Success or Failure? Ordered Probit Approaches to Measuring the Effectiveness of the Endangered Species Act

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ABSTRACT

The Endangered Species Act (ESA) is one of the most controversial pieces of environmental legislation. Part of the controversy stems from doubts about its effectiveness in generating improvements in species viability. This paper uses ordered probit models to test whether the ESA has been successful in promoting species recovery. We find that listing has a positive effect on species recovery. Additionally, we find evidence of positive effects for species-specific spending and the achievement of recovery goals. The evidence also shows that recovery plan completion and the designation of critical habit have had no effect on recovery.

Keywords: Endangered Species Act, ordered probit, species recovery.

I. INTRODUCTION

The Endangered Species Act (ESA) is one of the strongest pieces of environmental legislation in the U.S. [34, 37] and potentially one of the most costly. Smith *et al*. [37] and Bean [5] report a $4.6 billion estimate of the cost of implementing the ESA for all listed species. If private costs and the costs of foregone economic projects were added, the cost would undoubtedly be much higher.

The ESA is also extremely controversial[1]. The controversy centers on four issues. First, some natural scientists argue that the ESA's focus on species, rather than ecosystems, may be misdirected and may render the act ineffective [34, 37, 16, 27]. Second, the ESA may target species after it is too late to implement recovery [37, 34]. Third, others have argued that the ESA is flawed in its implementation. US Fish and Wildlife Service (FWS) actions may be politically motivated [1, 37], subject to ham-stringing bureaucratic and congressional directives [36] or pressure from public interest groups [36, 37], too focused on charismatic mega fauna [36, 37, 25, 26], or improperly constrained by consideration of the economic impacts of protective actions [34, 37, 36]. Fourth, the ESA is criticized for placing an inordinate share of the cost of species protection on private landowners and developers. Taken to its extreme, this argument suggests that the ESA is counterproductive to species recovery, as it generates perverse incentives that induce landowners to manage their land in a way that harms the species (see, e.g., [37], [22], [31], [18], [17], [30], and [21]).

Taken together, a substantive share of the criticisms of the ESA can be encapsulated as expressions of doubt about its effectiveness in preventing extinctions or generating improvements in species viability. In short, its critics argue that an ESA which is biologically misdirected, administered poorly or in a politically motivated fashion, or causes landowners to take substantive actions deleterious to species recovery is less likely to be effective in achieving its stated goal of providing a framework for the conservation of endangered and threatened species [22].

Not surprisingly, these criticisms have translated into disagreements regarding ESA funding (see, e.g., [4], and [5]). Those who consider it unsuccessful argue for less funding, while its proponents claim that it requires additional funds to be more effective.[2] The existing data on species recovery and federal expenditures on endangered species does not, at first glance, clarify the picture. Table I shows the ten species that received the highest percentage of federal and state spending between 1989 and 1996 and the changes in population status between 1990 and 1996, as reported by the FWS[3]. While these ten species represent 1.04 percent of all listed species in 1996, they are the object of a third of total spending, about $558 million. From Table I it is not clear that higher spending implies stronger recovery. Only the red cockaded woodpecker (*Picoides borealis*) was doing noticeably better, while the status of most of the species shown had not changed.

Table II tells the same story from a different viewpoint. Table II lists the six species showing the greatest improvement in recovery between 1990 and 1996, as measured by a recovery score discussed below, and the corresponding percentage of total expenditures between 1989 and 1996. It is not clear from Table II that recovery requires higher spending. The much-recovered red cockaded woodpecker received eight percent of total spending, or $128 million. On the other hand, the White River spinedace (*Lepidomeda albivallis*) and duskytail darter (*Etheostoma catonotus*) show equivalent changes in recovery, but received almost no funding.

Comparisons based on Tables I and II are, of course, incomplete. They do not simultaneously account for other actions triggered by an ESA listing. Nor do they account for relevant biological factors or the length of time the species has been under ESA protection. Many prior empirical studies of the ESA's effectiveness are similarly incomplete, focusing as they do on simple correlation analysis [33, 13, 6].

The purpose of this paper is to econometrically examine the ESA's record of success in promoting species protection, in a fashion that simultaneously accounts for many factors likely to affect recovery. Specifically, we develop two naturally ordered measures of ESA success related to changes in species' status, and then attempt to statistically explain these measures. The first measure is applied to all species in the Nature Conservancy's (NC) list of endangered species [39]. In section II we empirically measure the effect on changes in species viability of an ESA listing as a threatened or endangered species. We find statistical evidence of a positive effect on the probability of species' stability or improvement and a negative effect on deterioration in status. In section III, we consider a model of Fish and Wildlife Service (FWS) resource allocation decisions to implement the ESA, incorporating possible inefficiencies. The model motivates a statistical examination of the effects of FWS actions on changes in species' status. Although biologically these actions can be expected to matter, the model suggests their incremental effects might be zero. In section IV, we estimate an ordered probit model of changes in species viability. We find evidence of significant positive effects for species-specific spending and the achievement of recovery goals. The evidence also supports the null hypotheses that recovery plan completion and the designation of critical habit have no effect on changes in viability. Results are discussed in section V, and section VI concludes.

II. THE EFFECT OF LISTING ON RECOVERY

The ESA management process begins with a species listing decision. Any individual or organization can propose a species as a candidate for listing. If the FWS is able to collect enough data and judges that the species merits protection, it places a proposal in the Federal Register and, after allowing for public comments, makes a final decision. The species is listed as "endangered" if it is "in danger of extinction throughout all or a significant portion of its range". It is listed as "threatened" if it is "likely to become endangered in the foreseeable future" [48]. Several taxonomic units, including species, subspecies, and populations, are eligible for listing.

In this section we analyze the effect of an ESA listing on changes in recovery status. We consider the recovery of all threatened vertebrates according to the NC's ranking system [39]. This system ranks every vertebrate in the US according to its level of endangerment. We concentrate on five NC rankings: 1 (critically imperiled), 2 (imperiled), 3 (vulnerable), 4 (apparently secure), and 5 (demonstrably secure).[4] We have data for 1993 and 1996.

For each species, we determined whether the NC ranking had increased, remained the same, or decreased between 1993 and 1996. Based on this, we created three categories: if the ranking increased (i.e. the species was *more* endangered in 1996 than in 1993) the species received a “score” of 0; if there was no change, we assigned a “score” of 1; and if the ranking decreased (i.e. the species became less endangered), we assigned a “score” of 2. We use these naturally ordered “scores” as the dependent variable (RSCORE1) in an ordered probit analysis.

To test whether ESA listing has affected changes in NC rank, we include the independent variable, LISTED, an indicator variable equal to unity if the species had been listed by 1996, and 0 otherwise. We also control for biological characteristics of the species having an influence on their recovery. The conservation biology literature tells us that extinction is, particularly in the case of small populations, somewhat random [35, 14, 9].[5] However, the likelihood of extinction probably depends on population size [35, 15, 29, 28], longevity [29, 28], population growth rate, and the variability of growth rate and density [15, 29, 28]. Complete data on most of these variables is not obtainable for all the vertebrates in the US. However, longevity and growth rate are highly correlated with body size, which is readily available [10], although the nature of the relationship between these variables remains controversial. Specifically, Pimm *et al.* [29] and Pimm [28] argue (and verify empirically for certain birds) that, for small bodied species, extinction is more likely at low population densities. Tracy and George [40], on the other hand, argue that this contention is not supported by the data when environmental interactions are taken into account. Bennet and Owens [8] find that, among birds, extinction risk is not distributed randomly with respect to body size. However, they caution that the relationship between body size and environmental variables that affect extinction is not well understood. Johst and Brandl [19] include other species (in addition to birds) in a simulation model and find what seems to be a unifying result: the relationship between extinction and body size in their model is U-shaped. Given the persistent disagreements on this topic, we rely on this last result and include body length (BODYL) and its square (BODYLSQ) as explanatory variables.

Finally, we use the NC endangerment ranking (NRANK96) as a proxy for population size, since the NC's ranking is based on the number of occurrences or number of individuals of a species. Because the data are unavailable, we are unable to include a measures of growth rate or density.

Given the ordinal nature of the dependent variable, we estimated the model using an ordered probit. The results are in Table III.[6] The results show that listing does have a significant effect on species recovery. The LISTED coefficient is positive and statistically significant (a?.05). The coefficient for NRANK96 is statistically significant and the calculated marginal effects suggest population size positively affects the probability of a status improvement, and negatively affects the probability of no change and of status decline. The coefficient estimates for BODYL and BODYLSQ are both negative, but neither are statistically different from zero.

To better understand the effect of LISTED, we examine how the probabilities of the three possible scores change when LISTED takes its two different values (all other variables are held constant at their sample means). These marginal effects, appearing in Table IV, show that listing decreases the probability that a species experiences a change for the worse (RSCORE1=0) by nearly seven percent. Listing decreases the probability of no change in status (RSCORE=1) by nearly one percent, and increases the probability of improvement by nearly eight percent. However, listing is only the first step in the process of managing endangered species. We also wish to analyze the effect of other actions triggered by an ESA listing. We turn to this in the following sections.

III. SPECIES RECOVERY AND ALLOCATION OF RESOURCES

A. Management of endangered species under the ESA

Once listed, a species comes under several layers of protection and a prescription of administrative actions. The species is protected through restrictions on public and private activities that may harm it. Section 7 prohibits federal agencies from engaging in any action that harms a species directly, or results in the destruction or adverse modification of its habitat. Section 9 prohibits the "taking" of an endangered species by any person, private agency, or organization. This includes any direct harm to a species, as well as significant habitat degradation or modification.

Additionally, the ESA prescribes a number of management responsibilities aimed at speeding species recovery. One of these is the designation of critical habitat, which attempts to link recovery to the importance of habitat and ecosystem protection. Section 4 of the ESA originally required that critical habitat be designated for each species listed. Amendments enacted in 1982 require critical habitat designation only to the "maximum extent prudent and determinable". Furthermore, the amendments allow consideration of economic impact in the designation of critical habitat. Rohlf [34], Clark [11], Smith *et al*. [37], and others criticize the FWS for failure to designate sufficient acreage, or, in the majority of species, any acreage at all. Supporters of this controversial amendment contend that designation of critical habitat has a negative effect on the economy. Moreover, Belovsky *et al*. [7] contend that habitat loss is generally not decisive in species extinction when populations are already small. In 1996, 27% of listed vertebrates had critical habitat designated [52].

The preparation of a recovery plan by the FWS is also activity triggered by a listing.

Section 4 requires the FWS to develop recovery plans for listed species, unless such plans would "not promote the conservation of the species." Recovery plans identify management tasks and research needs, and identify measurable criteria for determining when recovery objectives have been attained. Some species do not have recovery plans, either because a state management plan is used instead or because the FWS considers the species probably extinct. In 1996, 79% of listed vertebrates had a recovery plan [52].

The FWS has been widely criticized for recovery plan procedures and results. Tear *et al*. [38] argue that most recovery plans fail to provide essential biological data for recovery decisions, including species abundance, demographics, and dynamics. Moreover, recovery plans are subject to lengthy delays [37] and plans frequently require five or more years for approval [38]. The plan for the Northern Rocky Mountain wolf was 14 years in preparation. Furthermore, recovery plans are not binding agreements and critics argue that they are not implemented in many cases [37]. Others argue that recovery plans sacrifice good biology for economic considerations or, alternatively, fail to address the political realities of species recovery [37].

It is important to distinguish between species recovery plans and recovery objectives. One can think of the elaboration of a recovery plan as more of a formal requirement, whereas recovery objectives are specific goals set for "on the ground" management of a species[7]. Furthermore, preparing a recovery plan is not a necessary condition for achieving recovery objectives. In 1996, the recovery plan for the least bell's vireo (*Vireo bellii pusillus*) was under development, but between half and three quarters of its recovery objectives had been achieved [52].

Finally, ESA listing makes a species eligible for spending of federal and state dollars on projects designed to promote recovery, such as habitat acquisition, censuses, mitigation, and scientific research. Such spending amounted to $348 million in 1995, an increase of over 800 percent since 1985 [4]. There is a widespread consensus that current spending levels are inadequate to achieve the ESA's stated goals [37, 22, 5]. However, the ESA's critics argue that funds are poorly spent and the goals are impossible to achieve. ESA supporters argue that additional spending would lead to improvements in species recovery. Simon *et al*. [36] find that species-specific spending is unrelated to FWS recovery rankings, but may reveal taxonomic biases. We are not aware of any studies directly testing the effectiveness of spending.

B. Models of FWS resource allocation

The FWS, working within a limited budget, must decide how to allocate the funding and management effort necessary to carry out the activities described in the preceding section. Consider a FWS with the goal of maximizing species' recoveries, but constrained by limited resources. FWS has two types of tools at its disposal for each species: 1) administrative effort devoted to the i^{th} species, E_i, and 2) spending on the i^{th} species, S_i. Denote the recovery function of the i^{th} species as $R_i(E_i,S_i;X_i)$, where X_i is a vector of other factors influencing recovery (e.g. body size). Assume that the partial derivatives of $R_i(\cdot)$ with respect to E_i and S_i are strictly positive. The FWS resource constraint is

$$B = B(E_1, S_1, E_2, S_2, ..., E_n, S_n) \quad ,$$

where n is the number of endangered and threatened species.

The FWS chooses E_i and S_i , i=1,2,….n, to solve

$$MAX \quad L = \sum_{i}^{n} R_i\,(E_i\,, S_i\,; X_i\,) + l\,(B - B(\cdot)) \quad ,$$

where ? is a Lagrangian multiplier. The first order conditions are:

$$\begin{aligned}
&\frac{\partial R_i}{\partial E_i} - l\,\frac{\partial B}{\partial E_i} = 0 \\
&\frac{\partial R_i}{\partial S_i} - l\,\frac{\partial B}{\partial S_i} = 0 \\
&B - B(\cdot) = 0 \qquad i = 1,....n.
\end{aligned} \tag{1}$$

Optimally, the marginal product of E_i per unit of resource cost is equal to the shadow value of resources, λ. Similarly for S_i. The efficient FWS will operate on the $R_i(E_i,S_i;X_i)$ frontier at the point where

$$\frac{\partial R_i / \partial E_i}{\partial R_i / \partial S_i} = \frac{\partial B / \partial E_i}{\partial B / \partial S_i} \quad , \tag{2}$$

or where the marginal rate of technical substitution between administrative effort and direct spending is equal to the ratio of rates at which E_i and S_i draw down the resource constraint. This (assumed) interior solution implies optimal levels of E_i and $S_{i,}$ with strictly positive marginal products in recovery.

Now consider the FWS in realistic terms, under legislative and bureaucratic pressures and buffeted by political winds. A good deal of pressure pertains to performing certain administrative efforts, including writing recovery plans and designating critical habitat. Both of these efforts are, at some level, likely to contribute to species recovery. However, when the FWS is prompted to perform them at too high a level, their marginal products can be reduced.

To capture the effect of this on FWS resource allocations, assume that the FWS obtains direct utility from administrative efforts, because, for example, such effort satisfy procedural mandates. Assume that spending does not provide direct utility. The FWS chooses E_i and S_i to solve

$$MAX\ L = \sum_{i}^{n} R_i(E_i, S_i; X_i) + U(E_1, E_2, ..., E_n) + l\,(B - B(\cdot)) \quad ,$$

where we have assumed an additive objective function because this is enough to make our point. The first order conditions are

$$\begin{aligned} &\frac{\partial R_i}{\partial E_i} + \frac{\partial U}{\partial E_i} - l\,\frac{\partial B}{\partial E_i} = 0 \\ &\frac{\partial R_i}{\partial S_i} - l\,\frac{\partial B}{\partial S_i} = 0 \\ &B - B(\cdot) = 0 \qquad i = 1,....n. \end{aligned} \tag{3}$$

For E_i, the first order condition equates its marginal product in recovery plus the direct marginal utility of effort per unit of resource cost to the shadow value of resources. Compared to equations (1), equations (3) imply larger E_i with smaller marginal product and smaller S_i with larger marginal product. The FWS operates at an inefficient point on the $R_i(E_i,S_i;X_i)$ frontier. From equations (3), we have

$$\frac{\partial R_i / \partial E_i}{\partial R_i / \partial S_i} = \frac{\partial B / \partial E_i}{\partial B / \partial S_i} - \frac{\partial U}{\partial E_i} \quad . \tag{4}$$

In the constrained equilibrium, the marginal rate of technical substitution between E_i and S_i is not equal to the ratio of rates at which E_i and S_i draw down on resources. Instead, the direct utility from effort induces more than the efficient level of E_i and less than the efficient level of S_i. Even with a zero marginal product for recovery, we could still observe positive E_i, because it provides direct utility, irrespective of its contribution to recovery.

IV. THE EFFECTS OF SPENDING AND EFFORT ON RECOVERY

In this section we empirically explore the effectiveness of spending and management efforts in promoting species recovery. In its biannual report to Congress, the FWS assigns a status to each species [42, 45, 49, 52]. The status categories we use are Extinct (E), Unknown (U), Declining (D), Stable (S), Improving (I), and recovered (R)[8]. For each listed vertebrate, we determined the change in status between 1990, or the first year listed, and 1996. Of all the different possible changes of status, we found sixteen combinations that actually occurred in our data set. We assigned each of these a score, ranging from 0 to 15, where a higher score implies more improvement in species recovery. These scores have ordinal, but not cardinal, significance.

The order of our scores is based on the assumption of decreasing marginal returns to species recovery efforts. That is, it is more difficult for a species to move from, say, stable (S) to improving (I) than from declining (D) to stable (S). We also consider an improvement better than no change, no change better than a change for worse, and no change at a higher status better than no change at a lower status. We made an exception to this rule in the case of species whose status remained constant at extinct (E), which received a score of zero. Finally, we gave consideration to the unknown status (U). It is not clear if a change from U to another status is a change for better or worse. A change from U to E is clearly for the worse. However, a move from U to any other status could reflect a change in information available about the species, or a change in the actual status of the species**.** Since it is impossible to distinguish between these possibilities, we used the following procedure. Beginning with 1990, whenever we found a status of U, we moved on to the next year's reported status. If this status was not U, we used it as a starting point. If this status was U again, we moved on once more, and so on. In this way, the only status changes starting with U that received scores were those from U to E, and no change from U to U.

The resulting recovery scores are shown in Table V. This matrix shows all the possible changes in status. Those occurring in the data are shaded along with the recovery score we assigned (RSCORE2). RSCORE2 is our measure for success or failure in species recovery. We use this naturally ordered measure as the dependent variable in an ordered probit econometric model.[9] To illustrate RSCORE2, consider a few specific examples: the Eastern Cougar (*Felis concolor couguar*) remained in status E and received RSCORE2= 0; the Loggerhead Sea Turtle (*Caretta caretta*) moved from declining to unknown with RSCORE2=4; the Western Snowy Plover (*Charadrius alexandrinus nivosus*) moved from stable to declining and has RSCORE2=6; and the Northern Spotted Owl (*Strix occidentalis caurina*) remained in declining status and receives an RSCORE2= 9.

The number of listed species that received each score is shown in Table VI. This shows that RSCORE2 reflects the arguments of the ESA's critics and supporters. The majority of species (69.2 percent) showed no change in status, receiving RSCORE2 = 0,8,9,10, or 11. Critics point to this widespread stasis as evidence of ESA failure, others consider it evidence of success [22, 5]**.** Improvements in status (RSCORE2=12,13,14, or 15) are achieved by 13.5

percent of species, bolstering the arguments of ESA supporters. However, its critics could point to the deterioration in status (RSCORE2=1,2,3,4,5,6, or 7) by 16.9 percent of species. RSCORE2 thus provides a mixed picture of ESA performance. It also provides a means of empirically linking changes in species viability with specific actions taken under the ESA.

As argued in section III, we hypothesize that recovery is a function of money spent on species recovery, efforts exerted by the FWS, and characteristics of the species. Species-specific funding (TSPEND) is total federal and state expenditures directed toward the recovery of a species for the years 1989-1996 [41, 43, 44, 46, 47, 50, 51, 53]. TSPEND includes all expenditures that are "reasonably identifiable" for a specific species, such as habitat acquisition, scientific research, population censuses, etc. Expenditures that cannot be assigned to a specific species, such as habitat acquisition for various species, salaries, and, more significantly, opportunity costs of forgone development opportunities, are not included in the report. Further, private spending is not included. Thus, our measure of spending does not necessarily include all the money spent on each species. Nevertheless, our main concern is with the effect of public expenditures on species recovery, and TSPEND accurately reflects these expenditures.

In addition to spending, the FWS may undertake other activities following a species listing. The variable HABIT=1 if the FWS designated critical habitat for the species, HABIT = 0 otherwise. Recovery planning activity is measured as RPLAN = 0 if the species had no recovery plan in 1996, 1 if the plan was under development, 2 if there was a draft of the plan, 3 if there was a revision under development, 4 if there was a revision drafted, 5 if there was a revision approved, and 6 if the final plan was approved. As a final measure of effort, we include the percentage of recovery objectives met, since a higher fraction of achieved objectives reflects higher effort. The variable is defined as RECOB = 1 if 0-25 percent of recovery objectives were achieved as of 1996, 2 if 26-50 percent, 3 if 51-75 percent, and 4 if 76-100 percent.

As in the previous model, we include body length (BODYL) and its square (BODYLSQ), and the NC rank for 1996 (NRANK96) to control for species characteristics and population size likely to affect recovery.

Additionally, we control for two other factors that may have an effect on recovery. First, TIMEL is the number of years the species has been listed, conservatively rounding up to the next full year (TIMEL). For example, if a species was listed in June of 1970, we start counting from 1971. Second, we include a variable measuring the existence of conflict between recovery and economic development. Although listing decisions must be made without regard for economic factors, this is not the case for setting priorities for spending or designating critical habitat. The FWS is allowed to exclude areas from designation if the costs of designation exceed the economic benefits. In its report to Congress, the FWS specifies which species' conservation efforts are in conflict with development. The corresponding variable is CONF=1 if there was conflict as of 1996, 0 otherwise.

Once again, we used an ordered probit to estimate this model. The results are shown in Table VII.[10] The coefficients for TSPEND and RECOB are statistically significant, whereas those for HABIT, RPLAN, TIMEL, and CONF are not.[11] We discuss these results in the following section. Now we take a closer look at the marginal effects of TSPEND and RECOB.

The marginal effects of changes in independent variables in an ordered probit model are not easy to interpret. They are not equal to the coefficients, nor do their signs necessarily correspond to the coefficients'signs (see Long [20]). Specifically, a typical marginal effect for

TSPEND is the change in the probability of a species being in the ith category given a change in spending given by

$$\frac{\partial \Pr(RSCORE\,2 = i)}{\partial TSPEND} = [f(m_{i-1} - \hat{b}'x) - f(m_i - \hat{b}'x)]\hat{b}_1 \quad ,$$

where x is the vector of explanatory variables, $\hat{b}$ is the vector of estimated parameters, $\hat{b}_1$ is the estimated parameter for TSPEND, $f(\cdot)$ is the standard normal probability density function, μ_i is the threshold parameter estimate, and $i = 0,\ldots,15$ are the fifteen recovery scores. We calculated this for each RSCORE2, for each observation, and then found the mean. The results are reported in Table VIII.

The results in Table VIII show that a unit increase in spending on behalf of a species decreases the probability of recovery scores from 0 to 9, and increases the probability of recovery scores 10 to 15[12]. That is, referring to TABLE IV, more spending decreases the probability of deterioration in status and of no change in poor (U or D) statuses, and increases the probability of no change at higher (S or I) levels and improvements in status.

To obtain the marginal effects of achieving recovery objectives (RECOB), we computed the probability of each RSCORE2 for RECOB=1,2,3, and 4, with all other variables held at their means. We then calculated the changes in these probabilities between RECOB=1 and RECOB=4. The results are shown in Table IX.

Table IX shows that the achievement of recovery objectives has a pattern of marginal effects similar to those of spending. Increasing the percentage of recovery objectives achieved leads to lower probabilities that a species experiences a negative change in population status, or remains stable at a low status. Conversely, the probability that a species remains stable at a higher status or that its status improves increases.

V. DISCUSSION

The results presented in sections II and IV provide insight into the effects of the management choices made by the FWS. First, listing a threatened species increases its chances of recovery. Second, for listed species, more spending and achievement of recovery objectives increase the likelihood of improvements in recovery status, but recovery changes are not affected critical habitat designation and the degree of completion of recovery plans. These latter two results are somewhat unexpected, particularly in the case of critical habitat. Many content that habitat alteration is a major cause of endangerment [24, 6, 37], so one expects that habitat designation would help them to recover. To understand why our results show that it may not, it is important to keep in mind that we are analyzing *marginal* effects. That is, our results do not suggest that critical habitat designation does not matter in absolute terms, only that it has no effect at the margin. This could occur if sufficient resources have been directed to designating critical habitat so that *additional* designations no longer affect recovery. This management effort may have been pushed beyond its optimal point, perhaps for the reasons suggested in Section III. The same argument holds for the degree of completion of recovery plans.

Another possibility is that these management efforts do not have an effect on recovery because of the inadequacies discussed in Section III, i.e. designation of habitat may be constrained by economic considerations or ineffective when populations are small, and recovery plans may be biologically inadequate, politically naïve, and subject to excessively lengthy delays [37, 38].

Our results suggest a reallocation of FWS's management efforts may have beneficial effects on species recovery. In particular, shifting resources from critical habitat designation and preparation of recovery plans to listing of additional species and management activities that contribute to achievement of recovery objectives will improve species viability. This recommendation is particularly relevant in light of the large backlog of almost 250 candidate species under review for listing [2]. Concluding the listing process for these species could contribute more to recovery than additional designations of critical habitat for species that are already listed. Yet the FWS recently announced that it might temporarily suspend the listing process cope with the large number of suits filed by environmental groups, most of which would mandate critical habitat designation for currently listed species [12, 2].

Additionally, the finding of a positive marginal effect for spending indicates higher funding for FWS management of endangered species will increase species viability, if the funds are directed in a species-specific manner. Thus, this year's cut of $9.1 million in the endangered species program budget [3] could impair recovery.

Finally, our results show that the existence of conflict with development and the time a species has been listed do not have a significant effect on recovery. The result concerning economic conflict is not easy to interpret. One possible explanation is that the FWS is in fact heeding the ESA mandate that economic considerations should not affect decisions concerning the management of endangered species (with the exception of critical habitat designation).

As for the time a species has been listed, our result may imply that once we control for the effect of the original listing decision, spending, and management effort, merely being listed longer does not increase the likelihood of recovery. That is, a species that is listed longer may receive more spending and management effort over time. This, and not the passage of time *per se*, may contribute to recovery.

VI. CONCLUSIONS

This paper provides statistical evidence on the effectiveness of ESA listing and recovery activities on improving the probability of species recovery. Theoretically, preference- and political-based influences may lead to allocations in which some activities are pushed beyond the point where they are effective at the margin. Our analysis confirmed this for some management tools, but not others. Specifically, we find that listing, spending, and achievement of recovery objectives have positive and significant effects on recovery. Neither critical habitat designation nor the degree of completion of recovery plans appear to be effective.

Our results suggest improvements can be gained by a redistribution of resources, putting more emphasis on listing additional species and activities that lead to completion of specific management objectives, and less emphasis on assigning critical habitat and completing recovery plans for species already listed. Additionally, increasing the FWS budget for the endangered species program will improve species recovery.

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Table I

Total Spending and Change in Status

Species	**Total Spending ($x10^6$)**	**% Total**	**Change in status**
Red Cockaded Woodpecker	128.0	7.79	Declining-Improving
Northern Spotted Owl	108.3	6.59	Declining-Declining
Bald Eagle	72.4	4.40	Improving-Improving
West Indian Manatee	38.3	2.33	Declining-Declining
Grizzly Bear	37.8	2.30	Stable-Stable
Mojave Desert Tortoise	37.5	2.28	Declining-Uncertain
Colorado Squawfish	37.2	2.26	Stable-Stable
American Peregrine Falcon	35.9	2.19	Improving-Improving
Marbled Murrelet	33.4	2.03	Declining-Declining
Loggerhead Sea Turtle	29.4	1.79	Declining-Uncertain

Table II

Total Spending and Recovery Score

Species	Total Spending ($x10^6$)	% Total	Recovery Score
Red Cockaded Woodpecker	128.0	7.79	15
Lahontan Cutthroat Trout	11.8	0.72	15
Kemp's Ridley Sea Turtle	10.5	0.64	15
Wyoming Toad	1.2	0.08	15
White River Spinedace	0.3	0.02	15
Duskytail Darter	0.03	0.0016	15

Table III

Model 1: Effect of Listing[a]

Variable	**Estimate** **(t Ratio)**
Constant	0.1899
LISTED	0.4730* (2.5)
BODYL	-0.3743 E-03 (-0.12)
BODYLSQ	-0.5524 E-05 (-0.5)
NRANK96	0.4664* (2.8)
Number of observations	551
Log-likelihood	-308.52
Likelihood Ratio Index[b]	0.0191

[a] *, significant at a = 0.01.

[b] Also known as McFadden's R^2 [23], this index is given by LRI = 1 – $\ln L/\ln L_0$, where $\ln L$ is the maximized value of the log-likelihood function, and $\ln L_0$ is the log-likelihood computed with only a constant term.

Table IV

Marginal Effect of LISTED

	Pr(RSCORE1 = 0)	**Pr(RSCORE1 = 1)**	**Pr(RSCORE1 = 2)**
LISTED = 0	0.1140	0.8295	0.0566
LISTED = 1	0.0466	0.8202	0.1332
Change	-0.0674	-0.0093	0.0766

Table V

RSCORE2

From/To	**E**	**U**	**D**	**S**	**I**	**R**
E	0					
U	2	8				
D	1	4	9	14	15	
S		3	6	10	12	
I			5	7	11	13
R						

Table VI
Number of Species per Recovery Score

Recovery Score 2	Number of Species	Percentage of Total
0	6	2.2%
1	2	0.7%
2	2	0.7%
3	5	1.8%
4	14	5.1%
5	3	1.1%
6	17	6.2%
7	7	2.6%
8	28	10.3%
9	67	24.5%
10	70	25.6%
11	18	6.6%
12	14	5.1%
13	1	0.4%
14	13	4.8%
15	6	2.2%

Table VII

Model 2: Spending and Effort Variables[a]

Variable	Estimate (t Ratio)
Constant	2.2732
TSPEND	0.1261 E-04* (2.30)
HABIT	-0.0947 (-0.62)
RPLAN	-0.4582 E-02 (-0.12)
RECOB	0.5141* (5.91)
TIMEL	-0.3691 E-02 (-0.49)
CONF	0.1620 (1.04)
BODYL	-0.2956 E-03 (-0.11)
BODYLSQ	-0.1187 E-05 (-0.14)

NRANK96	-0.1627* (-4.23)
Number of Observations	244
Log-likelihood	-506.61
Likelihood Ratio Index	0.0577

[a] *, significant at a = 0.01.

Table VIII

Marginal Effects of TSPEND

Recovery Score	**Marginal Probability Change**
RSCORE2 = 0	-2.6452 E-07
RSCORE2 = 1	-1.9891 E-07
RSCORE2 = 2	-9.5091 E-08
RSCORE2 = 3	-3.6674 E-07
RSCORE2 = 4	-9.3403 E-07
RSCORE2 = 5	-1.7998 E-07
RSCORE2 = 6	-8.3619 E-07
RSCORE2 = 7	-2.7183 E-07
RSCORE2 = 8	-6.6155 E-07
RSCORE2 = 9	-6.4233 E-07
RSCORE2 = 10	1.3453 E-06
RSCORE2 = 11	7.7349 E-07
RSCORE2 = 12	7.2005 E-07
RSCORE2 = 13	5.7550 E-08
RSCORE2 = 14	8.2914 E-07
RSCORE2 = 15	7.2565 E-07

Table IX

Marginal Effects of RECOB

	RECOB = 1	RECOB = 2	RECOB = 3	RECOB = 4	CHANGE 1-4
Pr(RSCORE2=0)	0.00693	0.00147	0.00024	0.00003	-0.00690
Pr(RSCORE2=1)	0.00879	0.00238	0.00050	0.00008	-0.00871
Pr(RSCORE2=2)	0.00483	0.00144	0.00033	0.00006	-0.00477
Pr(RSCORE2=3)	0.02150	0.00721	0.00186	0.00037	-0.02113
Pr(RSCORE2=4)	0.07124	0.02992	0.00970	0.00243	-0.06881
Pr(RSCORE2=5)	0.01631	0.00784	0.00290	0.00082	-0.01549
Pr(RSCORE2=6)	0.08869	0.04791	0.01993	0.00638	-0.08231
Pr(RSCORE2=7)	0.03462	0.02094	0.00973	0.00347	-0.03115
Pr(RSCORE2=8)	0.10424	0.07028	0.03645	0.01454	-0.08970
Pr(RSCORE2=9)	0.29301	0.25956	0.17869	0.09557	-0.19744
Pr(RSCORE2=10)	0.23726	0.30872	0.31297	0.24721	0.00995
Pr(RSCORE2=11)	0.05038	0.08905	0.12112	0.12678	0.07640
Pr(RSCORE2=12)	0.03104	0.06475	0.10395	0.12842	0.09738
Pr(RSCORE2=13)	0.00198	0.00455	0.00803	0.01090	0.00892
Pr(RSCORE2=14)	0.02137	0.05547	0.11118	0.17211	0.15074
Pr(RSCORE2=15)	0.00783	0.02853	0.08244	0.19084	0.18301

FOOTNOTES

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[1] Since 1992, the ESA has been funded only on an annual basis due to the lack of agreement on whether to weaken or strengthen it or to modify some of its provisions.

[2] For two good summaries of this debate, see Clark [11] and Smith *et al.* [37].

[3] This does not include four listed runs of salmon managed by the National Marine and Fisheries Service, who does not provide the same information as the FWS on population status.

[4] NC ranking not relevant to this analysis are “not of practical conservation concern”, “historical”, “accidental”, or “exotic”.

[5] Specifically, population size may be subject to four sources of stochasticity: (1) demographic stochasticity, which refers to survival and reproductive success; (2) genetic stochasticity, which refers to random changes in genetic make-up; (3) environmental stochasticity, which refers to unpredictable changes in environmental factors such as weather, food supply, etc.; and (4) natural catastrophes, such as floods, droughts, etc.

[6] A Hausman test showed that NRANK96 is endogenous. The results shown are for the corrected model. There was no qualitative change in the results before and after the correction.

[7] For instance, in the 1994 report to Congress the recovery objectives for the roseate tern (*Sterna dougallii dougallii*) included “increase nesting population to 5,000 pairs, including 6 productive colonies with more than 200 pairs, sustained for 5 years” [49].

[8] The 1996 report includes an additional category: existing only in captivity. Since this category is used only in 1996, and it applies only to two species, we ignore it so as to have consistency in the categories used in all years.

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[9] The FWS also uses changes in population status over time as a measure of performance, although their approach is simpler than ours (see, e.g. FWS [52]).

[10] We suspected that total spending (TSPEND) and the effort variables (HABIT, RPLAN, and RECOB) might be jointly endogenous. We used a test described by Pudney and Shields [32] and found that we could not reject the null hypothesis of (joint) exogeneity of these variables.

[11] Some of these results are not consistent with those of Rachlinski [33], who finds that time listed, recovery plans, the existence of economic conflict, and designation of critical habitat do affect recovery (although critical habitat is only marginally significant). These differences may be explained by the fact that his study considers variables in isolation, whereas we estimate a multivariate model. Our result concerning time listed also contradicts that of Beissinger and Perrine [6], who argue that species that have been listed longer seem to have more encouraging population trends. On the other hand, our result for the designation of critical habitat agrees with the reasoning of Belovsky *et al.* [7], who argue that setting aside habitat may not suffice to ensure the long-term persistence of species whose populations are already small.

[12] We also estimated this marginal effect by calculating the mean of all explanatory variables, and then estimating the change in probability for each recovery score caused by adding one to the mean of TSPEND [20]. The qualitative result was the same, i.e. a decrease in the probabilities of scores 0 to 9, and an increase in that of scores 10 to 15.