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Economic benefits of rare and endangered species: summary and meta-analysis

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Abstract

The economic value of rare, threatened and endangered species to citizens of the USA has been measured using the contingent valuation method for 18 different species. Annual willingness to pay (WTP) range from a low of $6 per household for fish such as the striped shiner to a high of $95 per household for the northern spotted owl and its old growth habitat. A regression analysis of WTP values shows that over half of the variation in WTP is explained by the change in the size of the population, whether the payment is one-time or annual, whether the respondent is a visitor or non-user and whether the species is a marine mammal or bird. This illustrates that the contingent valuation method can provide meaningful estimates of the anthropocentric benefits of preserving rare and endangered species. Thus, economic techniques are available to perform broad-based benefit-cost analyses of species preservation. However, the Safe Minimum Standard approach is offered as an alternative for endangered species preservation decisions. The values reported in this paper are most useful to assess whether the costs are likely to be disproportionate to the benefits. To date, for even the most expensive endangered species preservation effort (e.g., the northern spotted owl) the costs per household fall well below the benefits per household found in the literature.

Keywords: Existence value; Willingness-to-pay; Contingent valuation

1. Introduction

The Endangered Species Act (ESA) is often ridiculed for placing the well-being of fish and wildlife ahead of people. As will be shown in this paper, this is a false dichotomy. The studies in the literature show that people value a wide variety of species from the obscure striped shiner (a fish in the Milwaukee River) to whooping cranes. In re-authorizing ESA, Congress is not only considering lifting the current prohibition on the use of economic analysis in the listing process, it may go as far as *requiring* benefit-cost analysis in the listing decision. This paper provides a discussion of: (1) the types of economic benefits provided by Threatened and Endangered (T&E) species; (2) the primary technique used to quantify these benefits; (3) a summary of the economic valuation studies performed to date, many of which have not been reported in the published literature; (4) a meta-analysis regression to identify the variables which explain the variation in values of T&E species. Based on these analyses we recommend that if Congress requires economic analysis, one of two approaches would be superior to the

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current practice. First, valuation of multiple T&E species inhabiting the same ecosystems would be more sensible than the current species-by-species approach to valuation. Second, we suggest that an approach called the Safe Minimum Standard (Bishop, 1978) may be a better avenue for injecting economic analysis into re-authorization of ESA than relying on formal benefit-cost analysis.

2. Economic benefits versus impacts

To date, most of the economic analyses performed by opponents of species listing and the US Fish and Wildlife Service (in their critical habitat decisions) focus upon the short-run effects on local jobs. While these figures sometimes have significant shock value, rarely is it acknowledged that decreases in commodity production in one region are usually made up by increases in production (and corresponding employment gains) in other regions. This type of analysis is frequently called 'economic impact' or 'regional economic effects analysis' and often has little to do with the long-run benefits or costs of species preservation.

While a transfer of economic activity is not a cost of protecting T&E species, there are often real opportunity costs to society from protecting T&E species and their habitats in the form of higher costs of production or valuable uses foregone. As such, economic benefits and costs must be defined and measured in a commensurate fashion. Measuring benefits using willingness to pay (WTP) is the conceptually correct measure of benefits (Just et al., 1982) and is the currently accepted norm among federal agencies for benefit-cost analysis (US Water Resources Council, 1983) and Natural Resource Damage Assessment (Department of Interior, 1986). Since the public owns T&E species, willingness to accept for avoiding losses would often be the more appropriate measure. However the public's unfamiliarity with being offered compensation as compared to being asked to pay for programs, coupled with difficulties in empirical measurement, results in nearly all studies measuring WTP. The reliance on a conservative measure such as WTP may help to offset the concern that the survey technique used to elicit WTP (discussed below) may overstate values since payment is hypothetical.

The anthropocentric or human-centered benefits of protecting T&E species can be grouped into several categories: (a) *use value* such as viewing of the species; (b) *an option value* to maintain genetic information provided by populations of T&E species that may be useful for medicinal and genetic engineering applications (Loomis, 1995); (c) *existence value* derived from the satisfaction of knowing that a particular species has a sustainable population in its native habitat; (d) *bequest value* the current generation receives from knowing preservation today provides this species to future generations. Collectively these benefits are often referred to as Total Economic Value (Randall and Stoll, 1983). Some or all of these motivations are present when individuals value protection of T&E species.

It is also worth noting that while humans may appear to only directly value the 'charismatic megavertabrates', such a valuation may often include implicit valuation for the components of the ecosystem that supports these high-profile species. For example, humans may value watching bald eagles yet be unaware or indifferent toward pocket gophers. Yet if pocket gophers are a critical part of the raptors' food supply, then humans have a derived value for the pocket gophers and their habitat. Thus, while an anthropocentric valuation paradigm may seem to ignore many underlying and important ecological functions or biocentric values, this may not always be the case. The ecological inter-relationships necessary to support the high-profile species may mean that the entire ecosystem must be protected.

3. Contingent valuation method

Through various laws, society has declared that T&E species are not commodities to be bought and sold in markets. But these laws suggest that lack of a price for T&E species does not mean lack of value. Therefore economists have developed a hypothetical market method, called the Contingent Valuation Method (CVM), that uses a survey to measure household WTP. A CVM survey involves developing a hypothetical market or referendum which an individual uses to reveal or state his or her WTP for protection of a specific species in a particular location. The structure of the hypothetical market involves three elements: (1) description of the species and habitat proposed for preservation—this includes location of habitats and specific changes in population as well as the consequences of paying or not paying; (2) the form and frequency of the payment —for T&E species, common forms include higher income taxes, increases in utility bill and payments into a dedicated trust fund; (3) how they are asked their WTP—i.e., as an open-ended question (e.g., what is the most you would pay?), circling a dollar amount from a list of alternative figures on a payment card or simply responding 'yes' or 'no' to a single dollar amount (which varies across respondents). This latter question format is called 'dichotomous choice' or 'referendum' due to its similarity to voting on a bond issue (Hanemann et al., 1991). See Mitchell and Carson (1989) for a complete discussion of the CVM methodology.

Relying on statements of hypothetical or intended behavior is not without its critics (Diamond and Hausman, 1994). However, CVM has been upheld by the US District Court of Appeals (Department of Interior, 1989) and has been approved for use by federal agencies performing benefit-cost analysis (US Water Resources Council, 1983) along with valuing natural resource damages. In addition, carefully constructed CVM studies have shown to be valid when measuring the value of air quality in urban areas (Brookshire et al., 1982) and deer hunting permits (Welsh, 1986). Moreover, CVM values have been found to be reliable in test-retest reliability studies (Loomis, 1990).

4. Data sources

The studies reported in this paper were located by searching several bibliographic databases as well as by contacting CVM researchers to locate the gray literature in this area. Of the 20 studies, about half are not available in the published literature since they are contract reports, proceedings papers and dissertations. Since several studies reported multiple estimates of WTP, we used their 'best estimate' if identified by the authors. Otherwise we averaged across estimates unless the variation in estimated values related to our explanatory variables such as differences in the sample frame (e.g., visitors versus households) or WTP elicitation method (e.g., open-ended WTP question versus dichotomous choice). We used mean WTP rather than median, as mean WTP is appropriate for benefit-cost analysis. Since a majority of studies (particularly early CVM studies) surveyed only state residents, consistency suggested we rely upon these state estimates in those few cases where multiple geographical areas were sampled. The only exception occurred when the sample size of the local sample was quite small relative to the US sample. In this case we believe the added reliability of the much larger sample size is more important. We, of course, recognize that benefits of preserving federally listed T&E species are national in scope. Thus, both the value per household and number of households to aggregate over should include all US households. Nevertheless, our purpose here is not to provide such aggregate estimates.

5. Results

5.1. Annual values per household

Table 1 provides an overview of the WTP estimates for each species as well as the average value

Table 1
Summary of economic values of rare and T/E species ($1993)

	Low value	High value	Average of all studies
Studies reporting annual WTP			
Northern spotted owl	$44	$95	$70
Pacific salmon/Steelhead	$31	$88	$63
Grizzly bears			$46
Whooping cranes			$35
Red-cockaded woodpecker	$10	$15	$13
Sea otter			$29
Gray whales	$17	$33	$26
Bald eagles	$15	$33	$24
Bighorn sheep	$12	$30	$21
Sea turtle			$13
Atlantic salmon	$7	$8	$8
Squawfish			$8
Striped shiner			$6
Studies reporting lump sum WTP			
Bald eagles	$178	$254	$216
Humpback whale			$173
Monk seal			$120
Gray wolf	$16	$118	$67
Arctic grayling/Cutthroat trout	$13	$17	$15

Table 2
WTP per household ($1993) for rare and T/E species

Reference	Survey date	Species	Gain or loss	Size of change	Willingness to pay		CVM method	Survey region	Sample size	Response rate	Payment vehicle
					Lump sum	Annual					
Bowker and Stoll (1988)	1983	Whooping crane	Avoid loss	100%		$31.81	DC	TX and US	316	36%	Foundation
		Whooping crane	Avoid loss	100%		$49.92	DC	Visitors	254	67%	Foundation
Boyle and Bishop (1987)	1984	Bald eagle	Avoid loss	100%		$15.40	DC	WI households	365	73%	Foundation
		Striped shiner	Avoid loss	100%		$6.04	DC				
Brookshire et al. (1983)	1983	Grizzly bear	Gain for hunting permits			$36.58	OE	WY hunters	810	27%	Wildlife stamp
		Bighorn sheep				$29.86	OE				
Carson et al. (1994)	1994	Bald eagle Peregrine falcon Kelp bass White croaker	Speed recovery from a natural 50 year period to 5 years		$63.24		DC	CA households	2810	73%	One-time tax
Cummings et al. (1994)	1994	Squawfish	Avoid loss	100%		$8.42	OE	NM	921	42%	Increase state taxes
Duffield (1991)	1991	Gray wolf	Reintroduction		$68.84		DC	Local visitors	158	31%	Lifetime membership
Duffield (1991)	1991	Gray wolf	Reintroduction		$107.00		DC	US visitors	366	31%	
Duffield (1992)	1992	Gray wolf	Reintroduction		$117.52		DC	Local visitors	121	86%	Lifetime membership
Duffield (1992)	1992	Gray wolf	Reintroduction		$69.67		DC	US visitors	389	86%	
Duffield et al. (1993)	1992	Gray wolf	Reintroduction		$27.11		DC	Region household	189	47%	Life-membership
USDOI (1994)	1993	Gray wolf	Reintroduction		$20.50		DC	Region household	335	70%	Lifetime membership
USDOI (1994)	1993	Gray wolf	Reintroduction		$15.60		DC	Region household	345	70%	
Duffield and Patterson (1992)	1992	Arctic grayling	Improve 1 of 3 rivers		$17.36		PC	US visitors	157	27%	Trust fund
		Cutthroat trout			$13.02		PC	US visitors	170	77%	Trust fund
Hageman (1985)	1984	Gray-blue whale	Avoid loss	100%		$33.33	PC	CA households	180	21%	Increasefederal tax
		Sea otter	Avoid loss	100%		$28.88	PC		174		
Hagen et al. (1992)	1990	No. spotted owl	Avoid loss	100%		$95.42	DC	US households	409	46%	Taxes and wood prices
King et al. (1988)	1988	Bighorn sheep	Avoid loss	100%		$12.36	OE	AZ households	550	59%	Foundation

Loomis and Larson (1994)	1991	Gray whale	Gain	50%		$17.15	OE	CA households	890	54%	Protection fund
		Gray whale	Gain	100%		$19.23	OE	CA households	890	54%	
		Gray whale	Gain	50%		$26.50	OE	CA visitors	1003	72%	Protection fund
		Gray whale	Gain	100%		$31.51	OE	CA visitors	1003	72%	
Olsen et al. (1991)	1989	Salmon and	Gain	100%		$31.29	OE	Pac. NW household	695	72%	Electric bill
		Steelhead	Gain	100%		$88.40	OE	Pac. NW anglers	482	72%	
Reaves et al. (1994)	1992	Red-cockaded	% chance	99%		$10.64	OE	SC and US households	225	53%	Recovery
		woodpecker	of survival	99%		$14.82	DC		223	52%	fund
				99%		$9.52	PC		234	53%	
Rubin et al. (1991)	1987	Spotted owl	% chance of survival	30%		$28.09	OE	WA households	249	23%	Unspecified
				75%		$22.09	OE				
				100%		$44.25	OE				
Samples and Hollyer (1989)	1988	Monk seal	Avoid loss	100%	$119.70		DC	HI households	165	40%	Preservation fund Money and Time
		Humpback whale	Avoid loss	100%	$172.92						
Stevens et al. (1991)	1989	Atlantic salmon	Avoid loss	100%		$7.29	DC	MA households	169	30%	Trust fund
		Atlantic salmon	Avoid loss	100%		$8.10	OE				
		Bald eagle	Avoid loss	100%		$32.94	DCOE	New England	339	37%	Trust fund
		Bald eagle	Avoid loss	100%		$23.20		households			
Swanson (1993)	1993	Bald eagle	Increase in populations	300%	$254.63		DC	WA visitors	747	57%	Membership fund
				300%	$178.36		OE	WA visitors			
Walsh et al. (1985)	1985	26 species in CO	Avoid loss	− 100%		$58.00	OE	CO households	198	99%	Taxes
Whitehead (1991, 1992)	1991	Sea turtle	Avoid loss	100%	$12.99		DC	NC households	207	35%	Preservation fund

(when there are multiple studies). Dollar values were converted to a 1993 base year using the Consumer Price Index. Table 2 provides the details of each study we found in the literature. Not all of these studies could be used in the meta-analysis as it was difficult to obtain observations for all of the variables (e.g., it was impossible to calculate the percentage change in populations being offered in the Brookshire et al. grizzly bear and bighorn sheep study). This may not be surprising as this early study was performed to test several hypotheses rather than to solely provide an economic value for a given change in T&E species populations. Table 2 also includes CVM studies that elicited one value for a group of T&E species, which could not be used in a single-species meta-analysis (i.e., the Carson et al. and Walsh et al. studies were dropped due to this factor). Since several of the categories in Table 2 are used as explanatory variables in the meta-analysis, the categories are explained in the next section.

5.2. Meta-analysis

A regression-based approach to 'explaining' the variation in values from past literature has seen increasing application in non-market valuation (Smith and Kaoru, 1990; Walsh et al., 1992; Boyle et al., 1994). As Smith and Kaoru note, this approach to drawing conclusions from the literature has the advantage of being able to systematically account for the complex set of factors that influence any particular estimate of WTP. Our basic model to explain the WTP for T&E species includes variables that economic theory would suggest as important. In particular, if the size of the species population provides utility to humans, we would expect WTP to be greater in magnitude, the larger the increase in population proposed in the survey. A one-time payment should be larger in magnitude than an equivalent annual payment that continues into the foreseeable future. In addition, we include variables that the empirical literature on CVM has found to influence the estimated WTP (e.g., dichotomous choice versus open-ended question format). Our model is given in the following equation:

$$\begin{aligned}\mathrm{WTP}(\$93) = {} & B_0 + B_1\mathrm{CHANGESIZE} \\ & + B_2\mathrm{PAYFREQUENCY} \\ & + B_3\mathrm{CVFORM} + B_4\mathrm{VISITOR} \\ & \pm B_5\mathrm{FISH} + B_6\mathrm{MARINE} \\ & + B_7\mathrm{BIRD} - B_8\mathrm{RESPONSERATE} \\ & \pm B_9\mathrm{STUDYYEAR}),\end{aligned}$$

where WTP($93) is per household WTP; CHANGESIZE is the percentage change in population proposed in the survey; PAYFREQUENCY is coded 1 for a one-time payment or a purchase of a lifetime membership, 0 for an annual payment amount; CVFORM is coded 1 for dichotomous choice and 0 for open-ended and payment card; VISITOR is coded 1 if the sample frame were visitors and 0 if households; FISH is 1 if the species being valued is a fish; MARINE is 1 if species is a marine mammal; BIRD is 1 if species is a bird; RESPONSE RATE is survey response rate; STUDY YEAR is year the study is performed.

The signs in front of the variables indicate their hypothesized effect on WTP. The literature suggests that open-ended WTP questions give lower estimates of WTP (Walsh et al., 1992) and dichotomous choice often yields higher estimates of WTP (Walsh et al., 1992; Boyle et al., 1994). One would expect individuals who are viewing the species of interest to pay more for preservation than non-visiting households (Loomis and Larson, 1994). The sign on FISH is hypothesized to be ambiguous. The popular press would suggest less WTP for fish than more aesthetically appealing species. However, about half the fish species included in our analysis are salmon and steelhead which have a significant cultural value in the Pacific Northwest and the Northeastern US Marine mammals (e.g., 'save the whales') and birds are expected to have a positive influence on WTP. Response rate may be expected to have a negative sign on WTP for two reasons. First, the higher the response rate, the more likely that disinterested households have answered the questionnaires and thus the lower WTP is likely to be. Second, Boyle et al. (1994, p. 1059) suggest response rate may be an indicator of overall quality of the survey effort (i.e., higher quality questionnaires, more follow-up mailings, etc.) and they believe this would tend to lower WTP. Study year is included to control for other refinements in CVM methodology that have occurred over time (Smith and Kaoru, 1990, p. 427) and capture any trend in WTP values due to increasing negative publicity associated with ESA. Other variables such as survey mode (e.g., mail, telephone, in-person) were not considered since nearly all of the studies of individual species used mail questionnaires. To test the sensitivity of the analysis to functional form, we also estimated a double log model as well as a semi-log model. In the double log model, the natural log of WTP and the natural log of the continuous variables (i.e., non-dummy variables) were used. Thus, CHANGESIZE and RESPONSE RATE were logged in the full model.

Table 3 presents the results for the full meta-analysis regression as well as the reduced model of variables significant at the 0.1 level or higher. Overall, the regression equation does a fairly good job explaining the variation in WTP amounts presented in Table 1, as 58 to 68% of the variation in WTP is explained by the included variables. The pattern of signs and significance is fairly robust to alternative functional forms. A semi-log of the dependent variable also gives a similar pattern, but is not reported to conserve space (results available from the authors).

Several interesting observations are readily apparent from reviewing what is and is not significant in Table 3. As would be hoped for, the size of the change in T&E species populations proposed in the particular CVM survey is statistically significant at the 1% level in both the full and reduced models, using both the linear and double log functional form. This suggests that WTP results are not merely symbolic votes for preservation, but sensitive to the magnitude of the change proposed. The point estimates of the CHANGESIZE coefficients in the both the double log models suggests that each additional percent increase in a species population offered in the survey results in WTP rising by less than 1% (ranging from 0.769 in the full model to 0.803 in the reduced model). Thus, not only does WTP increase with increases in population, but it does so at a decreasing rate as would be suggested by economic theory.

Payment frequency matters as well, with one time payments about $42–45 higher than annual pay-

Table 3
Meta-analysis regressions for WTP for threatened and endangered species preservation

	Full models		Reduced model	
	Linear	Double log	Linear	Double log
Variable				
CONSTANT	100.04	4.32	−49.43	−1.13
(t-statistic)	(0.57)	(1.06)	(−3.91)	(−0.911)
CHANGESIZE	0.59	0.769	0.61	0.803
	(5.06)	(2.57)	(5.23)	(2.88)
PAYFREQUENCY	45.51	0.82	42.01	0.771
	(2.89)	(2.53)	(3.14)	(2.87)
CVFORM	14.33	0.05		
	(1.12)	(0.18)		
VISITOR	24.03	0.82	23.55	0.773
	(1.71)	(2.73)	(1.84)	(2.87)
FISH	24.26	0.028		
	(1.31)	(0.07)		
MARINE	49.87	0.75	35.76	0.85
	(2.58)	(1.83)	(2.59)	(2.96)
BIRD	33.41	0.57	21.72	0.648
	(1.85)	(1.52)	(1.66)	(2.48)
RESPONSE RATE	0.002	−0.12		
	(0.008)	(−0.38)		
STUDY YEAR	−1.89	−0.05		
	(−0.98)	(−1.29)		
Adj R^2 =	0.682	0.623	0.677	0.589
N =	38	38	38	38
F =	9.82	5.14	16.57	9.19

ments. Again, this suggests that respondents to CVM surveys about T&E species appear to be paying attention to the details. This is particularly encouraging since the vast majority of the results are from mail surveys, the survey mode that is believed to be the least preferred (Arrow et al., 1993).

As expected, visitors also have a higher WTP than households. As discussed earlier, this is quite sensible since visitors are likely to have a large recreation component to their total value and are likely to be more knowledgeable about the species. Finally, the WTP for marine mammals and birds are statistically greater than for other species such as fish, land mammals and reptiles.

Table 3 also reveals what did not have a statistically significant effect on WTP. For example, whether the WTP question was asked as dichotomous choice, payment card or open-ended appears not to matter in either the linear or double log meta-equation. Neither equation demonstrated a significant relationship of survey response rate or the year of the study on WTP. These are encouraging findings in terms of reliance on existing CVM values to infer the values of unstudied endangered species. Thus, when inferring a value of an unstudied endangered species from the existing literature, the analyst may not need to be overly concerned about what question format was used or what the response rate was in the original study.

6. Policy implications

This study suggests that CVM can provide estimates of Total Economic Value for rare and T&E species that are sensitive to the size of the change in population and frequency of the payment, and insensitive to WTP question format. It appears that these economic values can be developed from mail surveys that need not cost a million dollars. As more studies are performed and our meta-equation updated, the possibility exists that the equation itself could be used to infer a value for particular species. This could be performed by setting the dummy variable for the type of species (e.g., bird, marine mammal), inserting the proposed change in population and determining whether the primary beneficiaries are only households (VISITOR = 0). While such a benefit transfer carries with it the potential for greater error than performing an original study (Loomis et al., 1995), it may often provide a rough first estimate to determine whether the benefits are likely to be much larger or much smaller than the costs. In those cases where the annual value per household predicted from the meta-equation was close to the cost per household, an original CVM study may be undertaken to increase the confidence a decision maker would have in the benefit-cost comparison.

While CVM appears suitable to meet the challenge for calculating economic benefits of T&E species, the benefits quantified to date reflect a human-centered view, based on our current understanding of the role the species has in a particular ecosystem. This knowledge is frequently incomplete. In the face of our poor understanding of the ecological role of different species and given the fact that extinction is irreversible, a more cautious strategy would involve adoption of the Safe Minimum Standard (SMS) approach first proposed by Wantrup (1968) and promoted by Bishop (1978) and others (Castle and Barrens, 1993).

While entire papers have been devoted to SMS, the basic approach is nicely summarized by Randall (1987, pp. 413–414). Essentially, the opportunity costs of ensuring survival of the species are calculated and a species is preserved unless the cost is 'very high' or 'too high'. Of course, different individuals will judge what is 'too high' differently, but this is where the values estimated from the meta-equation can be judiciously employed. If the opportunity costs per household exceed by a substantial margin the benefits per household, then this might be one indicator that the costs are too high. It is worth noting that even in supposedly 'high cost' cases such as the Northern Spotted Owl, the costs per household have been relatively low. Hagen et al. (1992, p. 16) found the cost per US household to be $3.39, while Stone and Reid (1995) found the costs in British Columbia (BC) to be $5–6 per BC household for most habitat protection alternatives. Clearly these costs are well below the benefits per household presented in Table 2.

Thus, the dispute over the ESA is often not over whether benefits to the nation exceed the opportunity costs. The chorus of complaints arises from those who bear the costs, especially when the costs fall on private landowners. Therefore, distributional issues are often the real concern underlying ESA. While a carefully executed benefit-cost analysis can be performed at a disaggregated level to show who receives the benefits and who bears the costs (Loomis, 1993, p. 122), it does not answer the normative issue of whether the resulting distribution of these benefits and costs is equitable or fair. While benefit-cost analysis can contribute to an informed public debate over just how much critical habitat to protect, we believe it should not be looked upon by either side in the debate as the sole decision rule on listing species or allowing extinctions.

Of final note, conspicuously absent from Tables 1 and 2 are the benefits of preserving plants, even though over half the listed species in the USA are plants (US Fish and Wildlife Service, 1995). Plants are well known to be an important source of active ingredients for medicines and genetic engineering (Loomis, 1995). In principle, CVM can be applied to valuation of plant protection programs, so this should be an important avenue for further research, particularly in combination with attempts to apply CVM to ecosystem valuation. Valuation of plant preservation may also be a candidate for valuation of a coordinated program of T&E species protection. Rather than the current approach of valuing individual species, which misses both ecological complementarity among species (e.g., northern spotted owl, marbelled murlett and several races of salmon all depend on old-growth forest ecosystems) and substitution effects (both in the utility function and in the budget constraint), a habitat-based evaluation is likely to be more useful. More emphasis on a multi-species ecosystem or habitat approach to decision making would be a welcome enhancement in a re-authorized ESA for biologists and economists alike.

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