (Suckling and Taylor 2005), and so any cohort of declining species that entered the late period with recently designated critical habitat was probably too small to allow the detection of a negative correlation between critical habitat and declining trend in the late period.

We also considered that the observed correlation might be confounded by the effects of conservation actions unrelated

to habitat protection, such as controls on hunting and disease. Accordingly, we reestimated regressions, including only species that were known to be habitat limited. We obtained data from Wilcove and colleagues (1998), Clark and colleagues (2002), and Miller and colleagues (2002) enabling 985 species to be classified as habitat limited or not. As these studies were biased toward species with recovery plans, we balanced the data by adding 77 species chosen at random from among species lacking recovery plans, which we could classify as habitat limited or not on the basis of their listing rules. Logistic regressions in which critical habitat was a significant factor were repeated on this habitat-limited subset of species, and critical habitat was found to remain highly significant as a factor (table 1).

Finding 3: Dedicated recovery plans assist species recovery

With limited exceptions, the ESA requires the development of recovery plans for all listed species (sec. 4[f][1]). Recovery plans recommend site-specific recovery actions, time frames for accomplishment, and criteria for judging whether recovery has been achieved.

As of 1 September 2004, 83 percent of the species listed by the USFWS and 32 percent of those listed by the NMFS had recovery plans (Suckling and Taylor 2005). Implementation

Table 1. Influence of the Endangered Species Act (ESA) on the improving or declining population trends of species: estimated odds ratios (with 95 percent confidence limits) and significance tests for logistic regressions of improving and declining trends on independent variables in the early (1990–1994; N = 666) and late (1997–2002; N = 1013) periods of this study.

Independent variable	Odds ratios (range) and significance tests for logistic regressions of trends			
	Species status improving in early period	Species status declining in early period	Species status improving in late period	Species status declining in late period
Time listed under ESA (decades)	2.69 (1.43–5.07); P = 0.002*	2.35 (1.37–4.03); P = 0.002**	1.60 (1.15–2.22); P = 0.005**	1.62 (1.20–2.19); P = 0.002,** quadratic P = 0.025**a
Designation of critical habitat: all species (1 if designated for at least two years by mid-period, 0 if not)	Not significant; P = 0.435	2.09 (1.15–3.79); P = 0.015*	2.25 (1.49–3.40); P < 0.001***	Not significant; P = 0.493
Designation of critical habitat: habitat-limited species only (1 if designated for at least two years by mid-period, 0 if not) ^b	Not estimated	2.05 (1.06–3.93); P = 0.031*	2.19 (1.43–3.38); P < 0.001***	Not estimated
Dedicated recovery plan (1 if single-species plan exists for at least two years by mid-period, 0 if not)	2.66 (1.19–5.95); P = 0.017*	1.20 (1.03–1.40); P = 0.022*	1.49 (1.17–1.91); P = 0.001***	1.60 (1.22–2.10); P = 0.001***
Kingdom (0 if plant, 1 if animal)	0.51 (0.20–1.30); P = 0.157 ^c	0.55 (0.31–0.98); P = 0.043* ^c	Not significant; P = 0.378	0.55 (0.28–1.07); P = 0.076+ ^c
Listing status (0 if endangered, 1 if threatened)	1.67 (1.16–2.40); P = 0.006**	1.92 (0.92–4.02); P = 0.083+ ^c	Not significant; P = 0.818	1.54 (0.95–2.50); P = 0.079+ ^c
Percentage correctly classified	88.3	62.3	88.0	63.2
Hosmer-Lemeshow goodness of fit	P = 0.720	P = 0.160	P = 0.424	P = 0.694

Note: For improving net trend, species were scored 1 if improving, 0 if otherwise; for declining net trend, species were scored 0 if declining, 1 otherwise. Significance tests are for partial regressions. The presence or absence of multispecies recovery plans was not significant in any regression, at $P > 0.2$, and so is omitted.

a. Model with orthogonal quadratic time-listed variable was found to substantially lower the Bayesian information criterion (BIC).

b. N = 589 for early period; N = 870 for late period.

c. Marginally significant terms were retained in final models, as these models minimized the BIC compared with full models or models excluding these terms. However, such models also had poor fit. The goodness-of-fit statistics are for models excluding these marginally significant variables.

of recovery plans has been poor, however, with only 2 percent of USFWS-administered species having achieved more than 75 percent of their recovery objectives (USFWS 2004b). In addition, the plans have been criticized as vague, unlikely to abate threats, and lacking in biological rigor (Schemske et al. 1994, Tear et al. 1995, Clark et al. 2002, Lawler et al. 2002, Schultz and Gerber 2002, Stinchcombe et al. 2002). The criteria for determining whether species have recovered are often set too low (Tear et al. 1993, Foin et al. 1998, Doremus and Pagel 2001). For many vertebrates, even the complete implementation of plans may not result in biological recovery (Tear et al. 1995). Nonetheless, a positive correlation has been found between expenditures, as a percentage of funding recommended in recovery plans, and positive population trends (Miller et al. 2002). Thus, the lack of implementation may be a more significant problem than the quality of the recovery plans. We also note that the development of recovery plans has become more rigorous in recent years (Gerber and Hatch 2002, Hoekstra et al. 2002).

Boersma and colleagues (2001) found that species with multispecies plans are more likely to be declining than species with dedicated plans. On the basis of these findings, we expected species with dedicated plans to be strongly associated with improving trends, and those associated with multispecies plans to be less so.

Species with recovery plans for two or more years appeared to be more likely to be improving and less likely to be declining than species without such plans. Species with dedicated or single-species plans appeared to fare better than those with multispecies plans (figure 3). Using logistic regression to correct for the confounding effects of length of time listed and the presence of critical habitat, we found that species with dedicated recovery plans for two or more years were significantly more likely to be improving, and significantly less likely to be declining, in both early and late periods than species without such recovery plans (table 1). Our results are consistent with Rachlinski's (1997) finding that recovery plans are positively associated with improving trend in the 1994 USFWS report.

Finding 4: Multispecies recovery plans are less effective

Despite the many documented weaknesses of recovery plans, our results suggest that dedicated recovery plans have had a significant and consistent benefit for species recovery. However, there were no significant correlations between multispecies plans and population trends in either early or late periods. This does not mean that multispecies plans were ineffective, only that we failed to detect a correlation. The results are consistent with those of other studies finding relatively poor performance of multispecies plans—a matter of concern, since multispecies plans are becoming more common. Of plans developed since 2000, 73 percent were multispecies plans, compared with 55 percent of the plans developed in previous years. The reason for the lesser effectiveness of multispecies plans is unclear, but it has been attributed to a lack of management focus and consequent lack of sufficient attention to each species' needs (Clark and Harvey 2002).

Finding 5: Listing and regulation of take assist in species recovery

Critical habitat and recovery plans are central aspects of the ESA, but the law includes other significant regulations and conservation incentives. The most important of these is the protection of individuals from harm and species from extinction. Individual animals are protected from unregulated take (i.e., killing, harming, or harassing) by federal, state, and private parties (ESA sec. 9[a][1]). Habitat loss can be regulated as take, but only if it is likely to harm individual animals (*Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 515 U.S. 687, 707–709 [1995]). The destruction of unoccupied habitat does not constitute take, even if the area is important for recovery, because the absence of individuals precludes their being harmed (*New Mexico Cattle Growers Association v. United States Fish and Wildlife Service*, 248 F.3d 1277 [2001]).

Plants are also protected from harm, but to a lesser degree than animals, especially on nonfederal land (ESA sec. 9[a][2]). State and private parties are permitted to take animals as long as “the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild” (sec. 10[a][2][B][iv]).

Take by federal agencies is permitted as long as it does not “jeopardize” the existence of a listed species (sec. 7[a][2]). “Jeopardize” was defined by the Reagan administration in 1986 to mean “reduce appreciably the likelihood of both the survival and recovery of a listed species,” such that “injury to recovery alone would not warrant the issuance of a ‘jeopardy’ biological opinion” (Endangered and Threatened Wildlife and Plants: Interagency Cooperation, 50 C.F.R. pt. 402 [1986]). As discussed above, these regulations allowed continued population declines, and reduction of recovery potential, as long as species' survival was not placed at risk.

Using logistic regression, we estimated the accumulative effects of ESA listing that flow from actions other than critical habitat and recovery plans. In logistic regressions for

improving and declining trends, the partial regression coefficients for time listed were highly significant (table 1). In the early period, the likelihood of species improving more than doubled with each decade that they were listed, while the likelihood of species declining more than halved. These results are consistent with Rachlinski's (1997) finding, based on the 1994 USFWS biennial report, that species that were listed longer were more likely to be improving and less likely to be declining.

Rates of improvement, as indicated by odds ratios per decade listed, were lower in the late period (table 1). The proportion of species declining appeared to level off after 10 years in the late period (figure 1; USFWS 2003). To test for a non-linear effect, we included an orthogonal quadratic term for “time listed” in the regression model for declining trend in the late period. The quadratic term was significant and negative (table 1), confirming that the proportion of species declining approached a plateau with increasing time listed. Perhaps rapid early progress in addressing threats to species was followed by slower progress due to more intractable threats. Unfortunately, no specific data are available with which to test this hypothesis.

Finding 6: ESA protections do not favor animals over plants

Because of their differing levels of regulatory protection, we expected animals to have stronger recovery trends than plants. Animals appeared to be more likely than plants to be improving, but they were also more likely to be declining in the late period (figure 1). This pattern was confounded with other variables, as animals were more likely than plants to be listed for longer periods of time and to have critical habitat and recovery plans.

Correcting for confounding variables through logistic regression, we found that plants were less likely to be declining than animals in both periods (table 1). The differences were not highly significant, however. Thus, the expectation that differences in levels of legal protection would result in poorer recovery trends was not supported by the data. It is possible that the relative simplicity of managing imperiled plants compensated for the lower level of legal protection they receive.

Although we developed no predictions concerning differences in trends among animals, it was clear that they were far from homogeneous. A strikingly higher proportion of amphibians and mollusks were declining, and a lower proportion improving, than of other animals (figure 1).

Finding 7: Endangered species show less recovery than threatened species

Endangered species were significantly less likely to be improving than threatened species in early reports. They were also more likely to be declining in both early and late reports, although these differences were not highly significant (table 1). A higher proportion of endangered species than of threatened species had recovery plans (84 percent and 70 percent, respectively), but the proportion of endangered species with

critical habitat (36 percent) was much the same as for threatened species (35 percent). In light of the evidence that critical habitat may assist recovery, making critical habitat a higher priority for endangered species could to some extent compensate for the poorer recovery record of endangered species relative to threatened species.

The role of expenditures

Levels of conservation expenditure are known to be correlated in a complex manner with population trends of listed species (Restani and Marzluff 2001, 2002, Miller et al. 2002). However, expenditure was not examined as an independent variable in this study, mainly because expenditure is only a proxy measure for the conservation actions to which expenditure is directed (primarily those already included in our analysis: listing and regulation of take, critical habitat, and recovery plans). Tracking of expenditures is also incomplete, inconsistent, and not always uniquely assigned to individual species and conservation programs (USFWS 2000, Hoekstra et al. 2002, IG/USDOI 2003). Data that comprehensively identify expenditures by all federal, state, and private parties, separated by species and by program, were not available.

Conclusions

Our findings suggest that the ESA is effective and can be improved by prompt listing, protection of critical habitat, and dedicated recovery plans. Although few threatened and endangered species have fully recovered, the short time most have been protected (15.5 years on average) renders this a weak test of the effectiveness of the Endangered Species Act. A better measure is the extent to which the provisions of the ESA are moving species toward recovery.

Our analysis of USFWS and NMFS biennial reports indicates that the longer a species is listed and subject to the regulation of take, the more likely it is to be improving and the less likely to be declining, irrespective of recovery plans and critical habitat. This suggests that imperiled species should be listed under the ESA as soon as possible. Unfortunately, the ESA listing program has been chronically underfunded, and undermined by opposition to the listing of economically controversial species (Sidle 1998, Greenwald et al. 2005). The annual listing rate has declined steadily since 1994 and is currently at the lowest level in the history of the ESA (Norris 2004, Greenwald et al. 2005). Listing delays are likely to contribute to low population sizes at time of listing, which in turn slow the rate of recovery and make it more expensive (Wilcove et al. 1993).

Critical habitat was strongly negatively associated with declining trends in the early period and positively associated with improving trends in the late period, suggesting that it has been effective in assisting species recovery, despite administrative barriers. Nonetheless, critical habitat was rarely designated after 1986 and is still resisted by the Department of the Interior (Suckling and Taylor 2005). Recent court orders have resulted in the designation of more than 350 new critical habitats (Suckling and Taylor 2005). Our results suggest

that if this progress continues, the proportion of species with recovering trends will increase significantly.

Dedicated recovery plans were strongly associated with greater survival and recovery of listed species in both periods. Although progress was made in the 1990s toward reducing the backlog of recovery plans, the rate of plan development slowed significantly after 2000 (Suckling and Taylor 2005). Our results indicate that if all listed species were given recovery plans, the proportion recovering would be significantly higher. Our results also confirm other studies that suggest single-species recovery plans perform better than multispecies plans. Wildlife agencies should reconsider the growing emphasis on multispecies plans, or at least take care to ensure that multispecies plans include the same level of attention to the needs of single species as is found in dedicated plans.

Development and implementation of recovery plans, protection of critical habitat, listing, and regulation of take require substantial federal funding. The USFWS estimates that \$153 million is needed to complete work on the existing backlog of listings and critical habitat designations (Whitfield 2003). We recommend that this program be fully funded. We also endorse the recommendation of Miller and colleagues (2002), that the recovery program budget be increased by \$300 million.

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