Journal of Economic Perspectives—Volume 12, Number 3—Summer 1998—Pages 21–34

Conflicts and Choices in Biodiversity Preservation

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Decisions about endangered species reflect the values, perceptions, uncertainties, and contradictions of the society that makes them. The defining limitation of the economics of biodiversity preservation is the lack of a common denominator or natural anchor. As a society, we have not even come close to defining what is the objective. What *is* biodiversity? In what units is it to be measured? By contrast, even such a morally loaded field as health economics has at least adopted, in practice, a common denominator of human lives saved as a natural anchor. Until we as a society—in the United States narrowly, and more broadly on the planet Earth—decide what is our objective, all the scientific data imaginable will not help economists to guide policy. At the end of the day, all the brave talk about "win-win" situations, which simultaneously produce sustainable development and conserve biodiversity, will not help us to sort out how many children's hospitals should be sacrificed in the name of preserving natural habitats. The core of the problem is conceptual. We have to make up our minds here what it is we are optimizing. This is the essential problem confounding the preservation of biodiversity today.

We start the paper by showing, in a simple constrained optimization problem, exactly where biodiversity appears in a plausible objective function. Then we indicate for this version the basic properties of a solution. The relevant solution concept is cast in the form of a cost-benefit ranking criterion. We then use this ranking criterion, and this theory, as a vehicle for introducing a normative discussion about the economics of biodiversity preservation. Next, we turn to a positive "revealed

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preference" analysis of the economics of biodiversity preservation, as acted out in U.S. federal and state government decisions about the preservation of species under the Endangered Species Act. We conclude with a discussion of how economic analysis can help to uncover difficulties in the objectives and in the decision-making process about biodiversity.

The Economics of Diversity Preservation

The analytics of the preservation of biodiversity is plagued by the absence of a workable cost-effectiveness framework, within which, at least in principle, basic questions can be posed and answered. Current approaches to endangered species protection seem almost completely lacking in theoretical underpinnings that might reasonably guide policy. This section introduces a simple analytical framework that we believe represents a useful way of thinking about the economics of diversity. Rather than presenting a broad survey of the literature, we here attempt to home in on what we consider to be the characteristic features of the underlying problem—in the form of a specific model which will lead us to what we call the Noah's Ark Problem.[1] The main underlying issue is how to determine basic priorities for maintaining or increasing diversity. Seen this way, the central task is to develop a cost-effectiveness formula or criterion that can be used to rank priorities among biodiversity-preserving projects under a limited budget constraint.

In talking about biodiversity preservation, there is always a question about what is the appropriate level of discourse. In principle, the basic unit could be at the level of the molecule, cell, organ, individual, species, habitat, ecosystem, or other levels as well. For the purposes of this paper, we take the underlying unit of analysis to be the species, although we believe that the same basic issues and themes of the paper will arise at any level.

Our key point of departure involves conceptualizing the underlying conservation unit—the species—as if it were a library. A library, of course, is full of books, and the books can be thought of as roughly analogous to the genes (or other key characteristics) of the species itself. Naturally, the book collections in various libraries may overlap to some degree. In turn, a book/gene can be thought of as a container of information. To continue the metaphor, a library is at some risk of burning down, with possible loss of the building and the book collection that it houses. Various preventive measures can be undertaken that lower the probability of a fire, such as investing in fire extinguishers—at a cost. Concentrating on the question of how best to allocate scarce fire prevention resources among the various

[1] This approach is developed rigorously in Weitzman (1998). There are other approaches in the literature. Solow, Polasky, and Broadus (1993) were the first to present the problem of what to protect as an economic issue. See also Weitzman (1992,1993), Polasky and Solow (1993), and Crozier (1992).

species/libraries allows for a crisp formulation of the generic problem of optimally conserving diversity under a budget constraint.

The critical part of the preservation problem is specifying the exact form of the objective function. Recognizing that no single form will satisfy everybody, there are, nevertheless, two broad classes of benefits that belong in the objective function: direct utility from each library, and indirect utility coming from the overall "diversity" of library books. We can define the diversity more explicitly to be the number of different books, or the set consisting of the union of all books, in all the existing libraries. These two categories of benefits are sufficiently universal that virtually all justifications for preservation can be fit within them. Thus, in our setup, the value of a library consists of two components: the building itself and the collection of books that it houses. Each library is housed in a building that has some inherent value as a structure; in the species interpretation, this represents the direct utility of how much we like or value the existence of that species per se. Such valuations can come from many different sources, including commercial values, aesthetic values, and even moral or religious values.

Turning now to the book collections within each library, we would like to express their value in comparable units. But why do we care about the diversity of libraries or books in the first place? Two basic answers are possible. We might like many different books per se, just as we might like many different colors simply because of the more colorful world their sheer variety creates. This would be a kind of aesthetic value of diversity. Or we might want to have different books for the utilitarian reason that they are a potential source of future ideas about new medicines, foods, or whatever. This might be called the information content of a book collection. However, at a sufficiently high level of abstraction, these two answers blur into each other, and become essentially the same. In both cases, the reduced form is that we care about having a large number of different books, or separate pieces of information.

The Noah's Ark Problem is intended to be an allegory or parable that renders a vivid image of the core problem of preserving the maximum degree of diversity (plus direct utility) under a budget constraint. The parable goes as follows. Noah knows that a flood is coming. An Ark is available to help save some species/libraries. In a world of unlimited resources, the entire set of species might be saved. Unfortunately, Noah's Ark has a limited capacity; in the Bible, the capacity is given as $300 \times 50 \times 30 = 450{,}000$ cubed-cubits. Noah must choose which species/libraries are to be afforded more protection—and which less—when there are not enough resources around to protect everything fully. Boarding the Ark is a metaphor for investing in a conservation project, like habitat protection, that improves the survivability of a particular species/library. One especially grim version of the Noah's Ark Problem would make the choice a matter of life or death, meaning that all species/libraries that Noah does not take aboard are doomed. We might call this the Old Testament specification. But it is also possible to conceive of a gentler scenario, in which Noah's decision to take a species/library on board raises some-what its probability of survival—but the species/library has some lesser (but still positive) chance of surviving the flood regardless.

Let us suppose further that although Noah wishes to solve this problem, he does not want to mess around with an overly elaborate and complicated algorithm. Noah is a practical outdoors man. He needs robustness and rugged performance in the field. As he stands at the door of the ark, Noah wants to use a simple priority ranking list from which he can check off one species at a time for boarding. Noah wishes to have a robust rule in the form of a basic ordinal ranking system so that he can board first species #1, then species #2, then species #3, and so forth, until he runs out of space on the ark, whereupon he battens down the hatches and casts off.

Can we help Noah? Is the concept of such a ranking system sensible? Can there exist such a simple boarding rule, which correctly prioritizes each species? If so, what sort of formula should determine Noah's ranking list for achieving an optimal ark-full of species/libraries? The answer to these questions is essentially positive. Our approach here generates a methodology that has the feel of traditional cost-effectiveness approach and can deal with the conservation of diversity. Here, we will focus on a more intuitive form of the criteria, which is at least useful in suggesting the four fundamental ingredients on which Noah should focus when determining conservation priorities.

Noah will begin with the two broad classes of benefits already defined: direct utility from each species/library, and indirect utility coming from the overall diversity of genes/books. The utility of each species/library will be measured as a combination of commercial, recreational and, yes, emotional reactions to a given species. This will pose difficulties in practice, of course, but conceptually it is reasonably straightforward.

However, thinking about the concept of diversity and how to measure it is much less conceptually straightforward. This component of the objective function represents the non-standard part of the optimization problem. (Otherwise, the Noah's Ark Problem is just a straightforward capital-budgeting problem—just rank and board each species by its expected increase in direct utility per unit of space on the Ark.) In fact, the reader might be forgiven for thinking that the notion of the diversity contributed by a species is sufficiently unorthodox that it is difficult to say anything both general and interesting about the solution to the problem. Fortunately, it turns out that by imposing some further structure on the problem, a quite striking characterization is possible.

We now suppose that the book collections are as if they were acquired by an evolutionary branching process with a corresponding evolutionary tree structure. This critical assumption permits a crisp solution—and besides, it seems warranted in the present context. The particular branching process described here is called the *evolutionary library model*, and it is patterned on the classic paradigm of descent with modification that underlies biological species evolution. The evolutionary library model explains the existence of the current library assemblage as a result of three types of evolutionary-historical events.

1) Each existing library acquires new books at any time by independent sampling, at its own rate, out of an infinitely large pool of different books. The independent acquisition of different new books by each library corresponds to the evolution of genetic traits when species are reproductively isolated, with no gene pool mixing by lateral transfer.

2) New libraries can be created by a speciation event. A new branch library can be founded by adopting a complete copy of the current collection of an existing library, as if all of the existing library's books were cloned or photocopied. Henceforth, however, this new library will become reproductively isolated and acquire its new books independently, as described a moment ago.

3) Libraries can go extinct. When a library is extinguished, its entire collection of books is lost. Thus, libraries that have already gone extinct in the past do not show up in the set of currently existing libraries.

The evolutionary library model naturally generates a corresponding evolutionary tree. When a tree structure is present, it seems to induce a way of visualizing and comprehending intuitively relationships among objects that are quite subtle or complicated to describe without the tree. "Tree thinking" represents a prime example of how one picture may be worth a thousand words.

Now let us return to the question of how much a given species/library contributes to distinctiveness or diversity. It is natural to identify the distinctiveness of a library/species with its distance from its nearest neighbor or closest relative—which here means the number of books independently acquired since being split off from its most recent common-ancestor library. In the tree corresponding to an evolutionary branching model, the distinctiveness of a library is represented geometrically by its branch length off the rest of the evolutionary tree. When a species/library goes extinct, the loss of diversity is the length of its branch, which is being snapped off from the rest of the tree. Although this image obviously does not resolve all questions about how to measure diversity in practice, it does open up a way of considering how to do so.

Noah will thus begin by viewing the overall value of a species/library as a sum of two components: 1) the direct utility of the species/library; and 2) the diversity added by the genes/books of this particular species/library. However, there are yet two more considerations that must enter the picture. Any reasonable benefit calculation must weigh the enhanced survivability of the species from being boarded. This gain will be measured by estimating the difference in probability of survival if taken aboard the Ark minus probability of survival if *not* taken aboard. Noah should then calculate the expected gain of taking the species/library aboard the Ark by multiplying the change in survival probability times the sum of direct utility plus diversity value. Finally, Noah must weigh the expected gains against the costs. For the biblical Ark, costs are measured in units of cubed-cubits. In the world today, the relevant concept is the opportunity cost of the project extending an enhanced measure of protection to a particular species/library. If the expected gains are divided by the costs, then Noah will have expected gains per dollar expended.

Now we have at hand the outline of an answer to the Noah's Ark Problem.[2] Noah should take species/libraries on board the Ark in the order of their gains in utility plus diversity, weighted by the increase in their probability of survival, per dollar of cost.[3] A small amount of notation can help make this point concisely. Let the index i stand for a species/library. Consider the following four concepts:

D_i = *distinctiveness* of i = how unique or different is i

U_i = direct *utility* of i = how much we like or value i *per se*

ΔP_i = by how much can the *survivability* of i actually be improved

C_i = how much does it *cost* to improve the survivability of i by ΔP_i

Then we have the following mathematical result. Provided ΔP_i is "relatively small" (for all i) in the usual sense of the prototypical small project justifying cost-benefit investment methodology locally, then a priority ranking based on the criterion:

$$R_i = [D_i + U_i]\left(\frac{\Delta P_i}{C_i}\right)$$

is justified in the sense of giving an arbitrarily close first-order approximation to an optimal policy.[4]

Of course, it will not be easy in practice to quantify the four variables: utility of a species, distinctiveness of a species from other species, increased probability of survival, and cost of increasing the survivability of the species. Nor will it be easy to combine these variables routinely into a simple ranking formula. The real world is more than a match for any model. Instead, the worth of this kind of result is to suggest a framework and to organize a way of conceptualizing biodiversity preservation—a way which begins with this special, but not unreasonable, case, and leads to intuitively plausible results. Perhaps one could come away with a sense that when making conservation decisions in the name of preserving diversity, it might seem like a good idea at least to consider these four factors—especially in a policy world so otherwise lacking clear guidelines for endangered species protection.

[2] For an explicit and rigorous derivation of the main result within the optimization framework presented here, along with a detailed discussion of related issues, see Weitzman (1998).

[3] The argument here does assume that the cost of saving a species is "relatively small," so that many species can be saved. As a result, when one gets down to the choice of the last species to board the Ark, it may be that there isn't enough room (or money left) for the next species in line according to its ranking, and so one has to skip down the line a little to find a species where there is enough room (or money left) to accommodate it. However, if the costs of saving a species are "relatively small," then a priority ranking based on the criterion here will be justified in the sense of giving an arbitrarily close first-order approximation to an optimal policy.

[4] We again refer the reader to Weitzman (1998) for a formal derivation of the result.

The Endangered Species Act: What Are We Preserving?

We have argued in the previous section that four factors—*utility* of a species; *distinctiveness* of a species from other species; increase in *survivability* of a species following a conservation plan; *cost* of enhancing survivability—should all play a role in biodiversity preservation. Together, these four factors are used to compute Noah's ranking. But which of the factors actually matter in practice? On what species do we in the United States actually spend our scarce time, energy and money? In this section, we attempt to address such questions by looking at quantifiable actions taken in association with the Endangered Species Act.

Our strategy here will be to look at a number of actual empirical bureaucratic variables that have been gathered and catalogued as a result of the Endangered Species Act and its amendments. These variables can be used as proxies for the four theoretical variables that should be important in the analysis. In the discussion to follow, we explore some of the key places where the process of the Endangered Species Act gives rise to data that can help to answer the questions posed above. With these data in hand, we will then use several proxies for Noah's ranking as the dependent variable regressed on proxy variables for utility of a species, diversity of a species, increased probability of survival, and cost of this increased survival probability as our explanatory variables.[5] This regression framework will allow us to identify what factors really seem to matter for the decisions made about preservation of endangered species.[6]

The journey of a species towards protected status begins when some individual or organization, public or private, suggests formally to the Fish and Wildlife Service, a division of the Department of Interior, that a species should be listed under the Endangered Species Act. To be more specific, several different taxonomic units are eligible for protection under the act, including species, subspecies, and (for vertebrates) "populations." For the sake of simplicity, however, we will typically refer to all of the above as "species," except in the discussion of proxy variables for diversity, when the distinction between species and subspecies will make a conceptual difference. Once a species has been nominated, the Fish and Wildlife Service then calls on scientific sources, both internal and external to the organization, to determine whether the species is a viable candidate for protection. If the scientific data support listing, then the species may be officially proposed to be listed.

After a species is proposed, there is a 60-day period for public comments, during which any interested parties can go on the record with their opinions about the proposed listing. Virtually all species that reach this stage are eventually listed.

[5] All of the variables used in this paper can be found in the DEMES database, which is described and documented in Cash et al. (1997). Readers desiring further information on the variables used in these analyses should contact the authors to obtain the reference.
[6] Similar empirical studies of the Endangered Species Act can be found in Mann and Plummer (1993), Tear et al. (1993), Metrick and Weitzman (1996) and Cash (1997).

Listed species enjoy special protections from harm, and must have official recovery plans created by the Fish and Wildlife Service. Listed species are also eligible for public spending on their recovery. In a 1989 amendment to the Endangered Species Act, Congress required the Fish and Wildlife Service to collect annual spending information from all federal and state authorities and to impute such spending as if on a species-by-species basis. Several steps in this process offer the opportunity to obtain quantitative proxies for Noah's ranking.

A first proxy variable for Noah's rankings is the log of the number of favorable public comments made during the proposal stage. These comments are collected by the Fish and Wildlife Service. Afterwards, summary statistics—that is, number favorable, number unfavorable, number neutral, and total number—are published in the Federal Register. The list of taxa that have received the highest number of favorable public comments reads like a *Who's Who* of the political-environmental landscape, with the northern spotted owl handily topping the list. Naturally, such controversial projects achieve a large number of favorable and unfavorable comments, so focusing only on the favorable side may miss part of the story. However, in a spirit of simplicity, we take these favorable comments as a ranking proxy and do not attempt to explain the complex relationship between the different types of comments.

A second proxy variable for Noah's ranking is the listing decision itself. In our regressions, this will be a dummy variable, taking a value of 1 if a species is listed, and 0 otherwise. Although this variable is not a continuous one, in the way we would expect Noah's rankings to be, it does make sense as an on/off variable for whether a species has been boarded onto the Ark. Since the Ark-boarding policy does use a simple cutoff in which species are either on or off the boat according to Noah's ranking, the use of the on/off decision is a natural proxy. (It also fits in well with similar studies looking for latent rankings, like the decision to buy a car or enter the work force.)

Finally, as a third proxy for Noah's ranking, we use the amount of public money spent from 1989 to 1993 on the recovery of the species. The total amount spent each year has been steadily increasing, and the five-year overall total is $914 million. Four species have each had over $50 million spent on them over this period—chinook salmon, red-cockaded woodpecker, northern spotted owl, and bald eagle—and these four together make up about one-third of the total spending. Most species have had at least some funds spent on them; of the 229 vertebrate species listed as of 1989, all but five have at least $100 of reported spending.[7] Only the costs that can be attributed to individual species are included in our totals.

We use these three different proxies for Noah's ranking because, while each seems reasonable, none seems perfect. If forced to choose a single proxy, we believe

[7] We add $100 to each species reported spending so that we can take the log of the total; this $100 can be thought of as each species' share of a small portion of the program's overhead.

that spending is the most appropriate measure of the three because it strikes us as the most direct and least noisy measure of preservation attention.

We next try to identify proxies for our four key decision variables. We first look for proxies for the utility term. It is obviously not possible to quantify every way that humans derive utility from other species. In seeking proxy variables for utility, we choose to focus on the elements that are associated with the class of "charismatic megafauna," a term applied to describe large, popular animals. To get at this effect, we include dummy variables for each taxonomic class within the vertebrates: MAMMAL, BIRD, REPTILE, AMPHIBIAN, and FISH. For the "megafauna" portion, we use the log of the length of a representative individual of the species.

Our next right-hand-side variable is diversity. The contribution of a species to diversity can be quantified, as in the tree diagram of the evolutionary library model, by its genetic distance from other species. This measure can be roughly approximated by its taxonomic uniqueness. We use two dummy variables to capture this idea of distinctiveness. One variable, labeled UNIQUE, takes on a value of 1 if the species is the sole representative of its genus, where a genus is the taxonomic unit immediately above species, and 0 otherwise. A second dummy variable, labeled SUBSPECIES, takes on a value of 1 if a "species" is in fact from the lower taxonomic classification of subspecies or population, and 0 otherwise.

Next, as a proxy measure of a species' survivability or marginal recoverability, we use absolute endangerment. The variable we use comes from the Nature Conservancy, which ranks a comprehensive list of all U.S. vertebrate species (but not subspecies or populations) into a scale from 1 to 5, with 1 being the most endangered and 5 being the least endangered.[8] As long as the most endangered species are also those that would benefit most from small recovery projects—which is all that marginal endangerment means—then this will be a reasonable proxy. One could argue that early intervention is more cost effective, but that is not really the issue here. It is certainly true that there are several examples of species near extinction being saved. These are the cases where, by definition, the gain in survivability has been the highest. These may have been costly projects, but cost is a separate element of the decision.

The Fish and Wildlife Service has itself recognized the importance of several of these factors, and they have established a formal priority system to rank species for recovery projects. Their priority system takes into account four factors; in decreasing order of importance they are: "degree of threat," "recovery potential," "taxonomy," and "conflict with development." The first three factors are combined by the Fish and Wildlife Service to form a ranking from 1 to 18 (lower num-

[8] We again refer the reader to Cash et al. (1997) for a complete description of these variables and their sources. The ENDANGERMENT variable used in this paper is of a 1993 vintage, which is slightly different than the most recent measures. We use the 1993 variable because we want to come as close as possible to capturing the endangerment level at the time that the relevant cost decisions were made.

bers imply higher priority). The fourth factor, which indicates whether or not the recovery of a species conflicts with other public or private development plans, is meant to serve as a tiebreaker among species having the same priority ranking—with those species in conflict with development receiving the advantage. This "conflict" variable can be thought of as a proxy for cost—in this case, an opportunity cost. This proxy gives us at least one representative for each of the four variables in the conceptual solution to the Noah's Ark Problem. In our final test, we include both the priority ranking and the conflict tiebreaker as additional explanatory variables. The formal Fish and Wildlife Service priority system implies that conflict should have a positive effect on spending—a cost-benefit calculation would suggest otherwise.

The results of several regressions using these variables are summarized in Table 1. In all cases, comprehensive data collection is made possible only by restricting the sample to vertebrates; plants and non-vertebrate animals are excluded because of data limitations. We acknowledge that there are many econometric difficulties here: variables are measured at different times, many important considerations are omitted due to data constraints, our proxies are imperfect. For these reasons, we adopt a reduced-form approach and do not claim any structural interpretations. Rather, we hope that readers agree with us that the patterns of behavior are striking enough to yield insights despite the obvious difficulties.

In the regression in the first column, the dependent variable LNCOMMENTS is the log of the number of positive comments received after the species has been proposed. The sample includes all 142 vertebrate full species, subspecies, and populations that have been listed since 1975, when the data first become available. Using the taxonomic class dummies (MAMMAL, BIRD, REPTILE, and AMPHIBIAN—all interpreted relative to FISH, the left-out variable), along with SIZE, ENDANGERMENT, and UNIQUE as explanatory variables, we find only ENDANGERMENT to be significant at the 5 percent level. Note, however, that the coefficient on ENDANGERMENT would appear to be of the wrong sign; the more highly endangered a species is, the fewer favorable comments that it receives. (Recall that the most endangered species receive ENDANGERMENT ratings of 1, and the least endangered species receive ratings of 5.) One interpretation of this coefficient is that species which are not truly endangered must be very "charismatic" to have survived so far in the process, and this same charisma is driving the number of favorable comments. This explanation—that certain key variables proxying for charisma are likely to have been omitted—is a common theme in interpreting the results of these regressions.

In the regression of the second column, the dependent variable is LISTED: a dummy equal to 1 if a species has been listed, and 0 otherwise. The sample includes all vertebrate full species with ENDANGERMENT rankings of 1, 2 or 3. We restrict the sample in this way so that it includes virtually all species that may reasonably be considered candidates for listing; rankings of 4 or 5 are essentially never considered in the first place. Subspecies or populations are not included

Table 1
Regression Results

Regression #	*1*	*2*	*3*	*4*
Dependent Variable	*LNCOMMENTS*	*LISTED*	*LNSPEND*	*LNSPEND*
MAMMAL	−0.11	0.87*	0.73	0.42
BIRD	0.63	1.21**	0.39	0.59
REPTILE	−0.55	0.82	−1.79**	−1.71**
AMPHIBIAN	0.48	−1.51**	−0.71	−0.78
ENDANGERMENT	0.31*	−1.43**	0.62**	0.85**
SIZE	0.03	0.29*	0.86**	0.66**
UNIQUE	0.33	0.85**	0.06	—
SUBSPECIES	—	—	−0.52	—
PRIORITY	—	—	—	−0.10*
CONFLICT	—	—	—	1.19**
CONSTANT	1.24**	0.97*	9.17**	9.39**
Method of Estimation	OLS	Logit	OLS	OLS
Number of Obs.	142	509	229	229
R^2	.07	.25	.31	.41

Notes: Dependent variables and samples for each regression are (1) LNCOMMENTS: the log of total favorable comments received during the public comments period, as published in the Federal register, the sample includes the 142 vertebrate species listed after 1975; (2) LISTED: 1 if a species is listed (as of 1997) under the ESA and 0 otherwise; the sample includes all vertebrate full species that were ranked G1, G2 or G3 by the Nature Conservancy as of 1993; (3) and (4) LNSPEND: the log of total government spending from 1989 to 1993. The sample includes all taxonomic units (species, subspecies, and populations) that were listed as of 1989. Independent variables: MAMMAL, BIRD, REPTILE, and AMPHIBIAN are dummy variables which equal 1 when the species is a member of that taxonomic class and 0 otherwise. (Coefficients can be interpreted relative to FISH, the excluded dummy variable.) ENDANGERMENT is the Nature Conservancy's Global Endangerment Rank as of 1993. SIZE is the log of the physical length for a typical individual of the species. UNIQUE is a dummy variable equal to 1 if the species is the only species in its genus. SUBSPECIES is a dummy variable equal to 1 if the taxonomic unit is below the level of full species. PRIORITY is the FWS 1-18 priority ranking for the species. CONFLICT is the FWS priority tiebreaker indicating whether or not a species is in conflict with development. (*) and (**) indicate that the relevant coefficient is significant at the five percent and one percent levels, respectively. Please see Cash et al. (1997) for a detailed description of the variables used in these estimations.

in the sample because there is no comprehensive database of unlisted units below the level of full species. Several of the factors discussed above appear to play some role in the listing decision. Some dummies for taxonomic class are significant (relative to the excluded dummy for FISH): positive for MAMMAL and BIRD, and negative for AMPHIBIAN. Taxonomic uniqueness appears to play a positive role in the likelihood of listing, as does SIZE and ENDANGERMENT. All in all, the decision of what to place on the official endangerment list seems consistent with our conceptual framework.

The regression in the third column uses the log of the sum of public spending from 1989 to 1993, LNSPEND, as the dependent variable. Here, we use the same regressors as before, with the addition of SUBSPECIES, the dummy variable indicating that the taxonomic unit is below the level of a full species. The sample includes all protected taxonomic units (species, subspecies, and populations) that were listed as of the end of 1989, when the spending data was first collected. There are two important results from this regression. First, the coefficient on SIZE is large and significant. Since the SIZE variable is the log of physical length, its coefficient may be interpreted as an elasticity; it implies an 8.6 percent increase in spending for a 10 percent increase in length. Even more striking, however, is the positive and significant coefficient on ENDANGERMENT. As with the counterintuitive results for the regression in the first column, this sign implies that the more highly endangered a species is, the *less* attention it receives. (Again recall that the most endangered species receive ENDANGERMENT ratings of 1, and the least endangered species receive ratings of 5.) We have argued elsewhere that this result suggests either terribly perverse priority setting, or, more likely, an overpowering role for omitted unobservable charisma-like factors negatively correlated with ENDANGERMENT (Metrick and Weitzman, 1996). In either case, it is difficult to reconcile the sign of the ENDANGERMENT coefficient with the belief that more spending should go to the more highly endangered species, other things being equal. Owing to our belief that spending is the best proxy we have for Noah's ranking, we believe that this regression provides the most striking empirical results in the paper.

The regression in the fourth column is similar to the one in the third column, but adds the regressors PRIORITY (the Fish and Wildlife Service priority ranking from 1 to 18) and CONFLICT (a dummy equal to 1 if the species is in conflict with development according to the Fish and Wildlife Service), while dropping UNIQUE and SUBSPECIES since they are part of the PRIORITY calculation. The results show that while the Fish and Wildlife Service is following their system to some degree, the role played by CONFLICT is far larger than might be anticipated. In fact, this ostensibly least important criterion in the system, supposedly just a tiebreaker, dominates the other three. Although the sign of the CONFLICT coefficient is consistent with the intention of the Fish and Wildlife priority system, its magnitude is out of proportion. Furthermore, the sign on this coefficient is not consistent with the cost-benefit formula laid out earlier; apparently, the Fish and Wildlife Service gives priority to species with high opportunity costs. We believe that the setting of CONFLICT may be endogenous, and that the results of this regression suggest a commingling of supposed objective evaluation of endangerment levels with the preference-based spending decision. In turn, this suggests that the country might better be served by separating the intelligence-gathering and policy-making arms of the Fish and Wildlife Service.

What have we learned from these empirical exercises? First, charismatic megafauna effects do seem to matter a lot; in fact, there is strong evidence that people weigh utility the heaviest of the four criteria. Second, survivability, diversity, and costs do not seem to play their "expected" role in spending decisions. Third, the (ostensibly) scientific part of the priority system seems to be influenced by the same subjective factors that influence spending.

Conclusion

The core of the problem of biodiversity preservation today lies in specifying the objective that we are trying to preserve. We cannot evaluate the overall performance of conservation agencies, like the U.S. Fish and Wildlife Service, without specifying much more clearly what is the "output" on which they are to be graded.

At the end of the day, we must make up our minds about what is the objective function before we can properly use scientific information or formulate rational policies for good stewardship. This means confronting honestly the core problem of economic tradeoffs—because good stewardship of natural habitats, like almost everything else we want in this world, is subject to budget constraints. The evidence suggests that our actual behavior may not reflect a reasoned cost-benefit calculation. If this is true, then we should fix it. If it is not, then we should be honest about our desire to have "charismatic megafauna" effects dominate our decisions.

■ *We thank Judson Jaffe for research assistance, and Brad De Long, J.R. DeShazo, Alan Krueger, Rob Stavins, and seminar participants at Stanford for helpful comments. We are especially grateful to Timothy Taylor, whose help in rewriting this final version went far beyond the usual editorial obligations. We also acknowledge support under National Science Foundation grant SBR-9422772.*

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