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ANALYSIS

The total economic value of threatened, endangered and rare species: An updated meta-analysis

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ABSTRACT

This paper updates a 1996 meta-analysis of studies using the Contingent Valuation Method (CVM) to value threatened, endangered and rare species published in this journal by Loomis and White. A variable for studies conducted in or after 1995 was added to the model to test if new studies are systematically different from old studies and identify which explanatory variables influencing willingness-to-pay (WTP) for these species have changed over time. Generally newer studies yielded higher WTP. Variables such as the change in the size of the species population, payment frequency, survey mode, response rate, type of respondent, type of species, and a new variable for whether a species is a 'charismatic megafauna' or not, whether the species has use and nonuse value versus nonuse value only and year of the study, were found to significantly influence WTP. This model is used in a benefit transfer example and a comparison of original study estimates and model estimates is made to compare its accuracy. The average within sample benefit transfer error was 34–45%.

1. Introduction

Biodiversity is increasingly threatened given current trends in human population growth and development with the number as well as the rate of plant and animal extinctions on the rise. According to the World Conservation Union's 2007 Red List, one in four mammals, one in eight birds, one third of all amphibians, and 70% of the worlds assessed plants are now endangered. There is an awareness of the problems that arise with the loss of biodiversity and this is reflected in the Endangered Species Act (ESA) in the U.S.A. and similar legislation in numerous countries around the world.

Currently, economic analyses may not be incorporated in species listing decisions under the Endangered Species Act but can be incorporated in designating critical habitats and developing recovery plans after a species is listed. However, there has been considerable concern about how these economic analyses are conducted for critical habitat. For instance, Defenders of Wildlife and their Conservation Economics Program has argued that the Fish and Wildlife Service's current practice of monetizing costs while qualitatively describing benefits under the ESA is flawed. They call for more consistent measures of the benefits provided by species (Defenders of Wildlife, 2004). In addition, in 2004, the National Wildlife Federation released a report documenting how the Bush administration used flawed economic data to cut in half critical habitat designations under the ESA, overestimating the costs while ignoring many of the benefits of proposed designations (National Wildlife Federation, 2004). These concerns provide justification for the need of a consistent measure of benefits provided by threatened, endangered and rare species.

The Total Economic Value of the majority of these species consists of both recreational use and nonuse (existence and

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Table 1 – WTP per household ($2006) for threatened and endangered species

Reference	Survey date	Species	Gain or loss	Willingness to pay (2006$)			CVM method	Survey region	Sample size	Response rate	Payment vehicle
				Size of change	Lump sum	Annual					
Bell et al. (2003)	2000	Salmon	Gain	100%		$138.64	DC	Grays Harbor, WA households	357	49.1%	Annual tax—high income
						$91.55					Annual tax—low income
			Gain	100%		$141.27		Willapa Bay, WA households	386	61.7%	Annual tax—high income
						$90.64					Annual tax—low income
			Avoid loss	100%		$57.99		Coos Bay, OR households	424	58.4%	Annual tax—high income
						$47.70					Annual tax—low income
			Avoid loss	100%		$91.99		Tillamook Bay, OR households	347	53.2%	Annual tax—high income
						$28.39					Annual tax—low income
			Avoid loss	100%		$134.00		Yaquina Bay, OR households	357	59.7%	Annual tax—high income
						$87.84					
Berrens et al. (1996)	1995	Silvery minnow	Avoid loss	100%		$37.77	DC	NM residents	726	64.0%	Trust fund
Bowker and Stoll (1988)	1983	Whooping crane	Avoid loss	100%		$43.69	DC	TX and US households	316	36.0%	Foundation
		Whooping crane	Avoid loss	100%		$68.55	DC	Visitors	254	67.0%	Foundation
Boyle and Bishop (1987)	1984	Bald eagle	Avoid loss	100%		$21.21	DC	WI households	365	73.0%	Foundation
		Striped shiner	Avoid loss	100%		$8.32	DC				
Chambers and Whitehead (2003)	2001	Gray wolf	Avoid loss	100%	$22.64		DC	Ely and St. Cloud, MN households	352	56.1%	One-time tax
Cummings et al. (1994)	1994	Squawfish	Avoid loss	100%		$11.65	OE	NM	723	42.0%	Increase state taxes
Duffield (1991)	1990	Gray wolf	Reintroduction		$93.92		DC	Yellowstone National Park visitors	158	30.6%	Lifetime membership
Duffield (1992)	1991	Gray wolf	Reintroduction		$162.10		DC	Yellowstone National Park visitors	121	86.0%	Lifetime membership
Duffield et al. (1993)	1992	Gray wolf	Reintroduction		$37.43		DC	ID, MT, WY household	189	46.6%	Lifetime membership
USDOI (1994)	1993	Gray wolf	Reintroduction		$28.37		DC	ID, MT, WY household	335	69.6%	Lifetime membership
USDOI (1994)	1993	Gray wolf	Reintroduction		$21.59		DC	ID, MT, WY household	345	69.6%	
Duffield and Patterson (1992)	1991	Arctic grayling	Improve 1 of 3 rivers	33%	$26.47		PC	US visitors	157	27.3%	Trust fund
		Arctic grayling		33%	$19.84		PC	US visitors		77.1%	Trust fund
Giraud et al. (1999)	1996	Mexican spotted owl	Avoid loss			$68.84	DC	US households	688	54.4%	Trust fund

Giraud et al. (2002)	2000	Steller sea lion	Avoid loss	100%		$70.90	DC	AK and US households	1653	63.6%	Increase federal tax
Hageman (1985)	1984	Bottlenose dolphin	Avoid loss	100%		$36.41	PC	CA households	180	21.0%	Increase federal tax
		Northern elephant seal	Avoid loss	100%		$34.50	PC		174		
Hageman (1985)	1984	Gray-blue whale	Avoid loss	100%		$45.94	PC	CA households	180	21.0%	Increase federal tax
		Sea otter	Avoid loss	100%		$39.80	PC		174		
Hagen et al. (1992)	1990	No. spotted owl	Avoid loss	100%		$130.19	DC	US households	409	46.0%	Taxes and wood prices
King et al. (1988)	1985	Bighorn sheep	Avoid loss	100%		$16.99	OE	AZ households	550	59.0%	Foundation
Kotchen and Reiling (2000)	1997	Peregrine falcon	Gain	87.5%	$32.27		DC	ME residents	206	63.1%	One-time tax
Layton et al. (2001)	1998	Eastern WA and Columbia River Freshwater Fish	Gain	50%		$210.84	CE	WA households	801	68.0%	Monthly payment
		Eastern WA and Columbia River Migratory Fish	Gain	50%		$146.57					(converted to annual)
		Western WA and Puget Sound Freshwater Fish	Gain	50%		$229.31					
		Western WA and Puget Sound Migratory Fish	Gain	50%		$307.76					
		Western WA and Puget Sound Saltwater Fish	Gain	50%		$311.31					
Loomis (1996)	1994	Salmon and steelhead	Gain	600%		$79.53	DC	Clallam County, WA households	284	77.0%	Increase federal tax
		Salmon and steelhead	Gain	600%		$98.41	DC	WA households	467	68.0%	
		Salmon and steelhead	Gain	600%		$91.67	DC	US households	423	55.0%	
Loomis and Ekstrand (1997)	1996	Mexican spotted owl	Avoid loss			$51.52	MB	US households	218	56.0%	
Loomis and Larson (1994)	1991	Gray whale	Gain	50%		$23.65	OE	CA households	890	54.0%	Protection fund
		Gray whale	Gain	100%		$26.53	OE	CA households	890	54.0%	
		Gray whale	Gain	50%		$36.56	OE	CA visitors	1003	71.3%	Protection fund
		Gray whale	Gain	100%		$43.46	OE	CA visitors	1003	71.3%	
Olsen et al. (1991)	1989	Salmon and steelhead	Gain	100%		$42.97	OE	Pac. NW households	695	72.0%	Electric bill
			Gain	100%		$95.86	OE	Pac NW HH option		72.0%	
			Gain	100%		$121.40	OE	Pac. NW anglers	482	72.0%	
Reaves et al. (1994)	1992	Red-cockaded woodpecker	% chance of survival	99%		$14.69	OE	SC and US households	225	53.0%	Recovery fund
				99%		$20.46	DC		223	52.0%	
				99%		$13.14	PC		234	53.0%	Unspecified
Rubin et al. (1991)	1987	No. Spotted owl	% chance of survival	50%		$38.61	OE	WA households	249	23.0%	
				75%		$39.99	OE				
				100%		$60.84	OE				
Samples and Hollyer (1989)	1986	Monk seal	Avoid loss	100%	$165.80		DC	HI households	165	40.0%	Preservation fund
		Humpback whale	Avoid loss	100%	$239.53						Money and time
Stanley (2005)	2001	Riverside fairy shrimp	Avoid loss	100%		$28.38	PC	Orange County, CA households	242	32.1%	Annual tax

(continued on next page)

Table 1 (*continued*)

Reference	Survey date	Species	Gain or loss	Willingness to pay (2006$) Size of change	Lump sum	Annual	CVM method	Survey region	Sample size	Response rate	Payment vehicle
Stevens et al. (1991)	1989	Wild Turkey	Avoid loss	100%		$11.38	DC	New England households	339	37.0%	Trust Fund
			Avoid loss	100%		$15.36	OE	New England households			
		Atlantic salmon	Avoid loss	100%		$10.00	DC	MA households	169	30.0%	Trust fund
		Atlantic salmon	Avoid loss	100%		$11.12	OE				
		Bald eagle	Avoid loss	100%		$45.21	DC	New England households	339	37.0%	Trust fund
		Bald eagle	Avoid loss	100%		$31.85	OE				
Swanson (1993)	1989	Bald eagle	Increase in populations	300%	$349.69		DC	WA visitors	747	57.0%	Membership fund
				300%	$244.94		OE	WA visitors			
Whitehead (1991, 1992)	1991	Sea turtle	Avoid loss	100%		$19.01	DC	NC households	207	35.0%	Preservation fund

bequest) values, which can be measured by eliciting willingness-to-pay (WTP) for the preservation of a particular species. However, it is important to note that some species have nonuse values only. Currently, one of the most accepted methods used to estimate the Total Economic Value provided by species is the Contingent Valuation Method (CVM). This method employs the use of surveys outlining a hypothetical market or referendum (Mitchell and Carson, 1989). It has been found that people are willing to pay a small portion of their income towards the protection of endangered or rare species for a variety of reasons. While numerous CVM studies valuing threatened and endangered (T&E) species have been conducted, especially over the last 30 years, performing an original study to value every single species would be costly and time-consuming.

An important alternative is benefit transfer, a form of secondary research which has been used extensively in the past couple of decades. Rosenberger and Loomis (2003) define this term as the use of existing data or information in settings other than for what it was originally collected. The two forms of benefit transfers are value transfer and function transfer. In the former, a single estimate or average of multiple estimates, is transferred from the original site where primary research was conducted (called the study site) to a site with similar species that are being evaluated (called the policy site). In a function transfer, a statistical function is estimated based on the original studies and then this function is applied to the study site to calculate a value tailored to the study site. Function transfers are generally viewed as more accurate than value transfers because they can be tailored to account for differences in the site characteristics (Rosenberger and Loomis, 2003).

The two types of function transfers include demand functions and meta-regression analysis functions. The focus of this paper is on the meta-analysis, which helps to statistically explain the variation in the values obtained in different studies. For instance, looking at various CVM studies valuing threatened or endangered species, this method will help control for the effect of different study variables, such as question format, payment frequency, or type of respondent, to calculate WTP for that type of species. This information and its use in benefit transfer may assist in improving quantification of the economic benefits of critical habitat.

The purpose of this paper is to: (1) update information on the economic valuation of threatened, endangered, and rare species first published by Loomis and White in this journal more than twelve years ago. Using their same model, the first goal is to add new or overlooked CVM studies valuing threatened and endangered species conducted in the U.S.; (2) add a variable to the model to test if WTP from the new studies (conducted in or after 1995) are systematically different from old studies (conducted prior to 1995). This will help to identify whether people's valuation of threatened and endangered species has changed over time; (3) test new specifications, such as how a species 'charisma' affects the value placed on it, to identify an effective model which can be used in benefit transfer; (4) outline an example of how meta-analysis regression functions can be used in benefit transfer to estimate the value of various threatened and endangered species.

2. Methodology

2.1. Data sources

Various economic and scientific research databases were searched, including EconLit, JSTOR, and Web of Science. Eleven new or overlooked CVM studies valuing threatened, rare, or endangered species conducted inside the United States were found, consisting of 29 estimates of value. A summary of these added studies, as well as the 20 studies identified in the Loomis and White (1996) meta-analysis can be found in Table 1. All WTP values were converted to U.S. dollars in a 2006 base year using the Consumer Price Index for comparability. Under the CVM Method column in Table 1, DC represents surveys which used a dichotomous choice question format, OE represents surveys which used an open-ended format, PC represents those which used a payment card question format, CE stands for studies using a conjoint, or choice experiment, technique, and MB represents a multiple-bounded format. Looking at Table 1, the first study by Bell et al. (2003) uses an annual tax as the payment vehicle in their survey. The low income group represents respondents with incomes below $30,000 and respondents with incomes not below $30,000 are categorized as high income.

2.2. Meta-analysis model

In order to systematically explain the variation in the WTP values for threatened and endangered species obtained in different studies, a meta-analysis regression approach can be undertaken. The first meta-analysis on CVM studies valuing threatened and endangered species was published by Loomis and White (1996) and the first goal of this paper is to compare the meta-analysis regression results from their study with the results of a regression including all 31 studies found to date. In order to accurately compare findings, before adding any new variables to the model, the same model used in their study is used here. Their model takes on the following equation, which includes the variables that economic theory would suggest as important:

$$\begin{aligned}\mathrm{WTP} = \beta_0 &+ \beta_1\mathrm{CHANGESIZE} + \beta_2\mathrm{PAYFREQUENCY} \\ &+ \beta_3\mathrm{CVFORM} + \beta_4\mathrm{VISITOR} + / - \beta_5\mathrm{FISH} + \beta_6\mathrm{MARINE} \\ &+ \beta_7\mathrm{BIRD} + / - \beta_8\mathrm{OTHER} - \beta_9\mathrm{RESPONSERATE} \\ &+ / - \beta_{10}\mathrm{STUDYYEAR}.\end{aligned}$$

Willingness to pay for a particular species is a function of: the percentage change in the species population proposed in the survey (CHANGESIZE); payment frequency, coded 1 for a one-time payment or purchase of a lifetime membership and 0 for an annual payment amount (PAYFREQUENCY); contingent valuation format, coded 1 for studies using a dichotomous choice question format in their survey and 0 for those using an open-ended or payment card format (CVFORM); whether the survey respondents were visitors, coded 1, or households, coded 0 (VISITOR); dummy variables broken down by groups of similar species being valued, including fish, mammals, marine mammals, birds, and other, coded 1 if that represents the species being valued, 0 otherwise. MAMMAL is the omitted category from the model in Loomis and White (1996) and is omitted from this model as well. For the purposes of this meta-analysis regression two included studies valued species that did not quite fit into these similar species group variables. So a dummy variable labeled OTHER was included to account for the Riverside fairy shrimp and the sea turtle, coded 1. The final model variables include RESPONSERATE, which is simply the survey response rate, and STUDYYEAR, which is the year the study was performed.

The signs in front of the variables indicate their hypothesized effect on WTP, based on the results from previous literature. The change in the size of the species population being valued should have a positive effect on WTP because value should increase with the size of the population. The positive sign on CVFORM is due to the consistent findings in the literature that when valuing public goods, dichotomous choice, referendum format questions result in higher estimates than open-ended questions, all else constant. Brown et al. (1996) summarize 11 studies which elicit hypothetical WTP values for public goods using both a dichotomous choice and open-ended format, and find that mean WTP values are consistently higher when the survey question was posed using the dichotomous choice format. More recent studies dedicated to this topic find similar results (Balistreri et al., 2001). In addition, surveys using a sample frame of visitors to a particular area would be expected to result in higher values for threatened and endangered species than households, due to the fact that visitors have use as well as non-use values for threatened or endangered species. The hypothesized sign on the species variable coefficients are based on results from previous studies. Response rate is expected to have a negative impact on WTP. Boyle et al. (1994) find that response rate is an overall indicator of the quality of the CVM survey and this may lower WTP estimates. Finally, the year the study was conducted was hypothesized to have an ambiguous effect in Loomis and White (1996) and this is a topic which will be explored further in this study.

Staying consistent with Loomis and White, a full linear and double log model with all original variables thought to influence willingness-to-pay was estimated. In the double log model, the dependent variable, WTP, as well as the independent variables, CHANGESIZE and RESPONSERATE (non-dummy variables), are logged.

2.3. *Use of the Chow test to compare meta-analysis regressions for U.S. studies*

In order to test for differences between the original Loomis and White (1996) meta-analysis regression and the updated model with all U.S. studies, both old and new, the Chow test is used. In particular, if the WTP relationship in new studies is systematically different from that in old studies. The use of the Chow test will show if one or more of the model's variables has statistically changed, so the null hypothesis is that there has been no structural change in the willingness to pay meta-analysis regression model. Since Loomis and White (1996) included studies conducted prior to 1995, the alternative hypothesis is that there has been some structural change in the regression model after 1995. After sorting the data, three models need to be run to conduct the Chow test:

- One full model with all studies — 1983–2001
- One reduced model with studies conducted from 1983–1994
- One reduced model with studies conducted from 1995–2001.

The Chow test formula takes on the following form:

$$F = \frac{(RSS_{pooled} - RSS_{old} - RSS_{new})/K}{(RSS_{old} + RSS_{new})/(N_{old} + N_{new} - 2K)} \sim F_{(K,\ N_{old} + N_{new} - 2K)}$$

where RSS is the sum of squared residuals, N is the number of observations, K is the number of coefficients, pooled is the full model with all studies included, old is studies conducted prior to 1995 and new is studies conducted in or after 1995.

2.4. *New best fit model to explain WTP for threatened and endangered species*

Given the addition of new U.S. CVM studies valuing threatened and endangered species, a new specification or best fit model to explain the willingness-to-pay for threatened and endangered species in the United States will be estimated for the purposes of benefit transfer. Using the full sample of studies conducted in the U.S., seven new variables will be added to the meta-analysis regression to help find a best fit model that explains willingness-to-pay for the preservation of threatened, endangered and rare species. These new variables are NEWSTUDY, LOSS, MAIL, TELEPHONE, IN-PERSON, CHARISMATIC and NONUSE. It is not clear what the sign on the NEWSTUDY variable is expected to be. With some key environmental issues brought into the limelight by various media sources in the late 1990's and environmental issues making their way into the political mainstream by the turn of the decade, the argument could be made that these values would have increased over time. However, recently, economic concerns, the war in Iraq, climate change, etc., may have eclipsed T&E species as an area of concern. As a result, it is unclear but important to measure how these values have changed over time.

A second dummy variable, LOSS, was added to identify whether the change in the size of the species population being valued represented a gain or the avoidance of a loss. For instance, many of the included studies in the sample valued the avoidance of a certain percentage loss in the species population or the avoidance of a total loss in the species population rather than a percentage gain. This is expected to result in a higher WTP value because it puts the species closer to extinction, and thus conservation becomes a priority. Bulte and Van Kooten (1998) point out the importance of looking at the marginal valuation of a species and distinguishing between the benefits of preventing a species from going extinct versus the benefits of certain gains in the species population above the minimum viable population. Bandara and Tisdell (2005) find that the Total Economic Value for a species is likely to be underestimated when respondents feel that the population of the species is at a reasonably secure level. The LOSS variable is coded with a 1 for studies valuing the avoidance of a further loss in a species, and a 0 otherwise. The LOSS variable is expected to have a positive effect on WTP.

The next three variables added, MAIL, TELEPHONE and IN-PERSON, represent the various survey modes used in the included studies. Each variable is coded with a 1 if the survey mode represents that used in a particular study, 0 otherwise. Mail surveys are expected to result in lower WTP than phone or in-person interviews (Noonan, 2003). The IN-PERSON variable was removed to avoid the 'dummy variable trap.'

A variable CHARISMATIC was added to the model to test the effect of a species' 'charisma' or high profile status on the public's valuation. There has been substantial evidence found which indicates that a disproportionate amount of recovery funding goes to relatively few species and it is important to see if these policy measures are aligned with the public's Total Economic Value of these species. Due to the results from previous studies, this variable is hypothesized to have a positive effect on WTP. Although identifying what constitutes 'charismatic megafauna' requires some subjectivity due to the varying definitions of the term, they are generally thought to be large vertebrates which are appealing to humans and focused on to gain support for conservation campaigns. Studies valuing species that were thought to represent 'charismatic megafauna' using classifications from Metrick and Weitzman (1996, 1998) were coded with a 1, 0 otherwise.

One of the new CVM studies valuing T&E species by Layton et al. (2001) uses a conjoint, or choice experiment, technique rather than the Contingent Valuation Method to elicit the value of various anadromous fish populations. This stated that preference method differs from CVM in that it asks respondents to rate a set of alternatives, each one having a number of attributes. In this choice matrix, cost of the program is just one attribute, unlike in a CVM study where cost of the program is the key element. Use of these conjoint techniques to value natural resources have been found to result in higher WTP estimates than when CVM is used (Stevens et al., 2000). To account for these high values, a new dummy variable for studies using this conjoint technique was added, called CONJOINT. All studies are coded 0 except for the Layton et al. (2001) observations, which are coded with a 1.

Finally, while some threatened and endangered species have use values, such as viewing, hunting, and eating, as well as nonuse values, such as existence and bequest values, others have nonuse value only. A dummy variable was added to test this effect, coded 1 for species having nonuse value only and 0 for those having both use and nonuse value. This variable is expected to have a negative effect on WTP.

The question has also been raised as to what effect the level of endangerment facing a particular species has on WTP values. While some of the literature (Metrick and Weitzman, 1996) has shown that the likability of a species plays a more significant role in WTP than the level of species endangerment, recent studies (Tisdell et al., 2006) have found the opposite. While it would have been beneficial to include a variable in the meta-analysis regression model accounting for the level of endangerment faced by each particular species, there was insufficient information in the full sample of studies to test this effect. However, given that a little over half of the sample of studies did specify in the survey instrument the level of endangerment facing the species being valued, a model was run on this subset of the sample with an included dummy variable for threatened versus endangered species to test this effect on WTP. This variable came in insignificant at standard significance levels and the results can be obtained from the authors. Given the mixed findings on this topic, future original CVM studies valuing threatened and endangered species should include the level of threat facing the species so this effect can be further tested.

These new variables are added to the meta-analysis regression model to test whether these other factors could be affecting the public's valuation of threatened and endangered species. A new best fit model to explain WTP for the preservation of threatened and endangered species, including all studies conducted in the U.S., will be estimated to enhance benefit transfer. With the addition of these variables, the new model now takes on the following form:

$$\begin{aligned}\text{WTP (2006\$)} = {} & \beta_0 + \beta_1\text{CHANGESIZE} + \beta_2\text{PAYFREQUENCY} \\ & + \beta_3\text{CVFORM} + \beta_4\text{VISITOR} + / - \beta_5\text{FISH} \\ & + \beta_6\text{MARINE} + \beta_7\text{BIRD} + / - \beta_8\text{OTHER} \\ & - \beta_9\text{RESPONSERATE} + / - \beta_{10}\text{STUDYYEAR} \\ & + \beta_{11}\text{CONJOINT} + / - \beta_{12}\text{NEWSTUDY} + \beta_{13}\text{LOSS} \\ & - \beta_{14}\text{MAIL} + \beta_{15}\text{TELEPHONE} + \beta_{16}\text{CHARISMATIC} \\ & - \beta_{17}\text{NONUSE}.\end{aligned}$$

3. Results

3.1. *Average values per household by species*

Using the total sample of 31 studies with 67 willingness-to-pay observations, the average value of various threatened and endangered species can be found in Table 2, broken down by studies which reported an annual versus lump sum payment.

Table 2 – Summary of economic value of threatened, endangered and rare species ($2006)

	Low value	High value	Average of all studies
Studies reporting annual WTP			
Bald eagle	$21	$45	$39
Bighorn sheep			$17
Dolphin			$36
Gray whale	$24	$46	$35
Owl	$39	$130	$65
Salmon/Steelhead	$10	$139	$81
Sea lion			$71
Sea otter			$40
Sea turtle			$19
Seal			$35
Silvery Minnow			$38
Squawfish			$12
Striped Shiner			$8
Turkey	$11	$15	$13
Washington state anadromous fish populations	$147	$311	$241
Whooping crane	$44	$69	$56
Woodpecker	$13	$20	$16
Studies reporting lump sum WTP			
Arctic grayling	$20	$26	$23
Bald eagle	$245	$350	$297
Falcon			$32
Humpback whale			$240
Monk seal			$166
Wolf	$22	$162	$61

3.2. Comparison of meta analysis regression of new and old studies

Table 3 shows the results of the meta-analysis regression models before the new variables are added to compare them with the results from Loomis and White (1996). It is important to point out that the new CONJOINT variable is included to account for the considerable difference this set of observations was found to have on WTP values. The adjusted R^2 is 59% in the linear model and 56% in the double log model. The results in Table 3 show a good deal of consistency between the new expanded meta equation and Loomis and White (1996). With one exception, the variables significant in Loomis and White are significant in the new model. Likewise, insignificant variables in Loomis and White are insignificant in the new model as well. The only difference being that unlike in their model, CVFORM is now significant in the linear and double log models.

3.3. Use of the Chow test to compare meta-analysis regressions for U.S. studies

Despite the similar signs and significance of the variables in the two models, the magnitude of the coefficients may still be different between the two models. Thus, the next step is to formally test whether the model has changed over time using the Chow test. A check for collinearity among the explanatory variables shows a few possible problematic high correlations, given the small sample size of the model. In addition, examining the variance-inflating factor (VIF) for each independent variable regressed on all the other explanatory variables to check for multicollinearity also raises some concerns of multicollinearity in the small sample of new studies. To address this issue, and to conserve degrees of freedom, the Loomis and White (1996) *reduced* model will be used to conduct the Chow test. This includes variables that came in significant in their meta-analysis regression, which includes CHANGESIZE, PAYFREQUENCY, VISITOR, MARINE, and BIRD.

In the linear model, the *F* statistic for the Chow test is 17.96 and in the double log model the *F* statistic is 16.30. The critical *F* value at the 1% level is 3.12, meaning the null hypothesis that there was no structural change in the willingness to pay regression model between the two periods (prior to and after 1995) can be rejected at the 1% level. The results from these regressions are available in Richardson (2008). Some of this difference between new and old studies could be due to the new species mix given that many of the new studies included in the sample value fish, especially salmon. So the Chow test was applied to the linear and double log model with the inclusion of the variable FISH. The *F* statistic was still a rather high 12.852 in the linear model and 11.896 in the double log model so again, the null hypothesis that there was no structural change in the model can be rejected at the 1% level. These *F* statistic results are consistent with the fact that the adjusted R^2 of the pooled model is quite a bit lower than in the individual models.

One final application of the Chow test was performed. When the study using the conjoint technique (Layton et al., 2001) is removed or accounted for, it appears that some of the difference between new and old studies goes away. Running the Chow test without this study gives some insight as to whether this one unique study is driving the structural change. This results in an *F* statistic for the Chow test of 3.72 in the linear model and 4.55 in the double log model. Since the critical *F* value at the 1% level is 3.12, with the exclusion of the conjoint technique study, the null hypothesis that there was no structural change in both the linear and double log models can still be rejected at the 1% level. However, the *F* statistic went down quite a bit. The unique conjoint technique study clearly has an effect and drives a lot of the difference between the new and old studies, but there are still other factors driving this difference.

Use of the Chow test provided evidence that there has been some structural change in the willingness-to-pay meta-analysis regression model since 1995. However, the Chow test does not show whether the structural difference in the two regressions is due to differences in intercept terms, slope coefficients, or both. Including the NEWSTUDY variable in the pooled new and old studies model and interacting it with the remaining explanatory variables will allow for statistical testing of the differential effect studies conducted in or after 1995 have on the other variable's influence on WTP. When testing for a structural difference between the two regressions

Table 3 – Meta-analysis regressions of WTP for T&E species — studies with conjoint dummy variable

	Updated — all U.S. studies		Loomis and White (1996)	
	Linear	Double log	Linear	Double log
Variable				
CONSTANT	−422.65	−58.114	100.04	4.32
(*t*-statistic)	(−0.14)	(−1.54)	(0.57)	(1.06)
CHANGESIZE	0.18***	0.73***	0.59***	0.769**
	(3.02)	(4.24)	(5.06)	(2.57)
PAYFREQUENCY	55.24**	0.327	45.51***	0.82**
	(2.60)	(1.25)	(2.89)	(2.53)
CVFORM	34.89**	0.43**	14.33	0.05
	(2.23)	(2.16)	(1.12)	(0.18)
VISITOR	74.12***	1.18***	24.03*	0.82**
	(3.61)	(4.69)	(1.71)	(2.73)
FISH	43.11	0.279	24.26	0.03
	(1.51)	(0.80)	(1.31)	(0.07)
MARINE	77.18***	0.94**	49.87**	0.75*
	(2.63)	(2.61)	(2.58)	(1.83)
BIRD	65.79**	0.540	33.41*	0.57
	(2.42)	(1.63)	(1.85)	(1.52)
OTHER	40.72	−0.038		
	(0.88)	(−0.07)		
RESPONSERATE	−0.33	−0.341	0.00	−0.12
	(−0.70)	(−1.33)	(0.008)	(−0.38)
STUDYYEAR	0.19	0.030	−1.89	−0.05
	(0.13)	(1.55)	(−0.98)	(−1.29)
CONJOINT	217.70***	2.46***		
	(7.69)	(6.57)		
Adj R^2=	0.591	0.556	0.682	0.623
N=	67	67	38	38
F=	9.66***	8.51***	9.82***	5.14***

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

Table 4 – Reduced linear WTP model with interaction dummy variables for 'new study'

Variable	Coefficient	*t*-statistic	*p*-value
CONSTANT	−35.924	−2.157	0.036
NEWSTUDY	−70.801	−0.104	0.917
CHANGESIZE	0.255***	4.539	0.001
CHANGESIZE*NEWSTUDY	1.143	0.172	0.864
PAYFREQUENCY	84.567***	4.463	0.001
PAYFREQUENCY*NEWSTUDY	−95.002	−1.540	0.130
VISITOR	46.494**	2.446	0.018
VISITOR*NEWSTUDY	69.358	0.905	0.370
MARINE	56.016***	2.860	0.006
MARINE*NEWSTUDY	−18.191	−0.294	0.770
BIRD	57.914***	3.380	0.001
BIRD*NEWSTUDY	−30.809	−0.605	0.548
CONJOINT	277.983	0.799	0.428
Adj R^2=	0.631		
N=	67		
F=	10.423		0.00001
S.E. of regression	47.949		

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

with the Chow test, when the conjoint technique study was dropped the *F* statistic decreased, but there was still a structural difference. This one study drives a lot of the difference between new and old studies but there are still other factors behind this change. Interacting the NEWSTUDY variable with the other variables in the model will show which ones have changed significantly. Due to the small sample size and the relatively high number of variables, a reduced model is focused on to look at the interaction effects. The Loomis and White (1996) reduced model is a rational one to use because the same variables that they found to be insignificant are insignificant in this full model. Given that the Chow test showed the significant effect of the conjoint technique study, the variable CONJOINT will also be included in the model. Table 4 shows the regression results using the reduced model with the NEWSTUDY interaction term:

Looking at the coefficients as well as the significance of the variables gives some insight into what has changed. The variable PAYFREQUENCY is somewhat different from old to new studies because when interacted with the NEWSTUDY variable, it comes in marginally significant at the 13% level and by itself is significant at the 1% level. The NEWSTUDY variable itself does not show up statistically significant at standard significance levels in the model but this could be due to a collinearity issue affecting the results. Checking correlation coefficients, it is found that CONJOINT is indeed correlated with the NEWSTUDY variable at 0.41. Given that the sample only includes 67 observations, this is a relatively high correlation and could explain why these two variables do not come in significant in this model.

Conducting an *F* test on the joint significance of the NEWSTUDY variable as well as this NEWSTUDY variable interacted with the other explanatory variables shows that there is indeed a significant difference between new and old studies. This test results in an *F* statistic of 2.742 with degrees of freedom (6, 54) and a *p*-value of 0.0213, meaning we can reject the null hypothesis that these variables jointly equal zero at the 5% level and conclude that there is a significant difference between new and old studies. The results from this test are consistent with the results from the Chow test.

Table 5 – Initial full WTP models for benefit transfer

Variable	Linear			Double log		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*t*-statistic	*p*-value
CONSTANT	−15.712	−0.315	0.754	1.264	1.010	0.317
CHANGESIZE	0.177**	2.421	0.019	0.714***	4.244	0.001
PAYFREQUENCY	71.893***	2.887	0.006	0.387	1.493	0.142
CVFORM	15.652	0.932	0.356	0.131	0.711	0.480
VISITOR	62.080***	2.806	0.007	1.039***	4.516	0.001
FISH	61.978*	1.709	0.094	0.880**	2.344	0.023
MARINE	85.994***	3.009	0.004	0.917***	3.056	0.004
BIRD	93.532***	3.348	0.002	0.936***	3.198	0.002
OTHER	77.009	1.633	0.109	0.552	1.118	0.269
REPONSERATE	−0.339	−0.656	0.515	−0.430*	−1.771	0.083
NEWSTUDY	24.299	1.333	0.188	0.720***	3.849	0.001
CONJOINT	196.807***	6.124	0.001	2.108***	5.648	0.001
LOSS	−8.502	−0.477	0.635	−0.222	−1.164	0.250
MAIL	−27.661	−1.345	0.185	−0.633***	−3.011	0.004
CHARISMATIC	−5.054	−0.185	0.854	0.429	1.468	0.148
NONUSE	−50.434**	−2.055	0.045	−0.469*	−1.785	0.080
Adj R^2=	0.639			0.711		
N=	67			67		
F=	8.775		0.00001	11.826		0.00001
S.E. of regression	47.479			0.506		

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

3.4. New best fit model to explain WTP for threatened and endangered species

Utilizing the results of the previous regressions as a guide, a new meta-analysis regression to explain willingness-to-pay for threatened and endangered species in the U.S. is estimated for benefit transfer purposes. Ideally, this model includes all variables mentioned earlier that could potentially explain willingness-to-pay for these species. Unfortunately, a check for collinearity of the independent variables for this full model shows that STUDYYEAR and NEWSTUDY have a correlation coefficient of 0.86, which is to be expected. To account for this, the full model was run with each of these variables separately. The NEWSTUDY variable came in slightly more statistically significant, so this variable was kept in the full model, but both variables will be included separately in some of the reduced models that follow. The MAIL survey mode variable is correlated with TELEPHONE at about 0.82 and with IN-PERSON at about 0.52. To address this, the models were run with the MAIL survey mode variable only as well as with the TELEPHONE and IN-PERSON survey mode variables only. The models including the MAIL variable did slightly better in terms of statistical significance, so this variable is included in the full models below. In addition, the variables FISH and CHARISMATIC have a correlation coefficient of 0.83. This may be due to the fact that fish species are not classified as 'charismatic megafauna' and many of the studies valuing species other than fish tend to focus on those with 'charisma.' Kennedy (2003) characterizes a correlation coefficient as being high enough to be a serious problem at around 0.9 or above. The models were run with both variables kept in, as reported in Table 5.

When all variables are included in the linear meta-analysis regression model measuring the willingness-to-pay for threatened and endangered species, the variables CHANGESIZE, PAYFREQUENCY, VISITOR, FISH, MARINE, BIRD, CONJOINT and NONUSE come in significant at standard significance levels of 1, 5, or 10%. In the double log model, the variables CHANGESIZE, VISITOR, FISH, MARINE, BIRD, RESPONSERATE, NEWSTUDY, CONJOINT, MAIL and NONUSE come in statistically significant at standard significance levels. In order to find the best fit model to explain willingness-to-pay for threatened and endangered species for benefit transfer purposes, variables that that are not statistically different from zero at standard significance levels of 1, 5, or 10% were not included. However, variables that come in significant near the 10% level may be included in order to stay consistent with a 'test down' approach and avoid omitted variable bias. After testing various specifications, one linear model and two double log models fit the data best and explain WTP for threatened and endangered species quite well (the R^2's are approximately 0.7). Full results of the linear model can be found in Table 6 and full results of the two double log models can be found in Table 7.

As can be seen in Table 6, the model coefficients are statistically significant and the adjusted R^2 is 71%. CHANGESIZE, as expected, positively impacts WTP meaning that as the change in the size of the species population being valued increases, so does WTP, ceteris paribus. Payment frequency also comes in significant, with lump-sum payments about $50 higher than annual payments. Fish, marine mammals and birds result in a higher WTP than other species such as land mammals and reptiles. Studies using the conjoint, or choice experiment, technique result in WTP of about $200 higher than studies not using this method. In addition, species with nonuse values only result in a WTP about $40 lower than those with both use and nonuse values.

Finally, an interaction variable was included to test for a differential effect on the slope coefficient of CHANGESIZE arising from whether the respondent is a visitor or a non-visiting household. This was tested by interacting the VISITOR dummy variable with the CHANGESIZE variable. The slope coefficient for visitor WTP is greater than the slope coefficient of household WTP with respect to the percentage change in the size of the species population being valued. This is due to the fact that visitors have both use and nonuse values for an increase in species population whereas households have nonuse value only. Visitors WTP values for T&E species are therefore more strongly affected by population increases than are households WTP.

Table 7 presents the results of the double log models. With the logged dependent variable, WTP, and the logged continuous variables, CHANGESIZE and RESPONSERATE, the two log specification models appear to do the best job of explaining WTP for threatened and endangered species. The models are robust and include many of the explanatory variables which theory and past literature finds important in determining WTP, the only difference being that model 3 includes the variable NEWSTUDY, whereas model 4 includes the variable STUDYYEAR.

Both models have a high adjusted R^2, with the explanatory variables as a group explaining about 70% of the variation in WTP. However, it is important to point out that in both models, the variables FISH and CHARISMATIC are correlated at around 0.83. As mentioned earlier, Kennedy (2003) notes that a correlation coefficient of about 0.9 or higher should be

Table 6 – Reduced linear WTP model for benefit transfer purposes

Variable	Model 1			
	Coefficient	*t*-statistic	*p*-value	Sample means
CONSTANT	−4.700	−0.260	0.796	
CHANGESIZE	0.101**	2.010	0.049	119.784
PAYFREQUENCY	50.778***	2.967	0.004	0.194
FISH	42.641**	2.104	0.040	0.418
MARINE	47.745**	2.325	0.024	0.164
BIRD	40.280**	2.020	0.048	0.284
CONJOINT	198.189***	8.906	0.001	0.075
NONUSE	−39.069**	−2.411	0.019	0.149
VISITOR* CHANGESIZE	0.583***	5.429	0.001	26.358
Adj R^2=	0.712			
N=	67			
F=	21.419		0.00001	
S.E. of regression	42.368			
Sum squared residuals	104,115			

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

Table 7 – Reduced double log WTP models for benefit transfer purposes

Variable	Model 2			Model 3			
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value	Sample means
CONSTANT	0.344	0.359	0.721	−153.231***	−4.764	0.000	
LN CHANGESIZE	0.953***	6.754	0.0001	0.870***	6.256	0.0001	4.596
VISITOR	1.299***	6.588	0.0001	1.256***	6.378	0.0001	0.231
FISH	0.678**	2.198	0.032	1.020***	3.327	0.002	0.418
MARINE	0.583**	2.420	0.019	0.772***	3.100	0.003	0.164
BIRD	0.555**	2.535	0.014	0.826***	3.569	0.001	0.284
LNRESPONSERATE	−0.459**	−2.203	0.032	−0.603***	−2.749	0.008	3.894
CONJOINT	2.620***	8.389	0.0001	2.767***	8.868	0.0001	0.075
MAIL	−0.798***	−3.967	0.0002	−0.903***	−4.307	0.0001	0.851
CHARISMATIC	0.765***	3.091	0.003	1.024***	4.072	0.0001	0.493
NEWSTUDY	0.816***	4.835	0.0001				0.328
STUDYYEAR				0.078***	4.765	0.0001	1992.254
Adj R^2=	0.699			0.697			
N=	67			67			
F=	16.347		0.00001	16.161		0.00001	
S.E. of regression	0.517			0.519			
Sum squared residuals	14.940			15.068			

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

characterized as a serious problem while Gujarati (2003) points out that a correlation coefficient of about 0.8 or higher can be problematic. Collinearity does not seem to be degrading in this model due to the fact that the explanatory variables have the expected signs and are statistically significant. But to investigate the potential effect of high collinearity, an additional test is employed. In order to test the joint significance of these two variables in the models, a multiple linear restriction test is used to test if the error variance from the restricted model removing these variables is significantly bigger than the error variance when the variables are included in the model. The joint null hypothesis is that FISH and CHARISMATIC are equal to zero, or not significant to the models. Testing this restriction in model 2 in Table 7, the result is an F statistic of 4.779 with degrees of freedom of (2, 56) and a p-value of 0.0121. Testing this same restriction in model 3, the result is an F statistic of 8.429 with degrees of freedom of (2, 56) and a p-value of 0.006. Thus, for both models the joint null hypothesis that these two variables are not significant can be rejected at the 1% level and the conclusion is that the error variance from the restricted model is significantly bigger than the error variance in the unrestricted model, providing justification to include these variables. In addition, attempting to remove one of these variables from the model seems to result in specification bias.

Employing a logged model is useful in that the coefficients are interpreted as percentage changes in the dependent variable for a one percent change in the independent variables. This facilitates an elasticity interpretation of the coefficients and comparison to economic theory, such as diminishing marginal returns. For instance, CHANGESIZE has a coefficient of about 0.953 in model 3 and 0.870 in model 3, showing that as the proposed population of the species being valued increases, respondents' WTP increases but at a decreasing rate, consistent with economic theory. The double log models also show that visitors on average have a WTP about 250% higher than households holding all else constant; valuation of charismatic species results in a WTP about 115%–180% higher than non-charismatic species; as the year the study was performed increases, WTP increases by about 8%; and fish, marine mammals, and birds result in higher WTP than for other species such as land mammals and reptiles. In addition, higher response rates and studies using a mail survey mode decrease WTP, as expected. It should be noted that unlike in the linear model, the interacted VISITOR*CHANGESIZE variable did not come in significant at standard significance levels and therefore is not included here.

A full summary of the linear and two double log best fit models can be found in Table 8, with signs and significance levels of included variables for comparison. There is a substantial degree of consistency across models in terms of signs and significance.

Table 8 – Summary of signs and significance of the three WTP models

Variable	Linear	Double log	
	Model 1	Model 2	Model 3
CHANGESIZE	+/0.05	+/0.01	+/0.01
PAYFREQUENCY	+/0.01		
VISITOR		+/0.01	+/0.01
FISH	+/0.05	+/0.05	+/0.01
MARINE	+/0.05	+/0.05	+/0.01
BIRD	+/0.05	+/0.05	+/0.01
RESPONSERATE		–/0.05	–/0.01
STUDYYEAR			+/0.01
NEWSTUDY		+/0.01	
CONJOINT	+/0.01	+/0.01	+/0.01
MAIL		–/0.01	–/0.01
CHARISMATIC		+/0.01	+/0.01
NONUSE	–/0.05		
VIISITOR*CHANGESIZE	+/0.01		

Both a linear and double log model are beneficial for benefit transfer purposes in that they provide a different interpretation of the independent variable's effect on WTP for threatened and endangered species. Looking at the double log models, they have similar adjusted R^2, with the only difference being that model 2 includes the NEWSTUDY variable and model 3 includes the STUDYYEAR variable, both of which would be useful for benefit transfer purposes. Model 3 may be slightly preferable since it can account for any year as opposed to model 2 which simply provides a 'before 1995' and 'in or after 1995' split. Looking at all three models explaining willingness-to-pay for threatened and endangered species, the double log model 3 would most likely be the best model for benefit transfer purposes. This is due to the fact that managers and users unfamiliar with economic modeling would find the additional species related variables and fewer methodological variables more useful.

These same meta-analysis regression models were run without the conjoint technique study to see the effect this would have on results. The results are almost identical except for a reduced adjusted R^2. To be as inclusive as possible, it is important to keep this conjoint technique study in the model and account for it.

3.5. *Benefit transfer example and calculating the percent error for benefit transfer*

Now that we have determined what we believe to be best fit models to explain the variation in WTP for threatened and endangered species, these meta-analysis functions can be programmed for benefit transfer purposes. Using the reduced double log model 3 results in the following equation:

$$\begin{aligned} \ln \text{WTP (2006\$)} = & -153.231 + 0.870 \ln \text{CHANGESIZE} \\ & + 1.256\ \text{VISITOR} + 1.020\ \text{FISH} + 0.772\ \text{MARINE} \\ & + 0.826 - 0.603 \ln \text{RESPONSERATE} \\ & + 2.767\ \text{CONJOINT} + 1.024\ \text{CHARISMATIC} \\ & - 0.903\ \text{MAIL} + 0.078\ \text{STUDYYEAR}. \end{aligned}$$

This model was chosen for benefit transfer purposes due to its inclusion of more species related variables and less methodological variables. By plugging in sample means for the methodological variables and the appropriate values for the policy relevant variables, the estimated WTP value can be obtained. For instance, valuing a 50% gain in charismatic sea otter populations to non-visitors in the year 2007 results in the following equation:

$$\begin{aligned} \ln \text{WTP (2006\$)} = & -153.231 + 0.870(3.912) + 1.256(0) + 1.020(0) \\ & + 0.772(1) + 0.826(0) - 0.603(3.894) + 2.767(0) \\ & + 1.024(1) - 0.903(0.851) + 0.078(2007) \end{aligned}$$

which results in a total economic value of about \$88 dollars per household. It is important to note that to improve the accuracy of this benefit transfer estimate, the variable coefficients were taken out to six decimal places. Aggregating this benefit per household to a population of one million households would result in a Total Economic Value of \$88 million. However, this aggregated amount may depend on the location of these households. For instance, residents at a greater distance from where the survey took place may have lower benefits for the particular species being valued. See Loomis (2000) for a discussion of sample expansion issues to the population.

This example shows how a meta-analysis regression function can be programmed to provide an estimate of the willingness-to-pay for a particular threatened or endangered species under various circumstances. Models such as these can be used in various fields, and users do not need advanced training in economics to use the meta equation. Given the cost and time of conducting an original CVM study, the use of benefit transfer methods for purposes such as estimating the Total Economic Value of conserving a particular species will most likely continue to have great importance in both scientific and political arenas.

To test the accuracy of this benefit transfer meta model in predicting WTP estimates of the in-sample threatened and endangered species, a comparison of original study values versus predicted values from the meta-analysis function was conducted. To conserve space, the detailed table is not shown but can be found in Richardson (2008).

On average, the model #3 does a reasonable job of predicting WTP values for various threatened and endangered species, as the average absolute percentage error is 34% for studies reporting an annual WTP value and 45% for studies reporting a lump sum WTP value. In many applications this error bound may be acceptable, as compared to not having any value, whereby it gets treated implicitly as zero WTP. The meta-analysis benefit transfer provides an error estimate and if decision makers decide it is unacceptable, they can perform an original study. As more studies valuing threatened and endangered species emerge, providing a larger sample size, this model may become even more accurate, providing a low-cost and simple tool to predict WTP values for various species.

4. Discussion

From the results of this study, it is found that the Total Economic Value of species in the U.S. is sensitive to the change in the size of the species population, the type of species being valued, and whether visitors or households are valuing the species. The frequency of the payment being made, the response rate, survey mode, when the study is performed, the 'charisma' of a species, and what kind of values a species has (nonuse only or both use and nonuse) can also play a role. It is also apparent that studies using a slightly different valuation method, such as a conjoint, or choice experiment, technique can have a considerable effect on a meta-analysis with a relatively small sample size, so any variation such as this should be accounted for.

Given the need for a consistent measure of the benefits perceived by humans provided by threatened and endangered species, along with the time and cost associated with conducting original CVM studies, the use of benefit transfer will continue to play a significant role. By using the meta-analysis regression equation itself, users can estimate the Total Economic Value of a particular species. The ease and convenience of this technique is attractive to users across many fields of study. However, it is important to remember that this technique provides a rough estimate only and has an average in-sample error of 34% to 45%, depending on whether the study reported an annual or lump sum payment. In addition, both original CVM studies and benefit transfer techniques provide economic, not biological, benefits of a particular species. Like Loomis and White (1996) point out, these values are based on a human-centered understanding of the particular ecological role these species have. This understanding is in no way complete, and as such a more cautious strategy may need to be employed when determining listing and recovery plans for threatened and endangered species, for example a Safe Minimum Standard (see Ready and Bishop, 1991).

Given recent concerns that the Endangered Species Act is being undermined, especially by limiting species listings, there has emerged a very important argument that these species provide considerable benefits and have great value, pointing to the need for greater funding and more preventative measures in their recovery. Evidence from this study shows that people's valuation of T&E species has indeed increased over time, providing greater support for this argument.

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