Patterns of Behavior in Endangered Species Preservation

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ABSTRACT. *This paper analyzes statistically the main determinants of government decisions about the preservation of endangered species. As explanatory variables, we use proxies that include 'scientific' species characteristics, such as "degree of endangerment" and "taxonomic uniqueness," as well as 'visceral' characteristics, such as "physical size" and the degree to which a species is considered a "higher form of life." These proxies are used to study the government's protection and spending decisions on individual species. Overall, we find that the role of visceral characteristics is much greater than the role of scientific characteristics.* (JEL Q28)

I. INTRODUCTION

As a society, we seem to have made a generalized commitment to conserving biodiversity; but how do we spend our limited resources on this commitment? Our goal is to answer this question by studying actual decisions made by the U.S. government about which species to protect and how much to spend on them.

Narrowly, this paper is about explaining the species-by-species protection and spending decisions of certain relevant U.S. federal and state government organizations.[1] To perform this analysis, we have combined several distinct datasets from different government and scientific sources. We think that the resulting combination offers a rare opportunity for empirically based insights into preferences about biodiversity conservation. Decisions about endangered species reflect the values, perceptions, and contradictions of the society that makes them. Thus, more broadly, this paper addresses some very general issues about humankind's relation to nature and about our choices when confronted by competing and often unquantifiable objectives. Nevertheless, we should stress that our paper is strictly a positive study of government choices—no normative claims are made. This is not an attempt to value species, but rather an analysis of preferences revealed through actual decisions.

The Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1992b) gave the federal government the power to protect U.S. species from extinction. Simply by listing a species as endangered, the government opens a legal avenue for development projects to be delayed or canceled, and for millions of dollars in opportunity costs to be incurred. Indeed, once a species is placed on the endangered species list, cost-benefit analysis is practically precluded. Additionally, all listed species are eligible to have funds spent directly on their recovery, with the eventual goal of having their endangerment reduced to levels that would allow them to be removed from the list. Overall, the relevant government agencies face difficult problems of, first, deciding which species to place on the endangered species list and, second, deciding how much to spend on the recovery of each listed species. In the sections that follow, we examine these two decisions in detail. We believe this subject deserves serious attention from economists because the direct and indirect costs of this type of environmental protection are already substantial, and such expenditures are growing more rapidly than almost any other item of comparable size in the national economy.[2]

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We thank Shara Howie and Melissa Morrison at the Nature Conservancy and Judy Jacobs, Gloria Parham, and Jay Shepard at the Fish and Wildlife Service for generously providing us with data and background information. We also thank Mark L. Plummer and two anonymous referees for detailed, helpful comments. We alone retain responsibility for the contents, including errors and omissions.

[1] Readers interested in other studies of revealed preference of government decision making are referred to McFadden (1975, 1976), Weingast and Moran (1983), Thomas (1988), and Cropper et al. (1992). The most closely related work to our own is Mann and Plummer (1993).

[2] One illustration of this growth is the dramatic rise in direct expenditures on species-by-species preservation. These figures are studied in Section IV.

TABLE 1
THE TOP TEN SPECIES BY TOTAL SPENDING

Common Name	Spending ($Millions)	Cumulative Spending (%)
1. Bald Eagle	31.3	9.9
2. Northern Spotted Owl	26.4	18.3
3. Florida Scrub Jay	19.9	24.5
4. West Indian Manatee	17.3	30.0
5. Red-Cockaded Woodpecker	15.1	34.8
6. Florida Panther	13.6	39.1
7. Grizzly (or Brown) Bear	12.6	43.1
8. Least Bell's Vireo	12.5	47.1
9. American Peregrine Falcon	11.6	50.7
10. Whooping Crane	10.8	54.2

Table 1 lists every species on which over $10 million has been reported spent by all U.S. federal and state agencies from 1989 to 1991.[3] The species are listed in descending order of total reported expenditures. Also shown is cumulative spending as a percentage of all expenditures on endangered species. What follows now are some speculations, intended to be suggestive, on some possible spending patterns.

First, the spending appears to be extremely concentrated. Just 10 species account for over half of all expenditures, out of a total of 554 species that were officially listed as endangered or threatened as of November 1990. Next, notice that all of the species listed in Table 1 are animals. More precisely, they are all mammals or birds; in fact, most are relatively *large* mammals and birds. Furthermore, there might even be some doubt about whether these species are truly endangered, or even threatened, in any objective absolute sense. The Bald Eagle, Northern Spotted Owl, Florida Scrub Jay, and Grizzly Bear, for example, have relatively large viable breeding populations that, while being pressed upon by habitat destruction in some regions, do not appear to be even remotely exposed to any overall danger of going extinct. The same cannot be said, for example, of the Texas Blind Salamander, Monitor Gecko, Choctawahatchee Beach Mouse, or Waccamaw Silverside, which are objectively much closer to extinction, but nonetheless each claim less than $10,000 in total expenditures.

A quick reading of Table 1 would also appear to suggest that the degree of biological uniqueness plays no role, or even a perverse role, in expenditure decisions. Of the 10 listings, constituting over 54 percent of total spending, only 4 are full species (Bald Eagle, West Indian Manatee, Whooping Crane, Red-Cockaded Woodpecker). The other 6 are of a lower taxonomic rank. The Northern Spotted Owl, Florida Scrub Jay, Grizzly Bear, and so forth are *subspecies*. They each have very closely related near-twin subspecies, genetically very similar, that are in little danger of going extinct. At the opposite extreme are such creatures as the Sand Skink, Red Hills Salamander, and Alabama Cave Fish. Total spending on any one is less than $10,000, yet each of these three endangered species forms a monotypic genus—meaning that they are the genetically distinct unique representatives of an entire genus, having no sister-species and being only very distantly related to their nearest safe cousin-species in other genera.

The observations note above seem provocative. But are the perceived patterns real? And what do they mean? This paper is an attempt to answer these questions using a careful statistical analysis.

The remainder of the paper is organized as follows: Section II contains a discussion of various normative justifications for the preservation of biodiversity and of the difficulties of constructing a single objective function that the government might be expected to follow. We then identify a subset of these normative justifications that can be defined operationally and quantified, and we describe the data that we use for them. This subset includes 'scientific' characteristics such as "degree of endangerment" and "taxonomic uniqueness" as well as more 'visceral' characteristics such as "physical

[3] The exact source of the data, and other details, will be explained in the next section.

size" and the degree to which a species is perceived as a "higher form of life." In Section III, we describe the Endangered Species Act and the listing process in more detail, and then estimate a regression to determine the relative importance of these species characteristics in the listing decision. We find that both scientific and visceral elements play an important role in determining whether a species becomes listed. In Section IV, we focus on the government's direct spending to improve the condition of listed species. First, we describe the available spending data and the method by which it was collected. Then, using the same independent variables as in Section III, we estimate a regression with "species-by-species" spending as the dependent variable. We find that the visceral characteristics play a highly significant role in explaining the observed spending patterns, while the more scientific characteristics appear to have little influence. Next, in Section V, we extend the analysis to include explanatory variables of a more openly bureaucratic nature. The goal here is to determine how closely the government is following its own system for prioritization of spending. Results are mixed; while the formal priority system is followed to some degree, there is evidence that its least important component plays a disproportionate role. Finally, Section VI concludes with a summary of the results and a discussion of some broader themes which we believe are suggested by the analysis.

II. OBJECTIVES IN BIODIVERSITY PRESERVATION

A. Overview

In this section we attempt to identify all relevant variables which might influence endangered species policy. This exercise is not intended to have normative implications, but rather to frame the empirical analysis of the following sections. In an ideal study of this subject, we would have a well-defined objective function for society as a whole, and the observed government behavior could be judged on the basis of how well it satisfied such a standard. In the case of biodiversity preservation, however, the most striking feature is the almost complete lack of any such anchor. Even in fields as contentious as health policy or environmental risk management, there is some 'currency' around which the analysis can be framed. In biodiversity preservation, however, no such measure has yet been agreed upon, and decision-making bodies are left with a shopping list of objectives that are not easily comparable. In our opinion, it is essential to recognize this "lack of an anchor" as a central feature of biodiversity preservation, and we do not propose any solution to such a difficult problem. Instead, we study only the elements that are both *relevant* and *measurable*: relevant because they usually show up in the "shopping list of objectives," and measurable because it is possible to identify quantifiable proxies. Then, we attempt to determine which of these elements is actually important for explaining the patterns of behavior in the data.

Throughout our discussion, we use the conservation of *species* as the main vehicle for biodiversity preservation.[4] In this species-oriented approach, we find it useful to divide arguments for the preservation of biodiversity into three broad classes.[5] First, species may have *commercial* value in uses such as food, medicine, clothing, or tourism. Second, *existence* value represents the pleasure people derive from simply knowing that a species exists in the wild, even if representatives are never actually observed directly. Such existence values can also encompass

[4] We recognize that some conservation professionals would argue that the proper unit of measurement is not species, but ecosystems. At an extreme, researchers who hold this view might question the entire foundation of a species-oriented approach. We take no position in this debate. Since the relevant governmental organizations use a species approach, it is logical for us to use this same approach when studying their behavior.

[5] As we pointed out earlier, this discussion in no way attempts to claim that these categories are the normatively "correct" ones to be using. There is a huge literature on this topic, spanning many disciplines, and we could not do it full justice here. Rather, our choices of these categories is done purely out of convenience; we want to find out what actually influences government choices, and to do this we need some simple and efficient categorization.

moral arguments, originating ultimately from religious and philosophical convictions, that humankind has an ethical obligation to preserve species, notwithstanding any direct benefits. Third, it is sometimes argued that if we allow biodiversity to deteriorate below (currently unknown) critical levels, then ecosystems may collapse, thus causing significant repercussions in other spheres. We refer to this as a *contributory* value.[6] If we believe that this value is important, then we should act to preserve species that may be important "keystones" for their respective ecosystems. Note that "option values" can occur in any of these three categories, and cannot be thought of separately from the underlying value (commercial, existence, or contributory).

Within each of these three types of arguments, there may be several components that provide motivation for current government policy; in the next subsection we attempt to isolate those which seem to be both relevant and measurable. These "relevant and measurable" components fall exclusively within the category we have labeled existence value. This is not to say that the other two categories are not valid motivations; rather, it is that we cannot find measurable components of these other categories that can be used to understand current policy. The reasons are different in each case. First, although there are some exceptions, most endangered species have little or no commercial value, so this category can be effectively ignored as a significant motivation in government spending.[7] Next, the contributory value is not understood well enough to be useful for making decisions about individual species and, therefore, is not likely to explain any of the patterns in our data.[8]

B. Relevant and Measurable Objectives in Biodiversity Preservation

As stated previously, there are many components which might on principle be included in society's objective function for biodiversity, but only a subset are both relevant and measurable at this time. Below, we describe the three components of this subset that we have been able to identify, all of which fall into the class of existence values. Because it is not possible to obtain reliable measures of any component for all species of plants and animals, we confine our analysis to cover only vertebrate species, which in effect constitute a single phylum of the animal kingdom.

1. People often speak of the large amount of attention paid to "charismatic megafauna." Just knowing that elephants and pandas exist in the wild has value to some people, even if they never actually witness the wild elephants and pandas firsthand; such an effect is likely to be less pronounced for species of wild toads or eels. Since existence value of a species may indeed be a function of its charisma and physical size, we would ideally like some good measure of both. We capture the "megafauna" part by using the physical length of an average representative of the species.[9] At this stage, we have not obtained a satisfactory measure of "charisma," although we have received many creative suggestions.[10]

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[6] This usage is introduced in Norton (1988).

[7] Some fisheries fall into the class of exceptions, with whale species perhaps the most obvious examples. Since, as is explained later, our analysis does not include marine species, the importance of commercial value in our sample seems minimal.

[8] In rejecting inclusion of an "ecological significance" variable in the government's priority system, Fay and Thomas (1983, 43101) state that "this kind of information is seldom available at the time a species is considered for listing."

[9] Lowe, Matthews, and Mosely (1990) and Mosely (1992) give fairly precise length ranges for all species on the U.S. endangered species list. For non-listed species, we consulted several standard biological references to obtain length estimates (Allen 1983; Grzimek 1984; Lee et al. 1980; Nowak 1991). In some cases, we were not able to obtain a published length for a species and it was necessary to form an estimate by using data from closely related species.

[10] Among the suggestions are: eye-size or eye-body ratio, number of times the animal's name appears in children's books or in articles in *The New York Times*, space devoted to the animal in zoos, and subjective charisma ratings from an as yet unperformed psychology experiment. Our judgment at this time is that none of these measures would be useful enough to justify their inclusion, even if they were readily available.

2. Another possible component of existence value is the degree to which a species is considered to be a higher form of life. In many contexts, it seems obvious that human beings care about other people in proportion to the degree to which they are related to them or can 'identify' with them. We might believe that this feeling extends to higher forms of life as well. We are not suggesting that this is an ideal ethical criterion to use; in fact, we are making no normative judgment at all. Instead, we want to recognize that if people do actually make distinctions among species in this way, then it will necessarily be a component of existence value. To test for the possible role of such a component, we have divided the dataset into the five broad classes of vertebrates: mammal, bird, reptile, amphibian, and fish. In the regressions of the following sections, we include dummy variables for each of these classes to see if current policy discriminates among them.

3. Since we also may have existence value for "biodiversity" as a whole, some measure of the amount that a species adds to this diversity may play a role in deciding how much to spend on it. As a measure of such added diversity, we might use a species' taxonomic distinctiveness, or difference, from other species.[11] Other things equal, the more unique a species is, as measured by distance from its closest living relative, the more attention we would pay to its preservation. As a measure of taxonomic uniqueness, we use dummy variables to discriminate among three possibilities. First, a "Full Species" is our term for a genuine species in the generally accepted biological sense.[12] Next, a "Monotypic Genus" is a full species that constitutes the sole representative of its genus.[13] Finally, we use the term "Subspecies" to mean any taxonomic unit below the level of a full species. Of these three types, Monotypic Genus is the most taxonomically distinct, while Subspecies is the least.

Finally, a fourth factor to be considered does not relate directly to species value, but rather to the probability of preventing extinction.

4. Any preservation decision is likely to pay some attention to the actual level of endangerment of the species in question. Other things equal, we expect that preservation dollars would go to recover the more endangered species.[14] Our data for endangerment comes from the Nature Conservancy (NC), which tracks an exhaustive subset of all vertebrate "full species" in the U.S. and provides "global endangerment" ranks on a scale of 1 (most endangered) to 5 (least endangered). Overall, the NC ranking system is by far the most comprehensive and objective measure of species endangerment that we could find. Each of the interval rankings of 1 through 5 has a well-defined meaning, and a serious effort is made by the NC to apply the rankings consistently.[15]

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[11] This theme is developed more fully in Weitzman (1992, 1993).

[12] The "generally accepted" biological-species definition is typically ascribed to Ernst Mayr: "Species are groups of actually or potentially interbreeding natural populations reproductively isolated from other such groups."

[13] The Genus is the taxonomic level just above species.

[14] In a formal model of biodiversity preservation, such as Weitzman (1993), a more appropriate statement is something like the following: other things equal, we should spend more money on species with higher marginal decreases in extinction probability per dollar spent. In practice, there probably is a high correlation between a species' "absolute" and "marginal" level of endangerment, so the two concepts may actually turn out to be similar. Due to our data constraints, we are forced to finesse the possible distinction between marginal and absolute levels of endangerment.

[15] The Nature Conservancy distinguishes between global ranks, called "G-ranks," which are given to full species, and "T-ranks," which are given to subspecies or populations. In our dataset, we use the ranking relevant to the taxonomic unit being studied, i.e, G-ranks for full species and T-ranks for subspecies. The definitions of G-ranks given by the NC are: G1—critically imperiled throughout their range and typically have fewer than 6 occurrences in the world, or fewer than 1,000 individuals; G2—imperiled throughout their range and typically have between 6 and 20 occurrences, or fewer than 3,000 individuals; G3—vulnerable throughout their range and typically have fewer than 100 occurrences, or fewer than 10,000 individuals; G4—apparently secure throughout its range (but possibly rare in parts of its range); G5—demonstrably secure throughout its range (however, it may be rare in certain areas). See National Heritage Data Center (1992, 1993a, 1993b).

These four factors make up the subset that we feel is both relevant and measurable. In an attempt to adjust for the importance of any relevant but *unmeasurable* factors, we later define a "residual" component of existence value and attempt to estimate the effect of its omission from the regressions. This artificial construction will be explained in Section IV, where it plays an important role in interpreting the pattern of spending decisions.

III. THE LISTING DECISION

A. Background: The Endangered Species Act of 1973

The Endangered Species Act of 1973 ("the Act") created a framework for the preservation of endangered plants and animals in the United States. This framework is administered primarily by the U.S. Fish and Wildlife Service (FWS), an agency of the Department of the Interior, which oversees the recovery of all terrestrial and freshwater species of plants and animals.[16] The term "species," although having a fairly precise technical meaning to taxonomists, is defined in the Act to include subspecies, varieties (for plants), and populations (for vertebrates), in addition to 'true' species in the technical biological sense.[17] Where not otherwise specified, we follow this biologically imprecise terminology and use the word species to refer to any taxonomic unit eligible for protection under the Act.

The process of listing a species for protection begins when the species is proposed by FWS as a "candidate." During its period of candidacy, FWS gathers data from internal and external scientific sources in order to determine whether the species warrants listing and protection. The process stalls here for most candidates; of more than 3,600 candidates for listing in 1993, there was insufficient scientific data to make a decision on about 3,000.[18] If sufficient scientific data exist and the data are judged to warrant listing, then FWS can place a formal proposal in the Federal Register. After a public comment period, FWS makes a final decision. A species may be listed as "endangered" or "threatened." An endangered species is "in danger of extinction throughout all or a significant portion of its range." A threatened species is "likely to become endangered in the foreseeable future."[19] Both types are considered to be "listed" and, while there are some legal distinctions, in practice they are given the same protection under the Act. For the remainder of the paper, we ignore the distinction between endangered and threatened species and we refer to all listed species as endangered.

For good reasons, the decision to list a species is given considerable attention by the FWS. Once protected, endangered species can cause large disruptions and force developers to delay or even cancel projects that might harm the species. For expositional purposes, we can effectively divide the stipulations of the Endangered Species Act into 'protective' and 'recovery' measures. Protective measures are restrictions on activities which harm listed species. These restrictions are more stringent for public, especially federal, activities than for private activities. On federal land or in projects requiring federal permits, species are protected from any adverse effect of an activity, including habitat alteration. The most prominant examples of such activities are dam or other construction, and mining or logging on federal land. On private land, it is primarily forms of direct harm that are

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[16] The National Marine Fisheries Service is responsible for the administration of the Act for most marine species. In this paper, we focus our attention exclusively on the species monitored by the FWS. We focus on the FWS because the National Marine Fishery Service does not publish data comparable to our FWS sources. Since the vast majority of recovery programs are managed by the FWS, this restriction does not play a role in our results.

[17] A vertebrate "population" is a taxonomic group below the subspecies level. Our analysis combines subspecies and populations in the same category.

[18] This total includes invertebrates and plants as well as the vertebrates studied in this paper.

[19] The background and definitions are drawn from the Endangered Species Act of 1973 and from the FWS publication, "Placing Animals and Plants on the List of Endangered and Threatened Species," U.S. Fish and Wildlife Service (1993). This publication also includes a detailed description of the listing process.

restricted. Direct harm is defined specifically in the Act and includes such obvious examples as shooting, trapping, and selling.

Recovery measures give the government the power to improve the condition of listed species. The Act provides FWS with the authorization to develop and implement plans to preserve and improve the condition of listed species. More importantly, the Act gives FWS and other federal agencies the authority to purchase significant habitat sites and to aid state agencies that have agreements with FWS.

REGRESSION #1
THE LISTING DECISION

LISTED	Coef.	Std. Err.	t	$P > \|t\|$
MAMMAL	1.11	.42	2.679	0.008
BIRD	1.21	.38	3.224	0.001
REPTILE	.92	.44	2.102	0.036
AMPHIBIAN	−1.51	.45	−3.339	0.001
NCRANK	−1.47	.16	−9.238	0.000
LNLENGTH	.25	.14	1.713	0.087
MONOTYPIC	.84	.39	2.177	0.030
CONSTANT	1.07	.42	2.550	0.011

Notes: Dependent variable is *LISTED*; method of estimation is logit; 511 observations.

B. Regression #1: Factors in the Listing Decision

Since listing a species is the crucial first step in its protection, it would be helpful to gain a better understanding of the determinants of the government's decision. What role, if any, is played by the relevant and measurable objectives discussed in the previous section? To answer this question, we constructed a sample of all vertebrate full species which might possibly be considered for listing. This sample excludes all taxonomic units below the full species level; that is, we do not include any subspecies or populations. Such a sample is possible because the Nature Conservancy database contains an exhaustive list of *all* U.S. vertebrate (full) species.[20] We restrict our sample to all full species, listed and unlisted, that meet a minimum threshold of endangerment—the NC endangerment rank of 3 or lower. This leaves us with a sample of 511 full species, of which almost half are fish. Using this sample, we estimate a logit regression with a dependent dummy variable, *LISTED*, which is set to 1 if the (full) species was listed as of March 1993 and to 0 otherwise. The independent variables are Nature Conservancy degree of endangerment rank (*NCRANK*), log of physical length (*LNLENGTH*), dummies for the taxonomic class (*MAMMAL*, *BIRD*, *REPTILE*, and *AMPHIBIAN*—fish is the benchmark), and a dummy for monotypic genus (*MONOTYPIC*).

The results of Regression #1 indicate that many forces play a role in the listing process.

1. The coefficient on *LNLENGTH* is positive and significant at the 10 percent level; other things equal, a 1 percent increase in physical length translates into approximately a .05 percentage point increase in the likelihood of listing.[21]

2. Similar translations yield statistically significant estimates for mammals, birds, reptiles, and amphibians (relative to fish) of 20, 22, 17, and −27 percentage points, respectively. All of these results are significant at the 5 percent level.[22]

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[20] We exclude subspecies from this analysis because the NC does not track a complete list of U.S. subspecies. We do not even know how many non-listed subspecies exist, much less what they are.

[21] As a first approximation, logit coefficients can be translated into probability terms by multiplying by $p(1 - p)$, where p is the mean of the dependent variable. In this case, $p \approx .24$ and $p(1 - p) \approx .18$.

[22] Readers may notice that the order of listing preference suggested by this regression places fish ahead of amphibians, while an evolutionary tree would place humans closer to amphibians than to fish. We are not sure that an evolutionary tree is the correct measure of what constitutes a higher form of life, and the main reason we ran the regression with dummies rather than a single ordered "evolutionary" variable was to remain agonistic on this issue. Nevertheless, the overall pattern of the coefficient estimates is roughly consistent with a loose evolutionary interpretation of "higher" as being "more closely related to humans."

3. Monotypic genera show a statistically significant increased listing likelihood of 15 percentage points.[23]

4. *NCRANK* has the expected influence on listing. The negative coefficient implies that a low *NCRANK*—which implies high endangerment—results in a higher likelihood of listing. A translation of the coefficient into probability terms implies that a one unit increase in *NCRANK* results in an approximate 26 percentage point rise in the likelihood of listing.

Most of these coefficient values are not surprising. As mentioned in Section II, a species become listed only after there is significant scientific evidence on its endangerment. Thus, we would expect that well-studied species would have a greater chance of meeting the necessary scientific standard and passing from being a candidate for listing to becoming listed. Since humans allocate their scarce scholarly resources for many of the same reasons cited for preservation, our results may indicate which species we like to study as much as they indicate which species we want to preserve. This complication is unavoidable. Nevertheless, the results of this regression certainly show that species are listed for more than just scientific characteristics such as uniqueness and endangerment; visceral components of existence value, like size and the degree to which a species is considered a higher form of life, seem to affect the listing decision as well.

IV. THE SPENDING DECISION

A. Background: Spending Data and the 1988 Amendment

Once a species has been listed under the Act, FWS is charged with the creation of a "recovery plan," which sets out the steps to be taken to improve the condition of the species. Internal audits by the U.S. Department of the Interior estimate that the potential direct costs implied by the recovery plans of all listed species are about $4.6 billion (U.S. Fish and Wildlife Service 1990b, 7).[24] Since the total available budget falls far short of this figure, all agencies with spending programs must make choices among projects.[25] During the 1980s, some members of Congress seemingly became concerned that a disproportionate share of these limited conservation dollars were being used to preserve a small number of species. Apparently, there was sufficient interest in this issue to pass an Amendment to the Act in 1988 requiring FWS to prepare annual reports on the amount of federal and state spending, broken down by species. The data collected by FWS were first published for fiscal year 1989, and have subsequently been published for fiscal year (FY) 1990 and FY 1991.[26] Spending from these three years is the main object of study in this section. In the following paragraphs, we explain the nature of these data, how they were collected, and what types of spending are and are not included.

The 1988 Amendment specifically charged FWS with making a "good faith" effort to calculate all expenditures that were

[23] Although we are only able to study the *MONOTYPIC* dummy in this regression, we would ideally like to know if subspecies are treated differently from full species in the listing process. Since an exhaustive list of all vertebrate subspecies does not exist, it is impossible to answer this question formally. We can, however, make an educated guess by using some simple ratios. Tear et al. (1993) estimate that the ratio of subspecies to full species in North America is 6.9:1 for mammals and 4.9:1 for birds; in the sample of listed species, the ratio of subspecies to full species is 2.4:1 for mammals and 1.1:1 for birds. Although these ratios consider only one factor and cannot be calculated for all vertebrate classes, the disparity is at least suggestive that full species are given preference to subspecies at the listing stage.

[24] This figure includes only the costs that would be paid by the government to carry out its recovery plans. It does not include any estimate of private or other opportunity costs.

[25] Calculating the total budget available for recovery projects is not straightforward. There are several sources of discretionary funds that can be used for many purposes in any year, with biodiversity preservation only one possibility. Any way that it is calculated, however, the budget is much less than $4.6 billion.

[26] The relevant sources are U.S. Fish and Wildlife Service (1990a, 1991, and 1992a). We plan to update this dataset to include FY 1992 spending when FWS releases this information, but we do not anticipate major changes in our results.

"reasonably identifiable" to an individual species. If spending cannot be broken down by species, then it is not included in the final total. Although the term "reasonably identifiable" may seem somewhat imprecise, in practice it seems to cover fairly broad classes of expenditures that are more or less operationally defined. Examples of expenditures usually included are habitat acquisitions designed primarily for a single species, captive breeding programs, operating expenses of wildlife preserves mostly dedicated to a single species, population censuses, and scientific study. Examples of expenditures that are typically not identifiable to a single species are salaries of FWS personnel, operating expenses of general wildlife preserves, multi-species habitat purchases, and the opportunity costs of legal restrictions on development.

Since the published expenditure figures exclude some public as well as all private expenditures, they do not completely account for the overall cost of wildlife preservation. As a result of this incomplete data, and for other reasons, we do not envision ourselves here as doing any kind of formal, comprehensive, society-wide cost-effectiveness analyis of current policies. Basically, we think of the reported spending figures as a noisy reflection of some underlying measure of concern for the various species. In studying reported species-by-species spending, we seek only the modest goal of finding patterns in the data which may reflect underlying preferences of the relevant decision-making organizations.

As for mechanics of the spending decision, the first thing to note is that the aggregate government spending figures we use come from many different agencies, at both the federal and state levels. Some of the spending is on items specifically mandated in the budget of a relevant agency. In essence, the legislative branch controls this mandated expenditure directly. Another part of spending is discretionary and comes from funds managed by FWS or appropriated by FWS from other government sources. To guide these discretionary spending decisions, FWS has developed a system for prioritizing species; we discuss this prioritization system in Section V. In our opinion, it would be an oversimplification to ascribe some fraction of spending to Congress and the remainder to other relevant agencies, because many of the decisions are made with input from both sides. Therefore, we treat all of the spending as if it comes from "the government" in general, although this clearly leaves many subtle political factors beyond the scope of our analysis.

The spending figures published in the annual expenditure report are collected from three sources. First, FWS calculates its own spending. Second, expenditures by the states are reported to a central conservation organization, which then passes the totals along to FWS. Third, each federal agency reports its expenditures individually to FWS. Since its inception in the 1989 fiscal year, the process has become more efficient and agencies have become more adept at identifying conservation expenditures from within their budgets. (In the early years, for example, the state numbers were somewhat incomplete.) Some of the remarkable growth in total reported expenditures, which have risen from $43 million in 1989 to $102 million in 1990 to $177 million in 1991, is attributable to this improvement in data gathering. The bulk of the spending is done by the federal government, with FWS itself comprising about half of the federal total. For all three years, the federal total of conservation expenditures is $248 million, while the state total is $74 million. Expenditure data is collected on all listed plant and animal species. However, as already noted, we confine our attention here to the vertebrates. Since approximately 95 percent of the identifiable conservation budget is spent on vertebrates, we are confident that any patterns uncovered here would be robust in the complete sample of listed species.

B. Regression #2: Determinants of Spending

Regression #2 uses the log of total spending from 1989 to 1991 (*LNTOTAL*) as the dependent variable. Since we only observe spending on a species when it is greater than $100, the dependent variable is censored at ln(100) and the appropriate esti-

REGRESSION #2
THE SPENDING DECISION

LNTOTAL	Coef.	Std. Err.	*t*	$P > \|t\|$
MAMMAL	.75	.44	1.717	0.087
BIRD	.27	.37	0.721	0.472
REPTILE	−1.72	.50	−3.443	0.000
AMPHIBIAN	−.94	.66	−1.422	0.156
NCRANK	.65	.19	3.423	0.000
LNLENGTH	1.03	.15	6.747	0.000
MONOTYPIC	−.37	.50	−0.736	0.462
SUBSPECIES	−.35	.30	−1.177	0.240
CONSTANT	7.69	.45	16.959	0.000

Notes: Dependent variable is *LNTOTAL*; method of estimation is Tobit; 237 observations.

mating procedure is a Tobit regression.[27] The independent variables are the same as those in Regression #1, with the addition of a *SUBSPECIES* dummy for listed taxonomic units below the full species level.

Before discussing the regression results, it is helpful for the exposition to introduce a hypothetical variable which we call *CHARISMA*. We think of this variable as the unmeasurable part of existence value, and we *mechanically define it to be orthogonal to all of the independent variables used in Regression #1.*[28] Although it may seem to be an unorthodox construction, *CHARISMA* is just a statistically harmless fiction that enables us to discuss a possible bias in our estimates. In writing about this hypothetical variable as if it actually exists in the real world, we seek only to simplify the exposition. For this purpose, we treat *CHARISMA* as a 'real' variable omitted from the right-hand-side of Regressions #1 and #2, and we assume that its coefficient would have been positive in both regressions. We then discuss how the estimated coefficients on the other regressors would be biased by this omission.

In Regression #1, we could think of the sample as being randomly selected from the population of all vertebrate full species. By construction, *CHARISMA* is uncorrelated in this population with the right-hand-side variables: *LNLENGTH*, *NCRANK*, *MONOTYPIC*, and the taxonomic class dummies. Hence, in principle, there is no omitted variable bias introduced in Regression #1. The sample used in Regression #2, however, consists only of *listed* species, and thus is specially selected by the listing process. If *CHARISMA* has a positive influence on listing likelihood, then within this sample it may well be correlated with other variables found to affect the listing decision. For example, since the estimated coefficient on *LNLENGTH* is positive in Regression #1, then, other things equal, a species with high *CHARISMA* would require *lower LNLENGTH* to achieve the same listing likelihood. Therefore, in a sample of only listed species, *CHARISMA* and *LNLENGTH* are likely to be inversely correlated. Analogous reasoning can be used on each of the other regressors—in general, each variable's correlation with *CHARISMA* will be opposite to the sign of its respective coefficient in Regression #1. Thus, if we make the natural assumption that *CHARISMA* also has a positive influence on the spending decision, then the direction of the omitted variable bias on each coefficient in Regression #2 will also be opposite to the sign of the respective coefficient in Regression #1. The likely effect of this bias is discussed below on a case-by-case basis.

The results of Regression #2 suggest several patterns in spending behavior.[29]

[27] Because there are only two censored observations, the results of the Tobit estimation are practically identical to those of an OLS regression using the same variables.

[28] We can do a thought experiment to envision what the *CHARISMA* variable represents. First, imagine that we could create a perfect measure for the existence value of each species. Next, regress this perfect measure on the set of independent variables used in Regression #1. Define the residuals from this regression to be the *CHARISMA* variable. This variable should *not* be thought of as exactly the same thing as the common usage of the word, "charisma." Although the two meanings have some overlap, our *CHARISMA* is a statistical construct which will, by definition, have the specific properties that we need to use for our analysis.

[29] We note here that the patterns discussed below are not driven by a small subset of the sample. For example, if we exclude the 10 species with the highest spending, which together comprise more than half of all spending, then the same qualitative results are found.

1. The coefficient on *LNLENGTH* is highly significant, statistically and quantitatively. This coefficient may be interpreted here in the usual fashion as an elasticity; it implies an approximate 1 percent increase in spending for a 1 percent increase in length. Since our analysis suggests that *LNLENGTH* and *CHARISMA* are negatively correlated in the sample of listed species, the omission of *CHARISMA* from Regression #2 should bias the coefficient on *LNLENGTH* downward. This further strengthens our finding of a highly significant positive effect.[30]

2. The taxonomic class dummies, as a group, seem to have a significant effect on spending. Since the fish dummy is left out, all of the other taxonomic class coefficients measure spending on that class relative to fish. The results show that the *MAMMAL* dummy enters positively and the *REPTILE* dummy enters negatively. The coefficients on *BIRD* and *AMPHIBIAN* are of the expected sign, but the magnitudes are not significantly different from zero. The overall pattern to the coefficients is fairly consistent with the onetime official policy of FWS to give spending preference to the "higher" animals in the following order: mammal–bird–fish–reptile–amphibian. This policy was officially abandoned in 1983, when Congress explicitly directed the FWS to implement a priority system that *ignored* the distinction between "higher" and "lower" life forms. However, as the regression results suggest, such a policy may actually reflect underlying preferences.[31] The effect of omitted variable bias would mostly support this interpretation. Since *MAMMAL* and *BIRD* are probably negatively correlated with *CHARISMA* in this sample, their estimated coefficients should be biased downward. Conversely, the coefficient on *AMPHIBIAN* should be biased upward. Adjusting for this bias would tend to reinforce the pattern already found. Only for the coefficient on *REPTILE* would the omitted variable bias possibly change the coefficient sign, since it is likely to be biased downward in this estimate.

3. Since the Full Species dummy is left out, the other two taxonomy dummies measure spending relative to this class. Our qualitative prediction from the discussion in Section II is that taxonomic uniqueness should have a positive influence on spending, so that we should find a positive coefficient on *MONOTYPIC* and a negative coefficient on *SUBSPECIES*. Actually, we find estimated coefficients on both to be negative but statistically insignificant. Adjusting for bias due to the omission of *CHARISMA* yields inconclusive results. It is likely that the *MONOTYPIC* coefficient is biased downward and the *SUBSPECIES* coefficient is biased upward. This bias could conceivably be sufficient to mask a small role for taxonomic uniqueness.

4. A surprising and counterintuitive result is the highly statistically significant positive coefficient on *NCRANK*. At face value, this means that a *decreased* level of endangerment—thus, a higher *NCRANK*—implies *more* spending. The appropriate interpretation of this result depends on the size of the bias from the omission of *CHARISMA*. Suppose, at one extreme, that the omitted variable bias is small or negligible. Then, we would conclude that *NCRANK* actually plays a perverse role in spending decisions. We consider it to be an implausible conclusion that, controlling for all other observable factors, a more truly endangered species actually gets less money spent on it; nevertheless, such an interpretation cannot be excluded by our results.

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[30] To support a reproductively viable population, physically large species typically require more habitat than do physically small species. Hence, it is conceivable that the significant positive coefficient on *LNLENGTH* is capturing different species' "needs." We think the explanatory power of this argument is small. Nevertheless, as with all other plausible explanations, we would gladly return to this question if relevant data on species' needs become available.

[31] There is an issue here, and throughout the paper, about taking the spending on species at face value. For example, spending on fish living in rivers might be a proxy for our desire to preserve rivers, and have little to do with a desire to preserve fish per se. This kind of problem occurs often in empirical work and, at some level, it is impossible to eliminate completely. We have no reason to believe that the problem is particularly acute in this case.

At the other extreme, suppose that the omitted variable bias is large. Under this scenario, the 'true' *NCRANK* coefficient could be negative, but the omitted variable bias would be large enough to turn a significant negative coefficient into a significant positive coefficient. If this is indeed the explanation for the positive coefficient on *NCRANK*, then it is a powerful illustration of the role *CHARISMA* is playing in the spending decision. In this case, we would conclude that any influence of *NCRANK* in its "expected" direction is more than outweighed by the role of *CHARISMA*. We believe that this conclusion is probably correct. Since *NCRANK* plays a very significant role in the listing process, it is likely that *CHARISMA* and *NCRANK* are highly correlated in the population of listed species and that the omission of *CHARISMA* from Regression #2 severely biases the *NCRANK* coefficient upwards. There is also considerable casual evidence to support this conclusion. Species with the highest spending include many "charismatic" species with very low actual endangerment—the Bald Eagle, Florida Scrub Jay, and Grizzly Bear among the most prominent examples. Adjustments for other characteristics fail to explain why these species receive high spending, as each also has large positive residuals in Regression #2.

It seems fair to conclude that spending choices are determined much more by visceral than by scientific characteristics: *LNLENGTH* and taxonomic class play significant roles, while the effect of taxonomic uniqueness and *NCRANK* are, at best, overshadowed by bias due to the omission of *CHARISMA*. Indeed, the results are even more striking when we realize that the inclusion of taxonomic class dummies essentially restricts *LNLENGTH* to the role of explaining "within" class variation of spending; absent taxonomic class dummies on the right-hand-side, the coefficient on *LNLENGTH* would be even greater, as length explains some of the "between" class variation as well. Overall, the one-line message to take away from our study of spending behavior is "size matters a lot." Again, we should note that this is not necessarily 'wrong', since "size" might justifiably be included in a society's objective function. However, it should also be noted that such heavy weighting of visceral elements seemingly goes against the language and spirit of current FWS policy, which strongly stresses scientific characteristics. For example, the FWS numerical priority system is based entirely on scientific elements. In the next section, we study this priority system in more detail and test for its relative importance in the spending decision.

V. THE FWS PRIORITY SYSTEM

A. Background and Discussion

In 1983, FWS created a formal "priority system" to serve as a guide in its listing and spending decisions.[32] In this section, we describe the official system adopted for spending decisions and we discuss several aspects that can yield insights into underlying preferences towards conservation. Then, we test for the priority system's role in explaining the observed pattern of spending. Overall, the system is intended to be used as a guide rather than a strict set of rules; nevertheless, if the government were using the system as it was designed, we would expect the data to show some evidence of successful implementation.

To study this issue, Regression #3 includes a regressor called *PRIORITY*, a variable which is equal to FWS's published priority rank. *PRIORITY* ranges from 1 (FWS's highest rank) to 18 (FWS's lowest rank). There are three components of this number. In strictly decreasing lexicographic order of importance, these components are "degree of threat" (most important: 3 grades), "recovery potential" (middle importance: 2 grades), and "taxonomy" (least important: 3 grades), making a total of 18 combinations. In principle, "degree of threat" is a similar concept to *NCRANK*, as both attempt to

[32] The official FWS description and defense of its priority system is contained in Fay and Thomas (1983).

measure the absolute endangerment level of the species. Also, each is on a three-point scale in our sample. Despite this conceptual similarity, the two measures are not highly correlated—an issue we return to later. "Recovery potential" is a measure of the ease or difficulty of improving a species' condition. Species with a "high" recovery potential are perceived to have well-understood threats which do not require intensive management to be alleviated. The three "taxonomy" grades are the same as we used in Regression #2: monotypic genus, full species, and subspecies. In addition, the priority system recognizes species seen to be in "conflict with construction or other development projects or other forms of economic activity" (Fay and Thomas 1983, 43104). Species in conflict do not receive a higher priority number than those not in conflict, but they are given a tiebreaking preference between species with the same (#1–18) ranking. We include a dummy variable, *CONFLICT* (1 if species is in conflict, 0 if not), to recognize this additional distinction.

It is not part of our purpose here to have a complete discussion about the merits and faults of the priority system described above. Nevertheless, there are several observations about this system which may yield insight into the attitudes and preferences of its creators. First, it is notable that a lexicographic ordering is used in creating the ranking. This ordering means, for example, that any species with the highest grade of "degree of threat" will always be assigned a higher priority than any other species with the middle grade of "degree of threat," even if the latter species has higher grades of "recovery potential" and "taxonomy." Such a method effectively precludes any possibility of trade-offs among the three criteria. This rigidity suggests a very extreme objective function. Second, the inclusion of "recovery potential" could be viewed as an attempt to quantify the cost-effectiveness of recovery. But, by placing "degree of threat" prior to "recovery potential" in the ordering, FWS is essentially making the statement that "cost issues are dominated by endangerment issues." Our final observation concerns the use of conflict as a positive tiebreaker for species priority. It seems more reasonable to suppose that, other things equal, it is more cost-effective to spend money on species that are *not* in conflict with development, since species in conflict are already imposing opportunity costs on society. The stated preference for preserving species in conflict may reflect some underlying desire to pay attention to species that are in the public spotlight.

REGRESSION #3
THE SPENDING DECISION WITH FWS PRIORITIES

LNTOTAL	Coef.	Std. Err.	t	$P > \|t\|$
MAMMAL	.54	.40	1.354	0.177
BIRD	.46	.34	1.342	0.181
REPTILE	−1.62	.47	−3.470	0.000
AMPHIBIAN	−1.19	.62	−1.917	0.057
NCRANK	.80	.18	4.398	0.000
LNLENGTH	.85	.14	5.944	0.000
PRIORITY	−.10	.04	−2.716	0.007
CONFLICT	1.20	.29	4.177	0.000
CONSTANT	7.99	.47	17.126	0.000

Notes: Dependent variable is *LNTOTAL*; method of estimation is Tobit; 237 observations.

B. *Regression #3: The FWS Priority System*

Regression #3 is identical to Regression #2 except for the addition of *PRIORITY* and *CONFLICT* and the subtraction of *MONOTYPIC* and *SUBSPECIES* from the list of regressors. *MONOTYPIC* and *SUBSPECIES* are dropped for statistical reasons because they are included as components of *PRIORITY*.

The coefficient on *PRIORITY* is negative and statistically significant. Other things equal, high priority species, i.e., those with a low numerical *PRIORITY*, receive more spending than do low priority species. At first glance, this suggests successful implementation of the priority system. Such a conclusion is mitigated, however, by the size of the estimated coefficient on *CONFLICT*. Recall that *CONFLICT* is intended to be the least important component of the priority system, as it acts only to break ties between species with the same priority num-

REGRESSION #4
DETERMINATION OF DEGREE OF THREAT

DEGREE	Coef.	Std. Err.	*t*	$P > \|t\|$
NCRANK	.20	.05	4.333	0.000
CONFLICT	−.41	.07	−5.637	0.000
CONSTANT	1.28	.47	15.394	0.000

Notes: Adjusted $R^2 = .17$; dependent variable is *DEGREE*; method of estimation is OLS; 237 observations.

ber. In spite of this ostensibly small role, the estimated coefficient on *CONFLICT* is more than 10 times the estimated coefficient on *PRIORITY*, and its *t*-statistic is greater than 4. Since 10 units of *PRIORITY*—moving up from 14 to 4 on the 1–18 scale, is intended to play a far greater role than the existence of conflict, such a result seems difficult to explain within the framework of the FWS system.[33] It is possible, however, that the *CONFLICT* variable is capturing other influences which are playing a major role in the spending decision. Specifically, species in conflict may generate extra political attention. If so, then through a variety of mechanisms, such political attention might translate into increased spending.

There are also indications that species in conflict receive higher priority numbers than they objectively deserve. As mentioned earlier, the NC endangerment rank (*NCRANK*) and FWS's "degree of threat" component of *PRIORITY* attempt to measure the same thing. Nevertheless, the correlation between the two measures is far from perfect, and some of the deviation can be explained by the existence of conflict. To illustrate this point, we estimate an OLS regression of the FWS degree of threat (*DEGREE*) on independent variables *NCRANK* and *CONFLICT*.[34] (See Regression #4.) The coefficient on *NCRANK* is positive and significant, but considering that a coefficient of 1 would indicate a perfect correlation, the size of the coefficient seems low. The coefficient on *CONFLICT* is negative and significant; this implies that species in conflict are considered to be more endangered by the FWS than they are by the NC. Since the *NCRANK* measure is designed to take into account any conflict that threatens the global survival of a species, the results of Regression #4 suggest that FWS may be inappropriately factoring individual findings of local conflict into its supposedly objective endangerment ratings. Thus, not only does *CONFLICT* have a disproportionate influence on the spending decision, but it may also subtly influence the rest of the priority system as well.[35]

VI. CONCLUSIONS

How do we spend our limited resources on preserving endangered species? We analyzed this question by examining the actual listing and spending decisions of the relevant government agencies. The overall pattern to these results is clear: visceral characteristics of species, such as their physical size and the degree to which they are considered to be higher forms of life, explain a

[33] Mann and Plummer (1993) were the first to indicate the importance of the *CONFLICT* variable. Their results motivated us to include *CONFLICT* in our analysis.

[34] An OLS regression implies that we take the actual numerical *DEGREE* rankings seriously. If we believe that *DEGREE* rankings are only ordered classes, then the proper estimation procedure would be ordered logit. Since, in this case, the results of an ordered logit estimation are very similar to OLS, we only report the latter. In either case, the indicated choices of independent and dependent variables are natural because *DEGREE* is a somewhat subjective measure created by the FWS, while *NCRANK* and *CONFLICT* are more objectively determined. No specific standards have been published by the FWS to explain why species receive different *DEGREE* ranks. *NCRANK*, by contrast, has fairly specific guidelines summarized in National Heritage Data Center (1992). Also, *CONFLICT* is the most objective of the FWS ranks; the published guidelines state that "Any species identified . . . as having generated a negative biological opinion which concluded that a given proposed project would violate Section 7(a)(2) of the Endangered Species Act or resulted in the recommendation of reasonable and prudent alternatives to avoid a negative biological opinion would be assigned to the conflict category" (Fay and Thomas 1983).

[35] It is also possible to explain the results of Regressions #4 by positing that *CONFLICT* contains some superior information on the part of FWS. Because *NCRANK* is continually updated while *DEGREE* is not, we feel that this explanation is unlikely to be correct.

large part of both listing and spending decisions. More scientific characteristics, such as endangerment or uniqueness, play a role at the listing stage but are overpowered by strong visceral elements at the spending stage. The evidence indicates that we pay more attention to species in the degree to which they are perceived to resemble us in size or characteristics. A provocative interpretation is to summarize current preservation policy as an expansion of rights and obligations towards species that remind us of ourselves. Although it remains highly speculative, this interpretation of our results may indeed be the best single explanation.

We also analyzed the implementation of the government's current system for setting spending priorities. The analysis finds that, while the priority system is being implemented to some degree, the least important component of the system had an influence which far exceeded its prescribed role. This component, a fairly 'objective' measure of whether a species is in conflict with development, is also found to influence the priority system itself. Such influence suggests that it might be useful to have a more formal separation between an agency making policy and an agency gathering the scientific information necessary for the setting of priorities. Without such a separation, even a well-intentioned government is prone to mixing these two distinct activities.

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