

The worth of wildlife: A meta-analysis of global non-market values of threatened species

Vandana Subroy ^{*,a}, Asha Gunawardena ^{†,a}, Maksym Polyakov ^{‡,a}, Ram Pandit ^{#,a} and David

J. Pannell ^{§,a}

^a *Centre of Environmental Economics and Policy, UWA School of Agriculture and Environment, 35*

Stirling Highway, Crawley WA 6009, Australia

* Corresponding author:

Ms. Vandana Subroy

M087 / 35 Stirling Highway

Crawley, WA 6009

AUSTRALIA

E-mail: vandana.subroy@research.uwa.edu.au

† Email: asha.gunawardena@uwa.edu.au

‡ Email: maksym.polyakov@uwa.edu.au

Email: ram.pandit@uwa.edu.au

§ Email: david.pannell@uwa.edu.au

The authors have no competing interests to declare

1 **Abstract**

2 Clustered robust meta-regression analysis is applied to 109 willingness to pay (WTP)
3 estimates for threatened species from 47 stated-preference studies in 19 countries. Our
4 study updates previous meta-analyses on the topic and tests the effect of important
5 variables not previously considered—species’ threat status, use of coloured photographs of
6 species in a survey, and a country’s development status, on WTP. We also compared model
7 results obtained from weighting observations by the inverse standard error of WTP and
8 inverse sample size values. Inverse-standard error-weighted model results were more
9 aligned with published research and economic theory and had a better fit than inverse-
10 sample size-weighted model results. Average total present value of WTP was
11 \$414/household¹, but variation in reported values was large owing to the survey context.
12 WTP was significantly higher for charismatic and threatened species. Using coloured
13 photographs, or a country’s development status did not significantly affect WTP. Average
14 absolute within-sample- and out-of-sample transfer errors were estimated to be 17% and
15 48%, respectively. One-fourth out-of-sample transfers had an error of 10% or less. We
16 discuss limitations and issues in current literature and propose recommendations that will
17 allow future studies to be used in meta-analyses and benefit transfer.
18

¹ In 2016 US dollars

- 19 **Keywords**
- 20 Choice experiment
- 21 Contingent valuation
- 22 Endangered species
- 23 Species' charisma
- 24 Species' endangerment level

25 1. Introduction

26 The economic valuation of threatened species can provide valuable information for
27 managers and policy makers to understand the trade-offs involved in prioritising
28 conservation investments. Weighing the benefits and costs of conservation is, however,
29 challenging since societal utility from pure public goods like threatened species is seldom
30 captured in existing markets. Several non-market valuation (NMV) techniques, particularly
31 stated-preference methods², have been used to quantify the *anthropocentric* benefits
32 (Loomis and White, 1996) of threatened species. These measured benefits are largely in the
33 form of passive-use values³, namely, existence and bequest values. Conducting original
34 NMV studies can, however, be expensive, time-consuming and impractical to carry out for
35 each individual species (Richardson and Loomis, 2009). As such, the benefit transfer (BT)
36 technique of extrapolating willingness to pay (WTP) estimates from primary studies to
37 contextually compatible policy sites is seen as a practical and cost-saving alternative (Baker
38 and Ruting, 2014). A meta-regression analysis is a useful BT tool that systematically
39 combines WTP results from several comparable primary studies to estimate statistical
40 models controlled for heterogeneity, methodological differences, and biases among primary
41 studies, which can be applied to calculate values (WTP estimates) adjusted to the
42 characteristics of a policy site (Lindhjem and Navrud, 2008; Richardson and Loomis, 2009;
43 Shrestha and Loomis, 2001).

44 Existing meta-regression analyses of threatened-species-specific NMV literature
45 (Loomis and White, 1996; Richardson and Loomis, 2009), are, limited in terms of their
46 geographic focus, NMV technique used, the range of species included in the analyses, and
47 the age of the reviews (i.e. the latest of these analyses is a decade old). Both these papers
48 analysed contingent valuation (CV) studies from the United States with the exception of a

² Contingent valuation (CV) and choice experiment (CE) studies.

³ Spash and Vatn (2006) point out the incorrectness of the commonly used term "non-use" to denote passive-use values stating that "there are no non-use values in economics because all economic value derives from the utility it provides humans."

49 single choice experiment (CE) study included in the meta-analysis of Richardson and
50 Loomis (2009). Pandit et al. (2015) reviewed and qualitatively discussed global non-market
51 valuation studies of threatened species, but did not conduct a meta-analysis. There are a
52 few meta-analyses on global WTP for biodiversity conservation. However, they combine
53 disparate valuations making it problematic to value particular species. Specifically, they
54 either include WTP estimates for both species and habitats (wetlands, forests, deserts,
55 agricultural lands etc.), water quality and riparian vegetation, and other biodiversity features
56 in their analyses (Jacobsen and Hanley, 2009; Lindhjem and Tuan, 2012), or they combine
57 disparate studies that value both individual species and groups of species, including
58 threatened plants indistinguishable by type (Saloio, 2008). Additionally, the meta-analysis by
59 Saloio (2008) also included studies focusing solely on use values (hunting and fishing) and
60 policies aimed at indirectly increasing species' populations such as dam removal, in-stream
61 flow etc. The limitations in the scope of the above studies make it difficult for a decision
62 maker seeking non-market values for judgements about conserving threatened species to
63 use models from these analyses to derive WTP estimates.

64 The primary objective of our paper, therefore, is to address the above limitations by
65 reviewing and conducting a meta-regression analysis of NMV studies of threatened species
66 from around the world published up until 2017, including studies that use both CV and CE
67 survey techniques to identify global determinants of WTP for threatened species. We also
68 test the effect of several potentially-important variables not considered in previous meta-
69 analyses such as a species' threat status, the use of coloured photographs in the survey and
70 a country's development status.

71 A secondary objective of our paper is to demonstrate the importance of using the
72 correct metric for weighting in a meta-regression model. Weighting the values of the
73 dependent variable (WTP estimates, in our case) ensures that within- and between-study
74 heterogeneity can be separated, and corrects the consequences of differences in sample
75 sizes and other effects (e.g. from the survey format), which can affect the precision of WTP
76 estimates from the various primary studies (Gurevitch et al., 2018; Van Houtven, 2008).

77 While inverse-variance (or standard error) weighting is recommended and preferred
78 (Gurevitch et al., 2018; Van Houtven, 2008), most meta-analyses (e.g., Bergstrom and
79 Taylor, 2006; Ma et al., 2015; Van Houtven et al., 2017) use inverse-sample-size weighting
80 since most primary studies fail to report the standard error of the WTP estimate. We,
81 therefore, compared results from inverse-standard error-weighted and inverse-sample size
82 weighted clustered robust regression models to determine the effect of the metric used for
83 weighting in this paper. While not a primary objective of this paper, the significance of the
84 weighting metric became apparent to us when conducting our meta-regression analysis. The
85 comparison of different weighting metrics is, therefore, presented here to illustrate the
86 importance of choosing the weighting metric appropriately. This crucial aspect has not been
87 previously examined in the threatened species or biodiversity conservation meta-analysis
88 literature.

89 We also test the validity and reliability of WTP estimates from our meta-regression
90 model by comparing WTP estimates from our meta-regression model with those from
91 primary NMV studies and discuss the implications of transfer errors from the model
92 estimates.

93 As a consequence of the review, we also critically examined global NMV studies
94 published to date and discuss common methodological and reporting issues that we found.
95 We propose recommendations for reporting for future NMV studies that will enable them to
96 be used in meta-analyses and benefit transfer.

97 Our paper is structured as follows: in Section 2 we describe our methodology, including
98 literature search, moderator variables and models used. Section 3 presents model results
99 and discusses the effect of the weighting metric on the regression results. In Section 4 we
100 test the validity and reliability of WTP estimates from our final meta-regression model by
101 estimating within-sample and out-of-sample transfer errors. Finally, we discuss the
102 limitations of our data set and issues in current NMV literature of threatened species, and
103 provide reporting recommendations for future NMV studies.

104 **2. Methodology**

105 We followed reporting guidelines for meta-regression analysis summarised in Nelson
106 and Kennedy (2009) and Stanley et al. (2013). We also followed the specification and
107 estimation guidelines for meta-functions outlined in Bergstrom and Taylor (2006) to ensure
108 the consistency of the economic, welfare change, commodity, and study design variables
109 used in our models.

110 *2.1 Data sources and refinement*

111 We searched online databases EBSCO, JSTOR, ProQuest, Scopus, Web of Science
112 and Google Scholar for relevant NMV literature on threatened species. We also searched
113 the Environmental Valuation Reference Inventory (EVRI) and the US Fish and Wildlife
114 Service Conservation Library. Keywords included in the search were “non-market value” or
115 “non-market valuation” or “non-market benefits” or “economic value” or “economic benefits”
116 or “contingent valuation” or “choice modelling” or “choice experiment” or “conjoint analysis”
117 or “discrete choice” or “willingness to pay” and either “endangered species” or “threatened
118 species”. Web of Science produced the greatest number of relevant peer-reviewed studies.
119 Some studies were obtained from citations in other papers as well as from the meta-
120 analyses of Richardson and Loomis (2009) and Saloio (2008). The search was completed
121 on 1 May 2017 and produced 184 primary studies published between 1983 and 2017.

122 The 184 studies were examined and coded primarily by the first author with assistance
123 from the other authors. Studies focusing on the total economic values of specific animal
124 species with passive use as the dominant value were considered. Studies valuing wildlife or
125 species in general without specifying particular species, studies valuing threatened plants,
126 and studies that grouped different species making it difficult to calculate WTP for individual
127 species, were also excluded. Studies focusing on use values alone (hunting, fishing or
128 viewing) were not included. Studies that did not directly value species but instead valued
129 environmental enhancements that would lead to a gain (or avoiding loss) in species
130 populations were also excluded. Studies valuing gains in species’ populations as

131 enhancements to their threat status but not as specific percentages were also excluded from
132 the analysis since it was not clear what benefit the elicited values related to. This data
133 refinement resulted in 47 primary studies and 109 observations of WTP from 19 countries⁴
134 on which the meta-regression was performed. Appendix I presents the characteristics of the
135 studies included in our analysis such as species valued and survey year amongst others,
136 along with the WTP estimates and their standard errors.

137 2.2 Effect size

138 The dependent variable, called the effect size in a meta-analysis, standardises findings
139 across studies enabling them to be directly and easily compared (Ma et al., 2015). The effect
140 size in our study is the respondent's (total) WTP for a certain change in the population of a
141 threatened species (% gain/avoid % loss/avoid extinction/maintain) compared to the
142 baseline scenario stated in the survey. Our meta-regression function therefore takes the
143 form:

$$144 \quad WTP = \sum_k \beta_k M_k \quad (1)$$

145 where β_k are the coefficients and M_k are the moderator variables.

146 Since the reported WTP values differ across studies depending on the survey location
147 (country), survey year, and the frequency and duration of the payment, they are
148 standardised, i.e., converted to a common metric to enable comparison. The previous meta-
149 analyses of NMV studies of threatened species used the annual WTP in US dollars as the
150 effect size (Jacobsen and Hanley, 2009; Lindhjem and Tuan, 2012; Loomis and White, 1996;
151 Richardson and Loomis, 2009). We chose to use a total WTP, i.e., a lump sum payment
152 instead of annual to enable us to straightforwardly compare respondents' valuation of the
153 conservation scenario presented to them. The common metric in our study was, therefore,

⁴ See Table S.1.in the supplementary data for a distribution of estimates based on country

154 the total WTP (in 2016 US dollars). It was systematically obtained for each reported estimate
155 using the following steps:

- 156 1. Monthly or annual payments over a number of years were converted to the total present
157 value over the proposed duration of payments using a 5% real discount rate⁵ as used by
158 Ma et al. (2015).
- 159 2. This total present value of WTP in local currency was then converted into US dollars for
160 the survey year using the purchasing power parity (PPP)-adjusted exchange rate for the
161 survey year from the World Bank (2017). The PPP-adjusted exchange rate equalises
162 purchasing power across countries and is, therefore, more appropriate for currency
163 conversion than the financial exchange rate (Ready and Navrud, 2006).
- 164 3. The total WTP in survey year US dollars was then inflated to 2016 US dollars using the
165 consumer price index for the US (BLS, 2017).

166 In the case of choice experiments, we used the reported marginal WTP for the change in
167 species' population being valued and extrapolated it to calculate the total WTP in 2016 US
168 dollars using steps 1 through 3 described above.

169 *2.3 Moderator variables used*

170 The moderator variables included in our analysis (Table 1) were selected after examining
171 our refined database as well as other meta-analyses and were included to provide
172 consistency in study design variables, the commodity being valued, and the welfare change
173 being measured as advocated by Bergstrom and Taylor (2006). These variables account for
174 differences in sample characteristics, species type, the magnitude and type of change in
175 species population being valued, differences in survey method, mode of administration,
176 payment vehicle, and payment duration, among other things.

⁵ We explored a range of discount rates for doing this but found that it made no difference to the statistical results. Discount rates used by most developed European countries and the US and Canada are between 3 and 10% (Kazlauskienė, 2015). So we used 5% for all studies with payments that extended over more than one year.

178 **Table 1:** Moderator variables used and their summary statistics

Variable	Description	Mean	Standard Deviation	Range
TWTP2016	Total WTP (per household) in 2016 US dollars	414.12	791.94	[1.28 – 4,423.88]
SE2016	Standard error of WTP in 2016 US dollars	34.83	56.408	[0.05 – 304.60]
Sample size	Number of valid survey responses	417	759	[19 – 7,376]
Survey year	Year in which the survey was conducted	2001	7	[1984 - 2012]
Income2016	Sample or national mean of annual household income in 2016 US dollars	45,781	23,131	[3,244 – 109,934]
Developed	Whether the country was developed (=0) or not (=1)	0.11	–	[0 - 1]
Species ^a	Mammal=0 (baseline); Marine mammal or Reptile (turtles) =1; Bird =2; Fish = 3; Other =4	–	–	[0 - 4]
Charisma	If the species is charismatic (=1) or not (= 0)	0.66	–	[0 - 1]
Threat Status ^b	If the species is threatened (=1) or not (=0)	0.50	–	[0 - 1]
Mode of administration	Survey administration format (mail or drop-off =0; in-person or telephone =1; online =2)	–	–	[0 - 2]
Photo ^c	If a coloured photo (=1) was used in the survey or not (=0)	0.50	–	[0 - 1]
Format ^d	DC =0 (baseline); OE =1; PC = 2; CE =3	–	–	[0 - 3]
Payment Vehicle	Tax =0; Donation =1; Fee/Surcharge/Other =2	–	–	[0 - 2]
Payment duration	One-time or Annual up to 5 years =0; Annual ≥ 6 years to perpetuity =1	0.28	–	[0 - 1]
Change	Gain =0; Avoid Loss / Avoid Extinction =1; Maintain =2	–	–	[0 - 2]
Percentage gain	Percentage of population gain presented in the survey	167	297	[10 – 1,900 ^e]

179 ^a Reptiles included only turtles, and were, therefore, combined with marine mammals.; ^b IUCN threat status used: baseline
180 includes species with threat status of least concern, or data deficient, or not listed or near threatened. Threatened includes
181 species whose threat status is vulnerable, or endangered or critically endangered. ; ^b baseline included surveys that used no
182 photographs or black and white drawings or black and white photographs or those that did not state whether they used
183 photographs or not; ^d DC = dichotomous choice contingent valuation (CV), OE= open-ended CV, PC = payment card CV, CE =
184 choice experiment; ^e The Han et al. (2010) study estimated WTP for an increase from 10 to 200 Korean mountain gorals
185 (*Naemorhedus caudatus*), which gives the percentage of 1,900.

186

187 Respondent's income is often a significant determinant of WTP for biodiversity
188 conservation (e.g., Jacobsen and Hanley (2009)). The effect of sample income on WTP for
189 species was, therefore, controlled by including the mean sample household income as a
190 moderator variable. When the mean sample income was not reported, we first tried to obtain
191 the average income from the geographical location where the survey was conducted, failing
192 which, we used the national mean household income obtained from the country's
193 government database.

194 Qualitative evidence from Richardson and Loomis (2012) suggests that a country's
195 development status influences WTP with households in developing countries willing to pay a
196 higher percentage of their income to conserve nationally symbolic species than those in
197 developed countries. However, in general, we expected households in developing countries
198 to be willing to pay less in absolute terms to conserve species. Therefore, a country's
199 development status, taken from the World Bank website, was also included as a moderator
200 variable.

201 The survey year was included to capture possible unobserved advancements in study
202 design, methodology and changes in public attitudes over time towards threatened species
203 (Jacobsen and Hanley, 2009; Loomis and White, 1996).

204 Species characteristics included as moderator variables were the type/class of animal
205 (mammal, bird, fish, etc.), charisma, and species endangerment level (threat status). Since
206 different countries have different criteria for classifying the threat status of species, we based
207 the threat status of species on their IUCN threat status, which is a global criterion to classify
208 the endangerment level of species. This ensures consistency in comparing species' threat
209 status across countries. However, this also meant that many of the species in our meta-
210 analysis that were threatened in particular countries or regions but not globally threatened
211 under the IUCN criteria ended up being classified under lower threat levels unless they were
212 recognised as being part of small and declining populations in those regions and, therefore,
213 accorded a higher IUCN threat level. Also, some of our species were "data-deficient"
214 according to the IUCN. This resulted in only 50% of the species in our meta-analysis being

215 threatened according to the IUCN (i.e. having a threat status of vulnerable, or endangered or
216 critically endangered) (Table 1). Some studies have found species' charisma to be a
217 significant determinant of WTP (Colleony et al., 2017; Metrick and Weitzman, 1996;
218 Richardson and Loomis, 2009) but not others (Tisdell et al., 2007). Determining the
219 “charismatic” nature of a species is subjective, and there are various definitions of the term
220 (Richardson and Loomis, 2009). However, it is generally agreed that charismatic species are
221 typically large vertebrates (megafauna) that instinctively appeal to humans such as,
222 elephants, pandas, and whales (Metrick and Weitzman, 1996). Species were treated as
223 charismatic if they had been characterized as such in the original study, or elsewhere, for
224 example in other studies, or other publications, including online publications. The IUCN-
225 designated threat status of a species was used to provide an indicator of its endangerment
226 level that is consistent across countries.

227 We also included moderator variables to measure the effect of the type of change in
228 species' population being valued—gain, avoid loss, avoid extinction and maintain with the
229 baseline being the population at the time of the survey. We also recorded the magnitude of
230 the percentage benefit (e.g. of gain in population size) in the expectation that greater
231 benefits would result in higher WTP albeit at a lower marginal rate for larger gains (Loomis
232 and White, 1996).

233 Lastly, we also included variables to account for differences in survey format (single or
234 double-bounded dichotomous choice (DC), open-ended (OE), payment card (PC), choice
235 experiment (CE)), mode of administration (online, mail, drop off, in-person and telephone),
236 payment vehicle (tax, donation, fee and surcharge) and payment duration (one-time,
237 annual). Survey format has been found to be a significant determinant in WTP with DC
238 formats producing significantly higher WTP estimates compared to OE and PC formats
239 (Jacobsen and Hanley, 2009; Reaves et al., 1999; Richardson and Loomis, 2012). Evidence
240 about the effect of survey mode on WTP for non-market goods is mixed, with some studies
241 finding that telephone surveys produce lower WTP values compared to in-person surveys
242 (Maguire, 2009). To capture the diversity amongst studies regarding payment duration—with

243 some having a single payment, and others having multiple annual payments, we included
244 payment duration as a moderator variable as well.

245 WTP estimates may also be influenced by how realistically a survey questionnaire is
246 presented including the use of photographs in the survey. The influence of photographs,
247 especially colour photographs, on WTP estimates has been unresolved since the Arrow et
248 al. (1993) NOAA Panel Report on contingent valuation (Shr and Ready, 2016). Since then
249 there have been mixed findings of the influence of colour photographs (Labao et al., 2008;
250 Subroy et al., 2018). We tested its effect on WTP by including the use of colour photographs
251 of species in surveys as a dummy variable in the analysis.

252 We emailed the authors of primary studies if details about the survey including the
253 survey year, payment vehicle, payment duration, the type or magnitude of change, the use
254 of photographs, modelled observations, sample size or socio-demographic data, had not
255 been provided in the article or report. Almost all authors were emailed. About 80%
256 responded and provided answers to our questions, enabling us to use their studies in our
257 meta-analysis.

258 *2.4 Meta-regression models*

259 Many NMV studies provide more than one WTP estimate. As a result, a meta-analysis
260 dataset ends up having an unbalanced panel structure (Jacobsen and Hanley (2009),
261 Lindhjem and Tuan (2012)). Two main methods used to account for the panel structure are
262 fixed-effect panel data models and random-effect panel data models (Rolfe et al., 2015; Van
263 Houtven, 2008). However, there are problematic considerations of both fixed-effects and
264 random-effects models⁶ in meta-regression analysis. Clustered robust regression can be
265 used to address the issue of panel-effects in meta-analysis. It applies a nonparametric

⁶ Both fixed-effect and random-effect considerations can be problematic in meta-analysis modelling—the former because it can be difficult to separate variables having relatively small variation and the fixed-effect constant within a group, and the latter because of the issue of regression weighing that is often required but not included in most random-effect panel models See Van Houtven (2008) for more details.

266 Huber-White method to correct standard errors for potential correlation within clusters and
 267 variances across clusters (Van Houtven, 2008). Clustered robust regression has been used
 268 in several prior meta-analyses (Smith and Osborne, 1996; Van Houtven et al., 2007; Van
 269 Houtven et al., 2017). We clustered by sample to correct for the correlation of errors⁷ that
 270 would arise because the same set of respondents answered more than one WTP question.

271 Weighting each observation of the meta-dataset by different metrics is often used to
 272 separate within-study and between-study variation and also to correct for the biases in the
 273 precision of WTP estimates from multiple studies that may arise as a consequence of
 274 differences in sample sizes and other effects, such as from survey formats. Weighting using
 275 the inverse variance or standard error of the WTP estimate is recommended and preferred in
 276 meta-regression (Gurevitch et al., 2018; Van Houtven, 2008). However, many meta-
 277 analyses of NMV studies face the problem of lack of reporting of the standard errors of WTP
 278 estimates or other statistics from which the standard error can be calculated. Instead,
 279 inverse-sample size-weighting has become a common practice in meta-analysis (e.g.,
 280 Bergstrom and Taylor, 2006; Ma et al., 2015; Van Houtven et al., 2017). We estimated two
 281 clustered regression models⁸ to test the effect of the weighting metric on regression output—
 282 an inverse-standard error-weighted model (Model SE), and an inverse-square root of sample
 283 size-weighted model (Model SS). We anticipated different regression results from Model SE
 284 and Model SS as we found the standard errors (SEs) and the sample size (Figure 1) to only
 285 be weakly correlated ($r = 0.21$). For studies that did not report SEs of the WTP estimates, we
 286 calculated the SEs from other metrics if reported—either the standard deviations along with

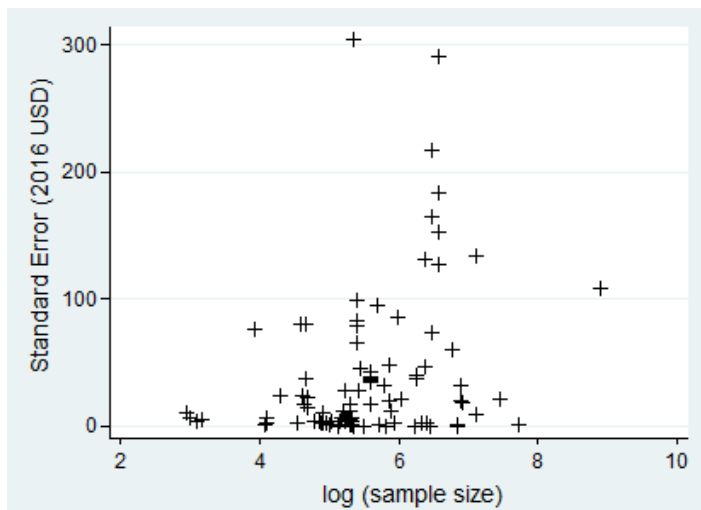
⁷ Multiple WTP value estimates from a single primary study or from the same respondent sample cannot be treated as independent. The estimates are always dependent due to a correlation of effect size parameters or a correlation of estimation errors (Hedges et al. (2010)).

⁸ Our meta-regression model essentially takes the following form based on standard practice for clustered ordinary least squares regression given by (Lindhjem and Navrud, 2015):

$$\ln(WTP_{si}) = \beta_0 + \beta_1 \ln(Income_{si}) + \sum_k \beta_k M_{si}(k) + \varepsilon_{si} \dots \dots \dots (3)$$

where, $\ln(WTP_{si})$ and $\ln(Income_{si})$ are the natural log of willingness to pay, and income, respectively, for estimate i of cluster s , β_0 is the constant term, and β_k the k coefficients of the k moderator/explanatory variables (M).

287 the sample size or the confidence intervals of the WTP estimates⁹. We present the results of
288 both models (Table 2). Stata/IC 14 (Statacorp LLC, USA) was used to analyse the data.
289



290
291 **Figure 1:** Scatter plot of the natural log of sample size and standard error of total WTP (in
292 2016 US dollars) of the studies used in the meta-analysis

293

294 3. Results

295 3.1 Some descriptive statistics from primary studies

296 Although the average total WTP (TWTP) was \$414 per household, its standard
297 deviation, which was nearly twice the TWTP value (\$792), and the wide range in TWTP
298 values (Table 1), indicate that there is a huge variation in WTP for threatened species across
299 the globe. Charismatic species accounted for two-thirds of the observations in the data-set,
300 while there was an equal percentage of WTP observations of threatened and non-threatened
301 species (50%). Welch's t-tests indicated a significantly higher ($p < 0.0001$) average TWTP

⁹ Studies that did not report the standard errors, standard deviations or the confidence intervals of the WTP estimates could not be included in the meta-regression analysis. Of the 165 observations from 71 stated preference studies that could possibly have been included in the meta-regression analysis, we could only include 109 observations from 47 studies in the analysis (i.e. we have excluded 56 observations from 24 studies, or about one-third of the total observations because the standard errors, standard deviations or the confidence intervals of the WTP estimates were not reported in these studies). There was no particular pattern in terms of the species that were omitted from these studies.

302 for charismatic species (\$572) compared to non-charismatic species (\$106), but no
303 statistically significant difference in average TWTP for non-threatened species (\$445)
304 compared to threatened species (\$383). Even though our dataset was skewed towards NMV
305 studies from developed countries (89%), Welch's t-tests indicated that there was no
306 significant difference between the average TWTP per household for threatened species in
307 developed countries (\$426) compared to developing countries (\$318). Surveys with coloured
308 photographs accounted for 50% of the observations in the dataset but t-tests¹⁰ indicated that
309 there were no significant differences in average total WTP values for surveys containing
310 coloured photographs of threatened species (\$499) and those that did not (\$330).

311 3.2 *Significant determinants of WTP from regression models*

312 Though both regression models fit the data well, the higher coefficient of determination
313 (R^2) and the lower root-mean-square error (RMSE) values of Model SE indicates that this
314 model provides a more superior fit than Model SS (Table 2).

315 Species' charisma, as well as its threat status, significantly affected WTP for its
316 conservation in Model SE (Table 2). Results from other studies highlight the importance of a
317 species' perceived "charisma" with the general public, for example, by finding either greater
318 conservation budgets allocated to charismatic species over endangered species (Metrick
319 and Weitzman, 1996) or, finding participants more likely to donate money to adopt
320 charismatic species over endangered species in zoo conservation programs (Colleony et al.,
321 2017). In Model SS, the coefficient for a higher threat status was negative (Table 2), implying
322 a lower willingness to pay, which is contradictory to our expectations.

323 WTP for marine mammals and turtles was significantly higher than for non-marine
324 mammals, whereas WTP for birds, fish and for other species that included crustaceans and

¹⁰ Results from t-tests can serve as indicators and are useful for initial discussions about the possible effect of various independent variables on WTP. However, the effects of multiple variables (some discrete and some continuous) from multiple studies on WTP can only be ascertained using a regression analysis. Therefore, the results of the regression analysis in section 3.2 supersede those from the t-tests.

325 insects was not significantly different than for non-marine mammals (SE model in Table 2).
326 This is partly in line with the findings of the meta-analyses of Loomis and White (1996) and
327 Richardson and Loomis (2009) who found WTP for marine mammals, birds and fish to be
328 significantly higher compared to mammals. It is likely that species' charisma might be a
329 bigger factor affecting WTP for conservation over the type of species on a global scale.
330 Results from Model SS, however, implied that WTP was not species-dependent.

331 Model SE indicated that respondents significantly valued avoiding loss or avoiding
332 extinction of a species, and also maintaining a species population relative to a baseline of a
333 gain in population. In line with economic theory and findings of previous meta-analyses
334 (Loomis and White, 1996; Richardson and Loomis, 2009), respondents positively and
335 significantly valued higher population gains. In Model SS, however, the type of change in
336 species' population or the magnitude of the gain in populations were insignificant factors,
337 which are contradictory to both economic theory and our expectations.

338

339 **Table 2:** Clustered robust regression models results weighted by (1) the inverse of the
 340 standard error of WTP estimates (Model SE) and by (2) the inverse of the square root of
 341 sample size (Model SS).

Independent Variable	Model SE (1)			Model SS (2)		
	Coefficient	Robust standard error	t-statistic	Coefficient	Robust standard error	t-statistic
Survey context						
Survey year-2016	0.004	0.031	0.120	0.004	0.033	0.130
log ^a (Income)	0.378	0.273	1.380	0.664***	0.229	2.910
Developing country (base ^b : Developed country)	-0.572	0.808	-0.710	1.268***	0.560	2.260
Visitors (base ^b : locals)	-0.446**	0.226	-1.970	-0.570*	0.317	-1.800
Species						
Marine Mammal or Turtle (base ^b : Mammals)	1.155***	0.240	4.820	0.130	0.326	0.400
Bird (base ^b : Mammals)	-0.025	0.315	-0.080	-0.601	0.429	-1.400
Fish (base ^b : Mammals)	0.268	0.371	0.720	-0.544	0.689	-0.790
Other species type ^c (base ^b : Mammals)	-0.364	0.353	-1.030	-0.566	0.603	-0.940
Threatened species ^d	1.021***	0.202	5.040	-0.054	0.263	-0.200
Charismatic species ^e	0.539***	0.232	2.320	0.547	0.371	1.480
Survey administration						
In-person or Telephone (base ^b : Mail or Drop-off)	0.297	0.631	0.470	0.162	0.487	0.330
Online (base ^b : Mail or Drop-off)	0.965	0.842	1.150	-0.049	0.740	-0.070
Survey design^f						
OE (base ^b : DC)	-0.852***	0.350	-2.430	-0.605***	0.299	-2.020
PC (base ^b : DC)	-1.506***	0.376	-4.000	-1.277***	0.399	-3.200
CE (base ^b : DC)	-0.616	0.642	-0.960	-0.207	0.503	-0.410
Coloured pic ^g	0.376	0.520	0.720	0.145	0.439	0.330
Payment vehicle						
Donation (base ^b : Tax)	0.128	0.297	0.430	-0.443	0.313	-1.410
Other ^h (base ^b : Tax)	-0.439	0.280	-1.570	-1.039***	0.367	-2.830
Payment durationⁱ						
Annual >=6 years to perpetuity	3.881***	0.536	7.240	2.509***	0.406	6.180
Type of change						
Avoid Loss/ Avoid extinction (base ^b : Gain in population)	2.503***	0.407	6.160	0.878	0.705	1.250
Maintain population (base ^b : Gain in population)	1.031***	0.369	2.800	0.524	0.724	0.720
log ^a (Magnitude of gain)	0.389***	0.067	5.840	0.074	0.151	0.490
constant	-3.262	3.438	-0.950	-3.149	2.374	-1.330
Dependent variable	log ^a (WTP)			log ^a (WTP)		
Observations	109			109		
Clusters	71			71		
R²	0.909			0.824		
RMSE^j	0.326			0.753		

342 ^a log refers to natural log; ^b base refers to baseline; ^c Other species type include crustaceans and insects ^d Threatened includes
 343 species whose threat status is vulnerable, or endangered, or critically endangered with the baseline being species whose threat
 344 status is least concern, or data deficient, or not listed, or near threatened; ^e baseline is species that are not charismatic; ^f DC =
 345 dichotomous choice contingent valuation (CV), OE= open-ended CV, PC = payment card CV, CE = choice experiment; ^g
 346 baseline included surveys that used no photographs, or black and white drawings, or black and white photographs, or those

347 that did not state whether they used photographs or not;^h Other payment vehicles included fees, surcharges and trust funds;ⁱ
348 baseline for payment duration included one-time payments or annual payments up to five years;^j RMSE = Root-mean-square
349 error; *, **, and *** indicate significance at the 90%, 95%, and 99% and higher levels of confidence, respectively.
350

351 While respondents in developing countries had lower WTP for species' conservation
352 compared to those in developed countries, the effect of a country's development status on
353 WTP was not significant in Model SE. In Model SS, however, WTP for species' conservation
354 was significantly higher in developing countries compared to those in developed countries. In
355 both models, visitors were significantly less willing to pay for species' conservation than were
356 local residents, which is in contrast to the findings of the meta-analyses of Loomis and White
357 (1996) and Richardson and Loomis (2009). It could be that the values expressed by visitors
358 were mostly use-values for the threatened species, whereas locals derived both use and
359 passive-use values from species.

360 The survey year coefficient was positive but not significant for both models (Table 2).
361 Income was found to have a positive but insignificant effect on WTP for species conservation
362 in Model SE, similar to the findings of Richardson and Loomis (2009). In Model SS, income
363 had a positive and significant effect on WTP similar to the findings of Jacobsen and Hanley
364 (2009).

365 Survey administration was not a factor affecting WTP in this meta-analysis: the
366 coefficients for online mode and in-person or telephone mode relative to the baseline of mail
367 and drop-off¹¹ were insignificant in both models. This agrees with the findings by Olsen
368 (2009) and Nielsen (2011) who find no significant difference in WTP between online and mail
369 stated preference surveys, or between online and in-person stated preference surveys,
370 respectively. However, Richardson and Loomis (2009) and Maguire (2009) found that mail
371 surveys and telephone surveys resulted in significantly lower WTPs compared to in-person

¹¹ Drop-off surveys were combined with mail surveys since they can be thought of as imitating the latter in that they had to be filled on paper and in the respondent's own time. Similarly telephone and in-person surveys were combined. In models where drop-off and telephone surveys (13 and 4 WTP values in total, respectively) were assigned their separate dummy variables, the coefficients were not found to be significant. Therefore, in the interest of parsimony, variables denoting mail and drop-off and telephone and in-person surveys were combined.

372 surveys. In their comprehensive review comparing the internet with other modes of survey
373 administration, (Lindhjem and Navrud, 2011) found no substantial difference in quality or
374 validity between internet and mail or telephone or in-person modes with welfare estimates
375 mostly equal across the administration modes, and possibly sometimes lower for internet
376 surveys. More surveys in the future will be conducted online; therefore, it is encouraging that
377 WTP values from online surveys were not significantly different from in-person or mail
378 surveys.

379 Open-ended (OE) and payment card (PC) type contingent valuation elicited lower WTP
380 values than dichotomous choice (DC) type contingent valuation surveys, with OE and PC
381 eliciting significantly lower WTP values in both models (Table 2). This is consistent with the
382 findings from many other studies (Reaves et al., 1999) as well as other meta-regressions
383 (Jacobsen and Hanley, 2009; Richardson and Loomis, 2012). Choice experiments (CE),
384 however, did not elicit significantly lower WTP estimates compared to DC contingent
385 valuation surveys. This does not agree with the findings of Richardson and Loomis (2009)
386 who found WTP estimates to be significantly higher from CE studies. However, their study
387 included just one CE study having five WTP estimates whereas ours included 22 CE
388 observations.

389 The coefficient for coloured photographs was positive but not significant in both models,
390 indicating that the inclusion of coloured photographs of threatened species in surveys, on the
391 whole, did not significantly affect WTP for their conservation relative to not including
392 photographs or including black and white photographs. These findings are in line with those
393 from Subroy et al. (2018) who found WTP to be independent of the inclusion of coloured
394 photographs of species in their NMW survey on West Australian households' WTP for
395 threatened native species and conservation management, but different from the findings of
396 Labao et al. (2008) who found coloured photographs to elicit a significantly higher WTP for
397 the preservation of the Philippine Eagle. It is possible that more studies may be necessary to
398 resolve the issue of the influence of coloured photographs of species on WTP.

399 We found that other payment vehicles¹²—donations, fees or surcharges—did not elicit
400 significantly different WTP compared to taxes in Model SE, whereas in Model SS, fees and
401 surcharges but not donations appear to elicit a significantly lower WTP. Voluntary payment
402 vehicles, such as donations, are usually seen to elicit lower WTP values owing to “free-
403 riding” by many individuals who like to enjoy the benefits of public goods without having to
404 contribute to the cost of providing the goods themselves (Stithou and Scarpa, 2012). The
405 Jacobsen and Hanley (2009) meta-analysis on biodiversity conservation found donations to
406 elicit a higher but not significantly higher WTP compared to taxes, while Lindhjem and Tuan
407 (2012) found mandatory payments (taxes, etc.) to elicit significantly higher WTP than
408 voluntary payments in their meta-analysis of species’ valuation in Asia and Oceania.

409 Expectedly, total WTP was significantly higher for longer payment durations than for one-
410 time payments or annual payments up to five years¹³ in both models.

411 From our results, it is sufficiently clear that the metric used for weighting significantly
412 alters the model output. To select the preferred model for our analysis, we consider the
413 following arguments: first, inverse-standard error-weighting is considered more accurate
414 than inverse-sample size-weighting owing to the incorporation of information on the precision
415 of the effect size, which the latter weighting scheme does not provide, and also because of
416 the possible biases that can be introduced by weighting with sample size (Gurevitch et al.,
417 2018; Van Houtven, 2008). Second, for stated preference studies, the information from
418 variation in experimental design and elicitation format cannot be captured using sample size,
419 and as such, results from inverse weighting using sample size only provides an
420 approximation, and are a practical second-best alternative when data on WTP statistics are
421 unavailable (Van Houtven, 2008). Finally, the coefficients of several important variables

¹² In general, Johnston et al. (2017) recommend avoiding nonbinding payment vehicles that do not provide incentives for truthful demand revelation such as donations.

¹³ We tested different categorical combinations of payment durations. We found no significant difference in coefficients for annual payments of 6 to 10 years than those for annual payments > 10 years to perpetuity. These two categories were therefore combined. Results also suggested no significant difference in annual payment up to 5 years compared to one-time payments resulting in just two categories as outlined in Table 1.

422 especially those on species' type, threat status, charisma, the type of change in population
423 being measured (avoid loss relative to gain) and the percentage of gain being measured
424 were not statistically significant in Model SS, which contradicts published literature and also
425 economic theory. We, therefore, selected Model SE as our preferred model, and used it in
426 the next section to test the reliability of the WTP estimates determined by this meta-
427 regression.

428 3.3 Reliability of WTP estimates

429 As recommended by Bergstrom and Taylor (2006) we determined the reliability of WTP
430 estimates from our meta-regression model (Model SE) for use in benefit transfer by
431 comparing WTP estimates determined by the model with those derived from primary NMV
432 studies. We estimated both within-sample and out-of-sample transfer errors using the
433 procedure outlined in Lindhjem and Navrud (2008). To calculate within-sample transfer
434 errors we compared the WTP from the primary study used in the meta-analysis with the
435 WTP predicted by Model SE. Out-of-sample transfer errors were calculated by leaving study
436 clusters out systematically, and calculating the model on the remaining clusters, then using
437 the model to predict WTP values for the observations in the cluster that was left out, and
438 comparing predicted WTP values with the ones estimated in the primary studies. The
439 absolute transfer error (TE) for each observation was calculated as (Lindhjem and Navrud,
440 2008):

$$441 \quad TE = \frac{|WTP_p - WTP_a|}{WTP_a} \times 100\% \quad (2)$$

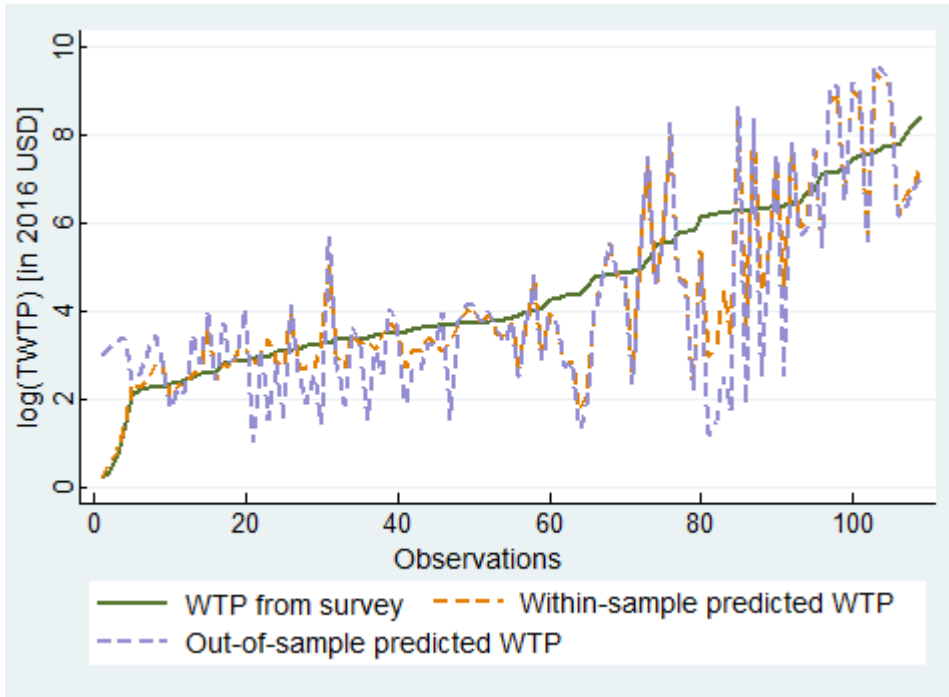
442 where subscripts *p* and *a* denote the model-predicted WTP and the actual WTP values
443 from the primary study, respectively.

444 Expectedly, out-of-sample TEs were found to be higher than within-sample TEs (Figure
445 2). Also, see Table S.2 in the supplementary data. Mean and median within-sample TEs
446 were found to be 17%, and 14%, respectively, while mean and median out-of-sample TEs
447 were found to be 48% and 21%, respectively. About 53 out-of-sample transfers or 48.6% of
448 our data showed TEs of 20% or less, with 25 out-of-sample transfers or 23% of the data

449 having TEs of 10% or less. 39.5% of in-sample transfers showed errors of 10% or less. As
450 with the results by Lindhjem and Navrud (2008) and Brander et al. (2007), TEs were seen to
451 be higher at the lower WTP values, and lower at higher WTP values (i.e. the meta-function
452 over-estimates at lower values and under-estimates at higher values). Correlation between
453 within-sample- and out-of-sample- predicted values of WTP was high (92.5%), indicating a
454 good agreement between within-sample-predicted values of WTP and out-of-sample-
455 predicted values of WTP in most cases (Figure 2).

456 TEs for our meta-model are comparable to the meta-analysis of endangered species in
457 Asia and Oceania by Lindhjem and Tuan (2015), who found a mean out-of-sample TE to be
458 45% for their full model where all variables were used. Within-sample TEs from our model
459 were lower than those determined by Richardson and Loomis (2009), who found mean
460 within-sample TEs to vary between 34-45% depending on whether the payment was annual
461 or lump sum. Our TEs are also in the range reported by meta-analyses in other contexts—
462 Shrestha and Loomis (2001) reported an average absolute TEs of 28% in their meta-
463 analysis on international outdoor recreation, Lindhjem and Navrud (2008) found mean TEs
464 of between 39-62% in the validity testing of a meta-analysis model of non-timber benefits of
465 CV studies from Norway, Sweden and Finland, and Brander et al. (2006) found mean
466 transfer errors of 74% in their meta-analysis on wetland valuation. Our meta-function,
467 therefore, provides reasonably reliable WTP estimates with TEs in the range reported by
468 other studies.

469



470

471 **Figure 2:** Plot of the natural log of total willingness to pay (log(TWTP)) estimates from the
 472 original study, and their within-sample and out-of-sample model-predicted values. TWTP
 473 values from the original studies have been sorted in ascending order. All values are in 2016
 474 US dollars.

475

476

477 **4. Discussions and Conclusions**

478 Our meta-regression analysis is the first we are aware of that considers NMV studies
479 (both contingent valuation and choice experiments) for threatened species of animals
480 globally. Some of our findings are similar to previous meta-analyses of WTP for biodiversity
481 conservation and individual species, namely the influence of survey format (a significant
482 influence on WTP) and the payment vehicle (an insignificant influence). Others results such
483 as the insignificance of income and survey year are in contrast to published meta-analyses
484 on the topic. The average total present value of WTP for a threatened species from all
485 primary studies in our meta-dataset was US\$414 per household (in 2016 dollars). However,
486 the large variation in the range of reported values indicate that there is a huge variation in
487 WTP for threatened species across the globe depending on the species and the survey
488 context.

489 We tested the effect of several variables not considered in prior meta-analyses—species'
490 threat status, the use of coloured photographs of species in the survey, and a country's
491 development status. In line with expectations and economic theory, we found endangered
492 species to be valued significantly more highly than non-threatened species. The
493 development status of a country, however, did not influence WTP estimates, and neither did
494 the inclusion of coloured photographs of species in the survey.

495 An important contribution of this paper is the demonstration of the effect of the choice of
496 weighting metric on the output of a regression model. We found that the inverse-standard
497 error-weighted model provided significant coefficients of important variables that were in line
498 with economic theory and with published literature. In agreement with the reviews of
499 Gurevitch et al. (2018) and (Van Houtven, 2008) we recommend future meta-regression
500 models to use inverse-standard error (or variance)-weighting rather than inverse-sample
501 size-weighting as far as possible.

502 It would have been interesting to explore the influence of pro-environmental attitudes or
503 ethical beliefs towards preservation in this meta-regression analysis, as they have been
504 found by Kotchen and Reiling (2000), Ojea and Loureiro (2007) and Subroy et al. (2019) to
505 significantly influence WTP for species' conservation. However, very few papers reported
506 asking such questions. Subsequent meta-analyses may benefit if future NMV surveys of
507 threatened species include questions about environmental attitudes or ethical beliefs of
508 respondents.

509 Our meta-analysis is limited in terms of the availability of primary studies—it included a
510 higher proportion of studies from developed countries as well as on terrestrial mammals and
511 marine mammals compared to lesser charismatic species such as insects and crustaceans.
512 The only NMV study on insects in our meta-analysis (Diffendorfer et al., 2014) was on a
513 charismatic species—the Monarch butterfly, while all the reptiles in the primary studies were
514 turtles that are also a charismatic species. Thus, even though our meta-regression model
515 provides reasonably reliable WTP estimates, it may not always be possible to use it to
516 estimate economic values for threatened species from developing countries or, for say,
517 threatened insects or non-charismatic reptiles given the lack of availability of primary studies.
518 A greater number of primary studies from developing countries as well as more studies on
519 less charismatic species would improve the applicability of future meta-functions on WTP for
520 threatened animal species. Also, for endemic species, particularly those having a limited
521 geographical range, it would be more appropriate to conduct original NMV studies rather
522 than deriving WTP estimates from a meta-regression model. Another aspect that cannot yet
523 be accurately captured in a meta-regression model of threatened species valuation is the
524 diminishing marginal utility of the WTP estimate. There is insufficient evidence in the existing
525 literature to provide a general estimate of how rapidly the marginal value of a threatened
526 species declines as the population size increases.

527 Limitations of current NMV studies and reporting recommendations for future
528 studies

529 Preparing data for meta-analysis is challenging because relevant data needs to be
530 extracted from original studies conducted in diverse contexts. Identifying effect-size or the
531 commodity (here the change of species population) being valued is a difficult task when it
532 comes to the valuation of species. Many of the reviewed studies were vague in defining the
533 scenario being valued, stating “protection or conservation of species” or some such similarly
534 ambiguous statement without any reference to a baseline. In the absence of a baseline, we
535 could not know what change in species’ populations was exactly being valued, and had to
536 regrettably reject those studies from our meta-analysis. Only a few studies explicitly
537 specified the counterfactual scenario; that is, what would happen if the conservation program
538 was not carried out—would the species’ population drop, increase or stay the same? Failure
539 to specify the counterfactual scenario means that it is left to the respondent to guess or
540 imagine what the counterfactual would be or to try to infer it from clues in the question. This
541 is highly likely to introduce unnecessary randomness into the set of responses. We
542 recommend that future non-market valuation studies of threatened species should be explicit
543 about the counterfactual in the wording of the survey question.

544 Many studies failed to report essential information such as the survey year, the standard
545 errors or confidence intervals of the WTP estimates, sociodemographic characteristics of the
546 sample (age, income, gender, education etc.), payment vehicle and payment duration. Many
547 studies also lacked clarity about the survey instrument including whether photographs were
548 used, details about survey administration and survey response rate. Such information can
549 enrich a meta-analysis and provide a more complete picture of factors affecting WTP for
550 species.

551 Meta-analyses help provide a comprehensive picture of phenomena being studied and
552 understand sources of heterogeneity (Gurevitch et al., 2018). To support future meta-
553 analyses and benefit transfers for threatened species valuation, we urge researchers in this

554 area to (i) explicitly define the counterfactual scenario in their survey instruments; (ii)
555 quantitatively express the effect sizes being measured; and (iii) report these details along
556 with essential information on the payment vehicle, payment duration, survey design (e.g. use
557 of photographs), sample sociodemographics, and either standard errors or confidence
558 intervals for the WTP estimates, which will allow these studies to be incorporated in future
559 meta-analyses and benefit transfers.

560 **Acknowledgments**

561 The first author would like to gratefully acknowledge the support of the Australian
562 Government's Research Training Program (RTP) Scholarship as well as the top-up
563 scholarship from the University of Western Australia (UWA) and the National Environmental
564 Science Programme's Threatened Species Research Hub (NESP-TSR) that have enabled
565 this research to be carried out. Asha Gunawardena and Ram Pandit also thank the NESP-
566 TSR for funding support. David Pannell and Maksym Polyakov are grateful for funding
567 support from the ARC Centre of Excellence for Environmental Decisions (CEED). The
568 authors would also like to acknowledge Dr Marit Kragt, Dr James Fogarty, and Professor
569 Michael Burton at the UWA School of Agriculture and Environment for their valuable inputs
570 that helped shape this paper. The authors are also grateful to the two anonymous reviewers
571 for their useful comments that helped to improve this article.

572 **5. References**

- 573 Arrow, K., Solow, R., Portney, P.R., Leamer, E.E., Radner, R., Schuman, H., 1993. Report of
574 the NOAA Panel on Contingent Valuation. *Federal Register* 58, pp. 4601-4614, pp. 4601-
575 4614.
- 576 Baker, R., Ruting, B., 2014. *Environmental Policy Analysis: A Guide to Non-Market*
577 *Valuation*. Productivity Commission Staff Working Paper, Canberra, Australia.
- 578 Bergstrom, J.C., Taylor, L.O., 2006. Using meta-analysis for benefits transfer: Theory and
579 practice. *Ecological Economics* 60, 351-360.
- 580 BLS, 2017. CPI Inflation Calculator. U.S. Bureau of Labor Statistics, Washington, DC, USA.
- 581 Brander, L.M., Florax, R., Vermaat, J.E., 2006. The empirics of wetland valuation: A
582 comprehensive summary and a meta-analysis of the literature. *Environmental & Resource*
583 *Economics* 33, 223-250.

584 Brander, L.M., Van Beukering, P., Cesar, H.S.J., 2007. The recreational value of coral reefs:
585 A meta-analysis. *Ecological Economics* 63, 209-218.

586 Colleony, A., Clayton, S., Couvet, D., Saint Jalme, M., Prevot, A.C., 2017. Human
587 preferences for species conservation: Animal charisma trumps endangered status. *Biological*
588 *Conservation* 206, 263-269.

589 Diffendorfer, J.E., Loomis, J.B., Ries, L., Oberhauser, K., Lopez-Hoffman, L., Semmens, D.,
590 Semmens, B., Butterfield, B., Bagstad, K., Goldstein, J., Wiederholt, R., Mattsson, B.,
591 Thogmartin, W.E., 2014. National valuation of monarch butterflies indicates an untapped
592 potential for incentive-based conservation. *Conservation Letters* 7, 253-262.

593 Gurevitch, J., Koricheva, J., Nakagawa, S., Stewart, G., 2018. Meta-analysis and the
594 science of research synthesis. *Nature* 555, 175.

595 Han, S.-Y., Lee, C.-K., Mjelde, J.W., Kim, T.-K., 2010. Choice-experiment valuation of
596 management alternatives for reintroduction of the endangered mountain goral in Woraksan
597 National Park, South Korea. *Scandinavian Journal of Forest Research* 25, 534-543.

598 Hedges, L.V., Tipton, E., Johnson, M.C., 2010. Robust variance estimation in meta-
599 regression with dependent effect size estimates. *Research synthesis methods* 1, 39-65.

600 Jacobsen, J.B., Hanley, N., 2009. Are There Income Effects on Global Willingness to Pay for
601 Biodiversity Conservation? *Environmental & Resource Economics* 43, 137-160.

602 Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A.,
603 Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C.A., 2017.
604 Contemporary Guidance for Stated Preference Studies. *Journal of the Association of*
605 *Environmental and Resource Economists* 4, 319-405.

606 Kazlauskienė, V., 2015. Application of Social Discount Rate for Assessment of Public
607 Investment Projects. *Procedia - Social and Behavioral Sciences* 213, 461-467.

608 Kotchen, M.J., Reiling, S.D., 2000. Environmental attitudes, motivations, and contingent
609 valuation of nonuse values: a case study involving endangered species. *Ecological*
610 *Economics* 32, 93-107.

611 Labao, R., Francisco, H., Harder, D., Santos, F.I., 2008. Do colored photographs affect
612 willingness to pay responses for endangered species conservation? *Environmental &*
613 *Resource Economics* 40, 251-264.

614 Lindhjem, H., Navrud, S., 2008. How reliable are meta-analyses for international benefit
615 transfers? *Ecological Economics* 66, 425-435.

616 Lindhjem, H., Navrud, S., 2011. Using Internet in Stated Preference Surveys: A Review and
617 Comparison of Survey Modes. *International Review of Environmental and Resource*
618 *Economics* 5, 309-351.

619 Lindhjem, H., Navrud, S., 2015. Reliability of meta-analytic benefit transfers of international
620 value of statistical life estimates: Tests and illustrations, in: Johnston, R.J., Rolfe, J.,
621 Rosenberger, R.S., Brouwer, R. (Eds.), *Benefit Transfer of Environmental and Resource*
622 *Values: A Guide for Researchers and Practitioners*. Springer, pp. 441-464.

623 Lindhjem, H., Tuan, T.H., 2012. Valuation of species and nature conservation in Asia and
624 Oceania: A meta-analysis. *Environmental Economics and Policy Studies* 14, 1-22.

625 Lindhjem, H., Tuan, T.H., 2015. Benefit transfer of nature conservation values in Asia and
626 Oceania based on meta-analysis: Data heterogeneity and reliability issues, in: Managi, S.
627 (Ed.), *The Routledge Handbook of Environmental Economics in Asia*. Routledge, New York,
628 USA, pp. 349-368.

629 Loomis, J.B., White, D.S., 1996. Economic benefits of rare and endangered species:
630 Summary and meta-analysis. *Ecological Economics* 18, 197-206.

- 631 Ma, C., Rogers, A.A., Kragt, M.E., Zhang, F., Polyakov, M., Gibson, F., Chalak, M., Pandit,
632 R., Tapsuwan, S., 2015. Consumers' willingness to pay for renewable energy: A meta-
633 regression analysis. *Resource and Energy Economics* 42, 93-109.
- 634 Maguire, K.B., 2009. Does mode matter? A comparison of telephone, mail, and in-person
635 treatments in contingent valuation surveys. *Journal of Environmental Management* 90, 3528-
636 3533.
- 637 Metrick, A., Weitzman, M.L., 1996. Patterns of behavior in endangered species preservation.
638 *Land Economics* 72, 1-16.
- 639 Nelson, J.P., Kennedy, P.E., 2009. The Use (and Abuse) of Meta-Analysis in Environmental
640 and Natural Resource Economics: An Assessment. *Environmental and Resource Economics*
641 42, 345-377.
- 642 Nielsen, J.S., 2011. Use of the Internet for willingness-to-pay surveys: A comparison of face-
643 to-face and web-based interviews. *Resource and Energy Economics* 33, 119-129.
- 644 Ojea, E., Loureiro, M.L., 2007. Altruistic, egoistic and biospheric values in willingness to pay
645 (WTP) for wildlife. *Ecological Economics* 63, 807-814.
- 646 Olsen, S.B., 2009. Choosing Between Internet and Mail Survey Modes for Choice
647 Experiment Surveys Considering Non-Market Goods. *Environmental and Resource*
648 *Economics* 44, 591-610.
- 649 Pandit, R., Subroy, V., Garnett, S.T., Zander, K.K., Pannell, D.J., 2015. A review of non-
650 market valuation studies of threatened species and ecological communities. Report to the
651 National Environmental Science Programme, Department of the Environment, Canberra,
652 Australia.
- 653 Ready, R., Navrud, S., 2006. International benefit transfer: Methods and validity tests.
654 *Ecological Economics* 60, 429-434.
- 655 Reaves, D.W., Kramer, R.A., Holmes, T.P., 1999. Does question format matter? Valuing an
656 endangered species. *Environmental & Resource Economics* 14, 365-383.
- 657 Richardson, L., Loomis, J., 2009. The total economic value of threatened, endangered and
658 rare species: An updated meta-analysis. *Ecological Economics* 68, 1535-1548.
- 659 Richardson, L., Loomis, J., 2012. Total Economic Valuation of Endangered Species: A
660 Summary and Comparison of United States and Rest of the World Estimates, in: K.N.Ninan
661 (Ed.), *Conserving and Valuing Ecosystem Services and Biodiversity: Economic, Institutional*
662 *and Social Challenges*. Earthscan, London, UK, pp. 25-45.
- 663 Rolfe, J., Brouwer, R., Johnston, R.J., 2015. Meta-analysis: Rationale, Issues and
664 Applications, in: Johnston, J.R., Rolfe, J., Rosenberger, S.R., Brouwer, R. (Eds.), *Benefit*
665 *Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners*.
666 Springer Netherlands, Dordrecht, pp. 357-381.
- 667 Saloio, J.H., Jr., 2008. Willingness to pay for international threatened and endangered
668 species: Meta-analysis and benefit transfer. The University of New Mexico, Ann Arbor, p.
669 221.
- 670 Shr, Y.-H., Ready, R., 2016. Are Pictures Worth a Thousand Words? Impacts of Scenario
671 Visualization in Choice Experiments: A Case of Preferences over Landscape Attributes of
672 Green Infrastructure, Working Paper, CAES & WAEA Joint Annual Meeting, Victoria, BC,
673 Canada.
- 674 Shrestha, R.K., Loomis, J.B., 2001. Testing a meta-analysis model for benefit transfer in
675 international outdoor recreation. *Ecological Economics* 39, 67-83.
- 676 Smith, V.K., Osborne, L.L., 1996. Do contingent valuation estimates pass a "scope" test? A
677 meta-analysis. *Journal of Environmental Economics and Management* 31, 287-301.

678 Spash, C.L., Vatn, A., 2006. Transferring environmental value estimates: Issues and
679 alternatives. *Ecological Economics* 60, 379-388.

680 Stanley, T.D., Doucouliagos, H., Giles, M., Heckemeyer, J.H., Johnston, R.J., Laroche, P.,
681 Nelson, J.P., Paldam, M., Poot, J., Pugh, G., Rosenberger, R.S., Rost, K., 2013. Meta-
682 Analysis of Economics Research Reporting Guidelines. *Journal of Economic Surveys* 27,
683 390-394.

684 Stithou, M., Scarpa, R., 2012. Collective versus voluntary payment in contingent valuation
685 for the conservation of marine biodiversity: An exploratory study from Zakynthos, Greece.
686 *Ocean & Coastal Management* 56, 1-9.

687 Subroy, V., Rogers, A.A., Kragt, M.E., 2018. To Bait or Not to Bait: A Discrete Choice
688 Experiment on Public Preferences for Native Wildlife and Conservation Management in
689 Western Australia. *Ecological Economics* 147, 114-122.

690 Subroy, V., Rogers, A.A., Kragt, M.E., 2019. Differences in stakeholders' preferences for
691 threatened species and invasive predator management in Western Australia—a scale-
692 adjusted latent class choice experiment. In Preparation.

693 Tisdell, C., Nantha, H.S., Wilson, C., 2007. Endangerment and likeability of wildlife species:
694 How important are they for payments proposed for conservation? *Ecological Economics* 60,
695 627-633.

696 Van Houtven, G., 2008. Methods for the Meta-Analysis of Willingness-to-Pay Data: An
697 Overview. *Pharmacoeconomics* 26, 901-910.

698 Van Houtven, G., Powers, J., Pattanayak, S.K., 2007. Valuing water quality improvements in
699 the United States using meta-analysis: Is the glass half-full or half-empty for national policy
700 analysis? *Resource and Energy Economics* 29, 206-228.

701 Van Houtven, G.L., Pattanayak, S.K., Usmani, F., Yang, J.C., 2017. What are Households
702 Willing to Pay for Improved Water Access? Results from a Meta-Analysis. *Ecological*
703 *Economics* 136, 126-135.

704 WorldBank, 2017. PPP conversion factor, GDP. The World Bank.

705

706

707

Supplementary Data

708

709 **Table S.1.** Country distribution of non-market valuation observations used in the meta-

710 regression analysis

Country	Number of observations	Percentage of total (%)
Australia	3	2.75
Austria	2	1.83
Canada	8	7.34
Chile	3	2.75
China	5	4.59
Greece	6	5.5
Ireland	1	0.92
Israel	6	5.5
Nepal	1	0.92
Norway	2	1.83
Poland	1	0.92
South Korea	5	4.59
Spain	4	3.67
Sri Lanka	7	6.42
Sweden	9	8.26
Taiwan	3	2.75
UK	11	10.09
USA	31	28.44
Vietnam	1	0.92
Total	109	100

711

712

713 **Table S.2.** Natural log of total willingness to pay (ln(TWTP)) from the original study, and its
714 corresponding within-sample and out-of-sample model-predicted ln(TWTP), along with the
715 within-sample and out-of-sample transfer errors (TEs). All values in 2016 US\$.

Observation ID	Sample ID	ln(TWTP) (from study)	Within-sample predicted ln(TWTP)	Out-of-sample predicted ln(TWTP)	TE (within-sample)	TE (out-of-sample)
1	1	8.221	6.836	6.782	16.849	17.498
2	2	7.779	6.220	6.140	20.044	21.073
3	3	3.604	3.091	2.654	14.243	26.350
4	4	2.872	3.163	4.038	10.141	40.591
5	5	6.175	2.971	1.212	51.891	80.376
6	5	6.229	3.192	1.525	48.763	75.518
7	5	6.260	3.461	1.755	44.706	71.967
8	5	6.275	3.619	1.889	42.325	69.893
9	5	6.237	4.443	2.528	28.767	59.461
10	5	6.321	4.443	2.528	29.707	59.996
11	5	6.423	4.443	2.528	30.831	60.636
12	6	2.284	2.780	2.856	21.701	25.039
13	7	5.823	2.236	2.203	61.596	62.174
14	8	2.581	2.730	2.806	5.771	8.727
15	8	2.858	2.730	2.806	4.487	1.818
16	9	2.382	2.018	1.800	15.297	24.459
17	9	2.466	2.390	2.161	3.082	12.337
18	10	2.259	2.464	3.100	9.090	37.247
19	10	2.278	2.836	3.441	24.462	51.014
20	11	2.255	2.276	2.588	0.919	14.761
21	12	2.487	2.548	3.452	2.436	38.781
22	13	5.771	4.788	4.747	17.038	17.750
23	13	4.257	3.936	3.893	7.550	8.564
24	14	0.247	0.219	3.010	11.217	1119.297
25	14	0.358	0.576	3.179	60.923	788.840
26	14	0.742	0.845	3.307	13.917	345.744
27	15	2.621	3.635	3.995	38.699	52.411
28	16	3.483	3.479	2.574	0.118	26.112
29	17	3.481	3.129	3.078	10.111	11.595
30	18	2.962	3.054	3.114	3.132	5.154
31	19	3.082	2.889	2.832	6.273	8.133
32	20	7.236	6.509	6.474	10.042	10.522
33	21	4.297	3.741	3.722	12.930	13.380
34	22	4.352	2.889	2.850	33.611	34.521
35	23	4.811	5.504	5.564	14.390	15.645
36	24	4.347	2.799	2.739	35.615	36.980
37	25	3.712	3.714	3.762	0.046	1.344
38	25	3.744	3.712	3.760	0.856	0.431
39	25	3.870	3.711	3.759	4.112	2.868
40	25	4.013	4.735	4.816	17.987	20.016

41	25	4.013	3.714	3.762	7.456	6.255
42	26	2.084	2.351	2.405	12.792	15.370
43	27	2.960	2.765	1.011	6.599	65.829
44	27	3.284	3.371	1.413	2.636	56.969
45	28	6.131	5.367	5.206	12.456	15.087
46	28	6.341	5.501	5.351	13.247	15.606
47	28	6.495	5.906	5.737	9.071	11.674
48	28	6.662	6.040	5.882	9.345	11.707
49	29	8.018	6.668	6.391	16.838	20.291
50	29	8.395	7.294	7.017	13.111	16.407
51	30	2.389	2.349	2.262	1.667	5.328
52	31	3.357	3.025	2.774	9.878	17.364
53	32	4.117	3.025	2.887	26.515	29.879
54	33	3.730	4.061	4.146	8.895	11.157
55	34	4.759	4.061	3.987	14.667	16.230
56	35	5.548	7.943	8.256	43.176	48.819
57	36	3.756	3.933	3.986	4.718	6.125
58	37	3.652	3.397	3.269	7.006	10.491
59	38	3.845	3.386	3.273	11.922	14.868
60	39	4.936	5.310	5.356	7.575	8.507
61	40	3.086	2.728	1.511	11.595	51.014
62	3	3.652	3.082	2.645	15.603	27.567
63	4	3.684	3.111	3.975	15.575	7.891
64	41	3.293	5.039	5.686	52.999	72.672
65	42	7.194	8.913	9.095	23.894	26.420
66	42	7.429	9.004	9.186	21.206	23.656
67	42	7.736	9.240	9.422	19.435	21.796
68	42	7.602	9.385	9.568	23.466	25.874
69	43	6.296	8.180	8.371	29.925	32.950
70	43	7.530	8.806	8.994	16.946	19.433
71	43	7.762	9.035	9.221	16.394	18.792
72	44	6.272	8.338	8.618	32.951	37.418
73	44	7.146	8.765	9.042	22.655	26.530
74	45	6.346	7.323	7.529	15.398	18.637
75	45	6.460	7.593	7.804	17.528	20.792
76	46	3.367	3.520	3.635	4.529	7.943
77	47	4.847	4.753	4.735	1.927	2.315
78	48	5.165	7.246	7.485	40.294	44.917
79	49	5.540	5.639	5.643	1.785	1.869
80	50	5.812	4.618	4.570	20.546	21.373
81	51	5.495	4.618	4.581	15.957	16.631
82	52	2.841	2.846	3.751	0.168	32.012
83	46	3.527	3.520	3.635	0.194	3.065
84	46	3.799	3.520	3.635	7.345	4.320
85	46	3.723	4.025	4.162	8.109	11.788
86	53	3.121	3.959	4.126	26.851	32.194

87	54	2.659	2.453	2.415	7.741	9.156
88	55	2.867	3.107	3.161	8.359	10.225
89	56	6.747	7.637	7.657	13.183	13.481
90	57	3.250	2.703	2.543	16.833	21.729
91	58	3.390	3.270	3.251	3.560	4.111
92	59	3.154	2.703	2.522	14.324	20.045
93	60	3.678	3.270	3.232	11.107	12.120
94	61	3.487	3.769	4.060	8.066	16.426
95	62	4.432	1.768	1.353	60.103	69.472
96	62	4.908	2.620	2.324	46.606	52.650
97	63	4.887	4.789	4.778	1.994	2.213
98	64	7.582	5.641	5.560	25.595	26.668
99	65	4.808	4.789	4.786	0.389	0.462
100	66	7.110	5.641	5.426	20.656	23.688
101	67	1.295	1.330	3.432	2.707	165.042
102	67	3.214	2.721	1.892	15.338	41.149
103	67	3.570	2.721	1.892	23.775	47.014
104	68	3.359	2.721	1.892	18.990	43.688
105	69	2.976	3.351	1.530	12.617	48.589
106	69	3.436	3.351	1.530	2.482	55.482
107	69	3.704	3.351	1.530	9.520	58.695
108	70	3.897	2.743	2.526	29.625	35.180
109	71	4.542	2.089	1.854	54.017	59.183

716

717

Appendix I: Studies used in the meta-analysis along with total willingness to pay (TWTP) estimates and standard errors of total WTP (SE) estimates in 2016 US dollars.

Paper	Reference	Study used in the Richardson and Loomis (2009) meta-analysis?	Document type	Country	Survey Year	Sample	Observation ID	Species	Population change measured	Magnitude of change (%)	TWTP (2016 US dollars)	SE (2016 US dollars)
1	Adamowicz et al. (1998)	No	Journal article	Canada	1995	1	1	Woodland Caribou	Gain	50	3717.58	85.8
							2	Woodland Caribou	Gain	50	2390.58	48.84
2	Aldrich et al. (2007)	Yes	Journal article	USA	1997	3	3	Peregrine Falcon	Gain	87.5	36.74	1.24
							4	Shortnose Sturgeon	Maintain		17.67	0.85
3	Bandara and Tisdell (2005)	No	Journal article	Sri Lanka	2001	5	5	Asian Elephant	Maintain		480.78	35.3
							6	Asian Elephant	Gain	25	507.4	36.79
							7	Asian Elephant	Gain	50	523.11	37.75
							8	Asian Elephant	Gain	75	531.06	38.27
							9	Asian Elephant	Loss	25	511.42	37.4
							10	Asian Elephant	Loss	50	555.93	39.45
11	Asian Elephant	Loss	75	616.07	42.51							

4	Baral et al. (2007)	No	Journal article	Nepal	2004	6	12	White-rumped Vulture	Loss	100	9.82	17.46	
5	Bartczak and Meyerhoff (2013)	No	Journal article	Poland	2011	7	13	Eurasian Lynx	Gain	66.67	337.99	95.7	
						8	14	Eurasian Griffon Vulture	Loss	60	13.21	1.02	
							15	Eurasian Griffon Vulture	Loss	100	17.43	1.31	
6	Becker et al. (2009)	No	Journal article	Israel	2003	9	16	Eurasian Griffon Vulture	Gain	100	10.83	0.85	
							17	Eurasian Griffon Vulture	Gain	260	11.77	0.91	
						10	18	Eurasian Griffon Vulture	Gain	100	9.57	0.78	
							19	Eurasian Griffon Vulture	Gain	260	9.76	0.78	
7	Bednar-Friedl et al. (2009)	No	Journal article	Austria	2006		11	20	Rock Partridge	Gain	30	9.54	0.08
							12	21	Austrian Ibex	Maintain		12.03	0.09

8	Boman and Bostedt (1994)	No	Report	Sweden	1993	13	22	Gray Wolf	Loss	100	320.98	134.78
							23	Gray Wolf	Loss	100	70.63	8.99
9	Cerde and Losada (2013)	No	Journal article	Chile	2011	14	24	Moon-toothed Degu	Gain	10	1.28	0.44
							25	Moon-toothed Degu	Gain	25	1.43	0.46
							26	Moon-toothed Degu	Gain	50	2.1	0.61
10	Cummings et al. (1994)	Yes	Journal article	USA	1994	15	27	Colorado Pikeminnow	Loss	100	13.75	2.96
11	Diffendorfer et al. (2014)	No	Journal article	USA	2012	16	28	Monarch Butterfly	Loss	100	32.57	1.41
12	Dong (2010)	No	Thesis	China	2009	18	17	Yangtze finless Porpoise	Gain	50	32.5	6.34
							30	Yangtze finless Porpoise	Gain	50	19.33	1.94
							19	31	Yangtze finless Porpoise	Gain	50	21.81

13	Ericsson et al. (2007)	No	Journal article	Sweden	2004	20	32	Wolverine	Gain	37	1387.88	109.07
14	Fredman (1994)	No	Thesis	Sweden	1993	21	33	White-backed Woodpecker	Loss	100	73.46	20.81
						22	34	White-backed Woodpecker	Loss	100	77.62	45.23
15	Giraud and Valcic (2004)	Yes	Journal article	USA	2000	23	35	Steller Sea Lion	Gain	100	122.9	21.27
16	Loomis and Ekstrand (1998);Giraud et al. (1999a); Giraud et al. (1999b)	Yes	Journal article	USA	1996	24	36	Mexican Spotted Owl	Gain	100	77.25	20.72
							37	Bottlenose Dolphin	Loss	50	40.95	4.15
							38	Elephant Seal	Loss	97.5	42.25	4.26
17	Hageman (1985)	Yes	Report	USA	1984	25	39	Sea Otter	Loss	93.33	47.93	4.55
							40	Blue Whale	Loss	61.24	55.32	6.03
							41	Gray Whale	Loss	91.875	55.32	6.03

18	Han and Lee (2008)	No	Journal article	South Korea	2005	26	42	Asian black Bear	Maintain		8.04	12.18
19	Han et al. (2010)	No	Journal article	South Korea	2008	27	43	Long-tailed Goral	Gain	400	19.3	0.22
							44	Long-tailed goral	Gain	1900	26.69	0.23
							45	Hen Harrier	Maintain		459.72	65.62
20	Hanley et al. (2010)	No	Journal article	United Kingdom	2009	28	46	Hen Harrier	Gain	20	567.3	79.38
							47	Golden Eagle	Maintain		661.85	83.49
							48	Golden Eagle	Gain	20	782.47	99.44
21	Harper (2012)	No	Thesis	Canada	2011	29	49	Woodland Caribou	Gain	50	3035.7	31.82
							50	Woodland Caribou	Gain	250	4423.88	20.1
22	Hynes and Hanley (2009)	No	Journal article	Ireland	2006	30	51	Corncrake	Gain	448.78	10.9	0.58

23	Jin et al. (2008)	No	Journal article	China	2005	31	52	Black faced Spoonbill	Maintain		28.7	2.81
						32	53	Black faced Spoonbill	Maintain		61.37	10.76
24	Johansson (1999)	No	Thesis	Sweden	1996	33	54	African Elephant	Loss	100	41.66	5.72
						34	55	African Elephant	Loss	100	116.67	12.04
						35	56	African Elephant	Loss	100	256.61	28.29
						36	57	African Elephant	Loss	100	42.78	5.44
25	Kim et al. (2012)	No	Journal article	South Korea	2010	37	58	Spotted Seal	Maintain		38.57	3.18
						38	59	Spotted Seal	Maintain		46.74	5.41
26	Kontogianni et al. (2012)	No	Journal article	Greece	2009	39	60	Mediterranean Monk Seal	Loss	100	139.22	12.3
27	Kontoleon and Swanson (2003)	No	Journal article	United Kingdom	1998	40	61	Giant Panda	Gain	150	21.88	1.32
28	Kotchen and Reiling (2000)	Yes	Journal article	USA	1997	3	62	Perigrine Falcon	Gain	87.5	38.56	6.46
						4	63	Shortnose Sturgeon	Maintain		39.82	17.57

29	Langford et al. (1998); Langford et al. (2001)	No	Journal article	Greece	1995	41	64	Mediterranean Monk Seal	Loss	100	26.93	7.13
							65	Steller Sea Lion	Gain	73.08	1331.48	127.4
						42	66	Steller Sea Lion	Gain	92.31	1683.4	153.27
							67	Steller Sea Lion	Gain	169.23	2289.53	183.23
							68	Steller Sea Lion	Gain	246.15	2001.39	290.52
30	Lew et al. (2010a)	No	Journal article	USA	2007		69	Steller Sea Lion	Gain	11.11	542.5	73.93
						43	70	Steller Sea Lion	Gain	55.56	1863.68	164.74
							71	Steller Sea Lion	Gain	100	2350.59	217.47
						44	72	Steller Sea Lion	Gain	16.67	529.32	46.83

							73	Steller Sea Lion	Gain	50	1269.52	132.07
31	Loomis and Larson (1994)	Yes	Journal article	USA	1991	45	74	Gray Whale	Gain	50	570.22	37.71
							75	Gray Whale	Gain	100	639.3	40.88
32	Loureiro and Ojea (2008)	No	Journal article	Spain	2005	46	76	Common murre	Gain	300	29	1.66
						47	77	Wild goose	Maintain		127.33	22.23
33	MacMillan et al. (2004)	No	Journal article	United Kingdom	2000		48	Wild goose	Loss	10	175.07	37.68
							49	Wild goose	Gain	10	254.65	80.96
							50	Wild goose	Gain	10	334.23	80.3
34	Macmillan et al. (2002)	No	Journal article	United Kingdom	2000	51	81	Wild goose	Gain	10	243.35	76.67
35	Myers (2014)	No	Journal article	USA	2010	52	82	Atlantic Red Knot	Gain	185.71	17.14	1.63
36	Ojea and Loureiro (2007)	No	Journal article	Spain	2005			Common murre	Gain	300	34.01	3.07
						46						
37		No		Spain	2005			Common murre	Gain	300	44.65	2.79

	Ojea and Loureiro (2009).		Journal article				85	Common murre	Gain	1100	41.4	3.3
						53	86	Red-cockaded Woodpecker	Gain	171.43	22.67	3.76
38	Reaves et al. (1999)	Yes	Journal article	USA	1992	54	87	Red-cockaded Woodpecker	Gain	171.43	14.28	3.66
						55	88	Red-cockaded Woodpecker	Gain	171.43	17.59	4.02
39	Stanley (2005)	Yes	Journal article	USA	2001	56	89	Riverside Fairy shrimp	Loss	100	851.59	304.6
						57	90	Loggerhead Turtle	Maintain		25.78	4.8
40	Stithou and Scarpa (2012)	No	Journal article	Greece	2003	58	91	Loggerhead Turtle	Maintain		29.68	6.89
						59	92	Monk Seal	Maintain		23.44	3.79
						60	93	Monk Seal	Maintain		39.58	11.05

41	Swanson et al. (1998); Swanson et al. (2002)	No	Thesis	United Kingdom	1996	61	94	Black Rhino	Gain	198.5	32.7	2.33	
42	Syring (2003)	No	Thesis	USA	2002	62	95	Lake Sturgeon	Maintain		84.14	24.48	
							96	Lake Sturgeon	Maintain		135.33	32.15	
43	Tanguay (1994)	No	Thesis	Canada	1992	63	97	Woodland Caribou	Maintain		132.49	27.88	
							64	98	Woodland Caribou	Maintain		1961.79	60.82
							66	100	Woodland Caribou	Maintain		1223.78	19.12
44	Tisdell et al. (2005)	No	Journal article	Australia	2002	67	101	Mahogany Glider	Maintain		24.88	4.01	
							102	Mahogany Glider	Maintain		35.51	6.47	

							103	Mahogany Glider	Maintain		28.76	3.7	
45	Truong (2005)	No	Thesis	Vietnam	2004	68	104	Javan Rhino	Maintain		3.65	0.07	
							105	Taiwan trout	Loss	39.58	19.6	0.09	
46	Tseng and Chen (2008)	No	Journal article	Taiwan (China)	2006	69	106	Taiwan trout	Loss	65.26	31.07	0.05	
							107	Taiwan trout	Loss	90.94	40.59	0.12	
						70	108	White-backed Woodpecker	Loss	100	49.26	15.12	
47	Veisten et al. (2004)	No	Journal article	Norway	1992		71	109	White-backed Woodpecker	Loss	100	93.89	24.15

References

- Adamowicz, W.L., Boxall, P.C., Williams, M., Louviere, J., 1998. Stated preference approaches for measuring passive use values: An application to woodland caribou conservation in Alberta, Canada. *American Journal of Agricultural Economics* 79, 1722-1722.
- Aldrich, G.A., Grimsrud, K.M., Thacher, J.A., Kotchen, M.J., 2007. Relating environmental attitudes and contingent values: how robust are methods for identifying preference heterogeneity? *Environmental & Resource Economics* 37, 757-775.
- Arrow, K., Solow, R., Portney, P.R., Leamer, E.E., Radner, R., Schuman, H., 1993. Report of the NOAA Panel on Contingent Valuation. *Federal Register* 58, pp. 4601-4614, pp. 4601-4614.
- Baker, R., Ruting, B., 2014. *Environmental Policy Analysis: A Guide to Non-Market Valuation*. Productivity Commission Staff Working Paper, Canberra, Australia.

- Bandara, R., Tisdell, C., 2005. Changing abundance of elephants and willingness to pay for their conservation. *Journal of Environmental Management* 76, 47-59.
- Baral, N., Gautam, R., Timilsina, N., Bhat, M.G., 2007. Conservation implications of contingent valuation of critically endangered white-rumped vulture *Gyps bengalensis* in South Asia. *International Journal of Biodiversity Science and Management* 3, 145-156.
- Bartczak, A., Meyerhoff, J., 2013. Valuing the chances of survival of two distinct Eurasian lynx populations in Poland - Do people want to keep the doors open? *Journal of Environmental Management* 129, 73-80.
- Becker, N., Choresh, Y., Bahat, O., Inbar, M., 2009. Economic analysis of feeding stations as a means to preserve an endangered species: The case of Griffon Vulture (*Gyps fulvus*) in Israel. *Journal for Nature Conservation* 17, 199-211.
- Bednar-Friedl, B., Gebetsroither, B., Getzner, M., 2009. Willingness to Pay for Species Conservation Programs: Implications for National Park Funding. *Eco Mont-Journal on Protected Mountain Areas Research* 1, 9-14.
- Bergstrom, J.C., Taylor, L.O., 2006. Using meta-analysis for benefits transfer: Theory and practice. *Ecological Economics* 60, 351-360.
- BLS, 2017. CPI Inflation Calculator. U.S. Bureau of Labor Statistics, Washington, DC, USA.
- Boman, M., Bostedt, G., 1994. Wildlife Valuation: Estimating the benefits of the wolf in Sweden. Swedish University of Agricultural Sciences, Department of Forest Economics, Umeå, Sweden.
- Brander, L.M., Florax, R., Vermaat, J.E., 2006. The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. *Environmental & Resource Economics* 33, 223-250.
- Brander, L.M., Van Beukering, P., Cesar, H.S.J., 2007. The recreational value of coral reefs: A meta-analysis. *Ecological Economics* 63, 209-218.
- Cerda, C., Losada, T., 2013. Assessing the value of species: a case study on the willingness to pay for species protection in Chile. *Environmental Monitoring and Assessment* 185, 10479-10493.
- Colleony, A., Clayton, S., Couvet, D., Saint Jalme, M., Prevot, A.C., 2017. Human preferences for species conservation: Animal charisma trumps endangered status. *Biological Conservation* 206, 263-269.
- Cummings, R.G., Ganderton, P.T., McGuckin, T., 1994. Substitution effects in CVM values. *American Journal of Agricultural Economics* 76, 205-214.
- Diffendorfer, J.E., Loomis, J.B., Ries, L., Oberhauser, K., Lopez-Hoffman, L., Semmens, D., Semmens, B., Butterfield, B., Bagstad, K., Goldstein, J., Wiederholt, R., Mattsson, B., Thogmartin, W.E., 2014. National valuation of monarch butterflies indicates an untapped potential for incentive-based conservation. *Conservation Letters* 7, 253-262.

- Dong, Y., 2010. Contingent Valuation of Yangtze finless porpoises in Poyang Lake, China, Faculty of Economics. Faculty of Economics, Leipzig University, Leipzig, Germany.
- Ericsson, G., Kindberg, J., Bostedt, G., 2007. Willingness to pay (WTP) for wolverine *Gulo gulo* conservation. *Wildlife Biology* 13, 2-13.
- Fredman, P., 1994. Values of an endangered species : the case of the white-backed woodpecker in Sweden. Sveriges Lantbruksuniversitet, Institutionen foer Skogsekonomi, Umeaa.
- Giraud, K., Valcic, B., 2004. Willingness-to-pay estimates and geographic embedded samples: case study of Alaskan steller sea lion. *Journal of International Wildlife Law and Policy* 7, 57-72.
- Giraud, K.L., Loomis, J.B., Johnson, R.L., 1999a. Internal and external scope in willingness-to-pay estimates for threatened and endangered wildlife. *Journal of Environmental Management* 56, 221-229.
- Giraud, K.L., Loomis, J.B., Johnson, R.L., 1999b. Two valuation questions in one survey: is it a recipe for sequencing and instrument context effects? *Applied Economics* 31, 957-964.
- Gurevitch, J., Koricheva, J., Nakagawa, S., Stewart, G., 2018. Meta-analysis and the science of research synthesis. *Nature* 555, 175.
- Hageman, R.K., 1985. Valuing marine mammal populations: benefit vauations in a multi-species ecosystem. Southwest Fisheries Center, La Jolla, California, USA.
- Han, S.-Y., Lee, C.-K., 2008. Estimating the value of preserving the Manchurian black bear using the contingent valuation method. *Scandinavian Journal of Forest Research* 23, 458-465.
- Han, S.-Y., Lee, C.-K., Mjelde, J.W., Kim, T.-K., 2010. Choice-experiment valuation of management alternatives for reintroduction of the endangered mountain goral in Woraksan National Park, South Korea. *Scandinavian Journal of Forest Research* 25, 534-543.
- Hanley, N., Czajkowski, M., Hanley-Nickolls, R., Redpath, S., 2010. Economic values of species management options in human-wildlife conflicts Hen Harriers in Scotland. *Ecological Economics* 70, 107-113.
- Harper, D.L., 2012. Analyzing the economic benefit of woodland caribou conservation in Alberta. University of Alberta (Canada), Ann Arbor, p. 196.
- Hynes, S., Hanley, N., 2009. The "Crex crex" lament: Estimating landowners willingness to pay for corncrake conservation on Irish farmland. *Biological Conservation* 142, 180-188.
- Jacobsen, J.B., Hanley, N., 2009. Are There Income Effects on Global Willingness to Pay for Biodiversity Conservation? *Environmental & Resource Economics* 43, 137-160.

- Jin, J., Wang, Z., Liu, X., 2008. Valuing black-faced spoonbill conservation in Macao: A policy and contingent valuation study. *Ecological Economics* 68, 328-335.
- Johansson, M.V., 1999. *Economics without markets: Four papers on the contingent valuation and stated preference methods*, Department of Economics. Umeå University, Umeå, Sweden.
- Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C.A., 2017. Contemporary Guidance for Stated Preference Studies. *Journal of the Association of Environmental and Resource Economists* 4, 319-405.
- Kazlauskienė, V., 2015. Application of Social Discount Rate for Assessment of Public Investment Projects. *Procedia - Social and Behavioral Sciences* 213, 461-467.
- Kim, J.-Y., Mjelde, J.W., Kim, T.-K., Lee, C.-K., Ahn, K.-M., 2012. Comparing willingness-to-pay between residents and non-residents when correcting hypothetical bias: Case of endangered spotted seal in South Korea. *Ecological Economics* 78, 123-131.
- Kontogianni, A., Tourkolias, C., Machleras, A., Skourtos, M., 2012. Service providing units, existence values and the valuation of endangered species: A methodological test. *Ecological Economics* 79, 97-104.
- Kontoleon, A., Swanson, T., 2003. The willingness to pay for property rights for the Giant Panda: Can a charismatic species be an instrument for nature conservation? *Land Economics* 79, 483-499.
- Kotchen, M.J., Reiling, S.D., 2000. Environmental attitudes, motivations, and contingent valuation of nonuse values: a case study involving endangered species. *Ecological Economics* 32, 93-107.
- Labao, R., Francisco, H., Harder, D., Santos, F.I., 2008. Do colored photographs affect willingness to pay responses for endangered species conservation? *Environmental & Resource Economics* 40, 251-264.
- Langford, I.H., Kontogianni, A., Skourtos, M.S., Georgiou, S., Bateman, I.J., 1998. Multivariate mixed models for open-ended contingent valuation data - Willingness to pay for conservation of monk seals. *Environmental & Resource Economics* 12, 443-456.
- Langford, I.H., Skourtos, M.S., Kontogianni, A., Day, R.J., Georgiou, S., Bateman, I.J., 2001. Use and nonuse values for conserving endangered species: the case of the Mediterranean monk seal. *Environment and Planning A* 33, 2219-2233.
- Lew, D.K., Layton, D.F., Rowe, R.D., 2010a. Valuing enhancements to endangered species protection under alternative baseline futures: the case of the steller sea lion. *Marine Resource Economics* 25, 133-154.
- Lindhjem, H., Navrud, S., 2008. How reliable are meta-analyses for international benefit transfers? *Ecological Economics* 66, 425-435.

- Lindhjem, H., Navrud, S., 2011. Using Internet in Stated Preference Surveys: A Review and Comparison of Survey Modes. *International Review of Environmental and Resource Economics* 5, 309-351.
- Lindhjem, H., Navrud, S., 2015. Reliability of meta-analytic benefit transfers of international value of statistical life estimates: Tests and illustrations, in: Johnston, R.J., Rolfe, J., Rosenberger, R.S., Brouwer, R. (Eds.), *Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners*. Springer, pp. 441-464.
- Lindhjem, H., Tuan, T.H., 2012. Valuation of species and nature conservation in Asia and Oceania: A meta-analysis. *Environmental Economics and Policy Studies* 14, 1-22.
- Lindhjem, H., Tuan, T.H., 2015. Benefit transfer of nature conservation values in Asia and Oceania based on meta-analysis: Data heterogeneity and reliability issues, in: Managi, S. (Ed.), *The Routledge Handbook of Environmental Economics in Asia*. Routledge, New York, USA, pp. 349-368.
- Loomis, J., Ekstrand, E., 1998. Alternative approaches for incorporating respondent uncertainty when estimating willingness to pay: the case of the Mexican spotted owl. *Ecological Economics* 27, 29-41.
- Loomis, J., Larson, D.M., 1994. Total economic values of increasing gray whale populations: results from a contingent valuation survey of visitors and households. *Marine Resource Economics* 9, 275-286.
- Loomis, J.B., White, D.S., 1996. Economic benefits of rare and endangered species: Summary and meta-analysis. *Ecological Economics* 18, 197-206.
- Loureiro, M.L., Ojea, E., 2008. Valuing local endangered species: The role of intra-species substitutes. *Ecological Economics* 68, 362-369.
- Ma, C., Rogers, A.A., Kragt, M.E., Zhang, F., Polyakov, M., Gibson, F., Chalak, M., Pandit, R., Tapsuwan, S., 2015. Consumers' willingness to pay for renewable energy: A meta-regression analysis. *Resource and Energy Economics* 42, 93-109.
- MacMillan, D., Hanley, N., Daw, M., 2004. Costs and benefits of wild goose conservation in Scotland. *Biological Conservation* 119, 475-485.
- Macmillan, D.C., Philip, L., Hanley, N., Alvarez-Farizo, B., 2002. Valuing the non-market benefits of wild goose conservation: a comparison of interview and group-based approaches. *Ecological Economics* 43, 49-59.
- Maguire, K.B., 2009. Does mode matter? A comparison of telephone, mail, and in-person treatments in contingent valuation surveys. *Journal of Environmental Management* 90, 3528-3533.
- Metrick, A., Weitzman, M.L., 1996. Patterns of behavior in endangered species preservation. *Land Economics* 72, 1-16.
- Myers, K.H., 2014. The effect of substitutes on willingness to pay for endangered species: The case of the Atlantic red knot. University of Delaware, Ann Arbor, p. 149.

- Nelson, J.P., Kennedy, P.E., 2009. The Use (and Abuse) of Meta-Analysis in Environmental and Natural Resource Economics: An Assessment. *Environmental and Resource Economics* 42, 345-377.
- Nielsen, J.S., 2011. Use of the Internet for willingness-to-pay surveys: A comparison of face-to-face and web-based interviews. *Resource and Energy Economics* 33, 119-129.
- Ojea, E., Loureiro, M.L., 2007. Altruistic, egoistic and biospheric values in willingness to pay (WTP) for wildlife. *Ecological Economics* 63, 807-814.
- Ojea, E., Loureiro, M.L., 2009. Valuation of wildlife: Revising some additional considerations for scope tests. *Contemporary Economic Policy* 27, 236-250.
- Olsen, S.B., 2009. Choosing Between Internet and Mail Survey Modes for Choice Experiment Surveys Considering Non-Market Goods. *Environmental and Resource Economics* 44, 591-610.
- Pandit, R., Subroy, V., Garnett, S.T., Zander, K.K., Pannell, D.J., 2015. A review of non-market valuation studies of threatened species and ecological communities. Report to the National Environmental Science Programme, Department of the Environment, Canberra, Australia.
- Ready, R., Navrud, S., 2006. International benefit transfer: Methods and validity tests. *Ecological Economics* 60, 429-434.
- Reaves, D.W., Kramer, R.A., Holmes, T.P., 1999. Does question format matter? Valuing an endangered species. *Environmental & Resource Economics* 14, 365-383.
- Richardson, L., Loomis, J., 2009. The total economic value of threatened, endangered and rare species: An updated meta-analysis. *Ecological Economics* 68, 1535-1548.
- Richardson, L., Loomis, J., 2012. Total Economic Valuation of Endangered Species: A Summary and Comparison of United States and Rest of the World Estimates, in: K.N.Ninan (Ed.), *Conserving and Valuing Ecosystem Services and Biodiversity: Economic, Institutional and Social Challenges*. Earthscan, London, UK, pp. 25-45.
- Rolfe, J., Brouwer, R., Johnston, R.J., 2015. Meta-analysis: Rationale, Issues and Applications, in: Johnston, J.R., Rolfe, J., Rosenberger, S.R., Brouwer, R. (Eds.), *Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners*. Springer Netherlands, Dordrecht, pp. 357-381.
- Saloio, J.H., Jr., 2008. Willingness to pay for international threatened and endangered species: Meta-analysis and benefit transfer. The University of New Mexico, Ann Arbor, p. 221.
- Shr, Y.-H., Ready, R., 2016. Are Pictures Worth a Thousand Words? Impacts of Scenario Visualization in Choice Experiments: A Case of Preferences over Landscape Attributes of Green Infrastructure, Working Paper, CAES & WAEA Joint Annual Meeting, Victoria, BC, Canada.
- Shrestha, R.K., Loomis, J.B., 2001. Testing a meta-analysis model for benefit transfer in international outdoor recreation. *Ecological Economics* 39, 67-83.

- Smith, V.K., Osborne, L.L., 1996. Do contingent valuation estimates pass a "scope" test? A meta-analysis. *Journal of Environmental Economics and Management* 31, 287-301.
- Spash, C.L., Vatn, A., 2006. Transferring environmental value estimates: Issues and alternatives. *Ecological Economics* 60, 379-388.
- Stanley, D.L., 2005. Local perception of public goods: Recent assessments of willingness-to-pay for endangered species. *Contemporary Economic Policy* 23, 165-179.
- Stanley, T.D., Doucouliagos, H., Giles, M., Heckemeyer, J.H., Johnston, R.J., Laroche, P., Nelson, J.P., Paldam, M., Poot, J., Pugh, G., Rosenberger, R.S., Rost, K., 2013. Meta-Analysis of Economics Research Reporting Guidelines. *Journal of Economic Surveys* 27, 390-394.
- Stithou, M., Scarpa, R., 2012. Collective versus voluntary payment in contingent valuation for the conservation of marine biodiversity: An exploratory study from Zakynthos, Greece. *Ocean & Coastal Management* 56, 1-9.
- Subroy, V., Rogers, A.A., Kragt, M.E., 2018. To Bait or Not to Bait: A Discrete Choice Experiment on Public Preferences for Native Wildlife and Conservation Management in Western Australia. *Ecological Economics* 147, 114-122.
- Subroy, V., Rogers, A.A., Kragt, M.E., 2019. Differences in stakeholders' preferences for threatened species and invasive predator management in Western Australia—a scale-adjusted latent class choice experiment. In Preparation.
- Swanson, T., Mourato, S., Swierzbinski, J., Kontoleon, A., 1998. Conflicts in conservation: aggregating total economic values, Paper presented at World Congress of Environmental and Resource Economists, Venice, Italy, 24-27 June 1998.
- Swanson, T., Mourato, S., Swierzbinski, J., Kontoleon, A., 2002. Conflicts in conservation: The many values of the black rhinoceros, in: Pearce, D., Pearce, C., Palmer, C. (Eds.), *Valuing the environment in developing countries: case studies*. Edward Elgar, Cheltenham, UK and Northampton, MA, USA.
- Syring, M.E., 2003. Economic value associated with viewing lake sturgeon (*Acipenser fulvescens*) in Wisconsin, *Environmental Science and Policy*. University of Wisconsin-Green Bay, USA.
- Tanguay, M.R., 1994. An economic evaluation of woodland caribou in northwestern Saskatchewan. University of Alberta (Canada), Ann Arbor, pp. 112-112 p.
- Tisdell, C., Nantha, H.S., Wilson, C., 2007. Endangerment and likeability of wildlife species: How important are they for payments proposed for conservation? *Ecological Economics* 60, 627-633.
- Tisdell, C., Wilson, C., Swarna Nantha, H., 2005. Policies for saving a rare Australian glider: economics and ecology. *Biological Conservation* 123, 237-248.
- Truong, T.D., 2005. Willingness to pay for conservation of Vietnamese rhinoceros, Research Paper. University of Economics, Ho Chi Minh City, Vietnam.
- Tseng, W.-C., Chen, C.-C., 2008. Valuing the potential economic impact of climate change on the Taiwan trout. *Ecological Economics* 65, 282-291.

Van Houtven, G., 2008. Methods for the Meta-Analysis of Willingness-to-Pay Data: An Overview. *Pharmacoeconomics* 26, 901-910.

Van Houtven, G., Powers, J., Pattanayak, S.K., 2007. Valuing water quality improvements in the United States using meta-analysis: Is the glass half-full or half-empty for national policy analysis? *Resource and Energy Economics* 29, 206-228.

Van Houtven, G.L., Pattanayak, S.K., Usmani, F., Yang, J.C., 2017. What are Households Willing to Pay for Improved Water Access? Results from a Meta-Analysis. *Ecological Economics* 136, 126-135.

Veisten, K., Fredrik Hoen, H., Navrud, S., Strand, J., 2004. Scope insensitivity in contingent valuation of complex environmental amenities. *Journal of Environmental Management* 73, 317-331.

WorldBank, 2017. PPP conversion factor, GDP. The World Bank.