THE ECONOMIC VALUE OF BIRDWATCHING:

A META-ANALYSIS AND SUMMARY OF STATED PREFERENCE STUDIES

A Thesis

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by

Marley Bonacquist-Currin

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Abstract

The economic value of birds in the United States and Canada has been measured using 27 stated preference surveys. Consumer Surplus per person, per day (CS_PPPD) ranges from a low of $0.29 (2020$) to a high of $824.53 over 442 observations, with a mean of $56.74. A fixed-effects regression analysis of consumer surplus shows that variation in CS_PPPD can be explained by a variety of method, resource, and context attributes. This provides economic value to the anthropocentric value of bird watching, wildlife viewing (where birds are included), and the potential for Benefit-Transfer to climate change policy using the models developed and values found in this meta-analysis.

Keywords: Stated preference; Wildlife watching; Bird watching; Consumer Surplus

Biographical Sketch

Marley earned her B.A. in Economics with a minor in Environmental Studies from Siena College (2018). Afterwards, she enrolled in Cornell University's M.S. in Applied Economics and Management program, with a focus on Environmental and Natural Resource Economics. Broadly, she is interested in environmental and ecological economics. Her specific focuses are on ecosystem services (of avian populations) and people's willingness-to-pay for such, environmental public policy and conservation efforts, and environmental ethics and justice. Her research sits at the intersection of Environmental Economics and Environmental Studies/Sciences, looking at the coupling of human-environment systems.

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Contents

Introduction

The Anthropocene faces many challenges and a lengthy list of environmental problems. Within the 21st century, our defining problem is biodiversity loss and the impacts on ecosystem services (Rosenberg, et al., 2019, p. 1). Not only is the loss of ecosystem health and biodiversity inherently bad, but these issues are impacting human wellbeing. A crisis of our own creation. From loss of habitats due to industry, to morphing ecosystems from climate change, ecosystem services are struggling as species go extinct and biodiversity declines (Rosenberg, et al., 2019, p. 1). However, policy prescriptions fall short of addressing the root of the cause, evidenced by a tendency to focus on species extinction and natural disaster relief. This choice leaves out the root and ignores many warning signs.

Loss of biodiversity is foreshadowed in our environment. Species can indicate coming natural disasters, shifting ecosystems, worsening air and water quality, etc. With the era of the Anthropocene fueled by species extinctions and abundance reductions, ecosystem functionality and the resulting ecosystem services are detrimentally affected (Rosenberg, et al., 2019, p. 1). These ecosystem services have ecological and economic interactions crucial to the understanding and formation of effective policy for climate change mitigation and adaptation. So how, in the “global biodiversity crisis,” as The Cornell Lab of Ornithology calls it, can we respond, react, and fix? 2.9 billion birds have been lost since 1970, an astounding loss of 29% abundance (Rosenberg, et al., 2019, p. 1). Birds, the choice taxa indicator for biodiversity, are vital to environmental health and ecosystem integrity, and conveniently are the easiest to monitor of the animal taxa (Rosenberg, et al., 2019, p. 1).

For many reasons, birds motivate and move policy makers. Due to the ecosystem services birds provide - such as seed dispersal, pollination, and pest control - a value can be placed on bird declines (Rosenberg, et al., 2019, p. 3). An astounding $9.3 billion/year (by 47 million people) is spent on activities such as bird hunting and bird watching (Rosenberg, et al., 2019, p. 3), leading to intense economic consequences of reduction and extinction of species. The loss of abundance researched and remarked upon by Rosenberg, et al, paints a dire, but accurate, picture of the threats of avifaunal collapse and the resulting losses to the ecosystem (2019, p. 1). What is merely touched upon however, are the economic ramifications of the ecosystem functionality loss (Rosenberg, et al., 2019, p. 1).

Knowing that avian populations are influential in policy decisions, and having the beginnings of data and analysis to construct models to encourage action, it is imperative to begin. The bird's eye view is such: Avian populations are a valuable measure of biodiversity and can be used in policy formation and climate change modeling to assess the impacts of biodiversity and abundance loss to ecosystems and the economy. Due to their high trophic level and visibility, birds serve as a beneficial indicator of environmental quality in terms of ecosystem services they provide, and the interregional effects of climate change due to migration of species. In order to progress further with this idea, and introduce it into policy prescription in a meaningful and effective manner, benefit transfer using values from a meta-analysis will best help development. Current economic literature uses stated and revealed preference to value wildlife and bird watching. These values can be used to determine a per person per day valuation of different species, at different locations, etc. Evaluating the ecosystem services of birds using non-market valuation determines the willingness-to-pay of individuals for environmental conservation and restoration, as well as placing a value on environmental policies (such as those for water and air quality). In order to population declines, we must merge ecology and the economy for a holistic view of the issue to influence policy decisions moving forward.

To begin this process, a meta-analysis of 28 stated preference papers is conducted. While some may quarrel with placing monetary values on the environment, without monetary motivation it is difficult to press the importance of ecological relationships into policy. We must be exceedingly careful in our valuation measures, to include environmental ethics and inherent values, while persuading our policy-making counterparts of the vital importance of conservation measures (Loomis & White, 1996, pg. 198). And so, by conducting a meta-analysis of bird watching values using stated preference methods, the beginnings of valuation for these ecosystems as a whole are modeled. This, in turn, creates an economic value that can be assigned into policy budgets to help combat the climate crisis, in regards to ecosystem health. Additionally, as birds (as an indicator species) tell scientists (and thus policy makers) much about environmental health conditions effects on humans, the values derived in this paper can be used in benefit-transfer applications for human health.

Literature Review

Meta-Analyses

The earliest meta-analysis analyzed, and the basic formula followed in this meta-analysis is Loomis and White (1996). Loomis and White analyze the annual values per household of willingness to pay for 17 endangered and rare species over 20 studies. Loomis and White provide the first look at how continent valuation can provide important estimates to motivate conservation of rare and endangered (1996, p. 197). By discussing the economic benefits provided by such species and analyzing available economic values, the meta-analysis regression they provide gives policy advice for moving forward with reauthorizing The Endangered Species Act (Loomis & White, 1996).

Because a meta-analysis involves explaining variation in the literature through regression analysis, meta-analyses power lies in the ability to account for a large set of variables that influence willingness-to-pay (Loomis & White, 1996, 202). Here full and reduced models are run in linear, semi-log, and double log formats with variables including the change in size of the population, payment frequency, stated preference format, visitor or household, dummy variables for fish species, marine mammal species, and bird species, as well as the study response rate and year. Loomis and White note that with increased studies on the value of these species, there is the potential for further research and benefit transfer work. Loomis updated this meta-analysis in 2009 with Leslie Richardson. One of the many benefits to meta-analyses is that with preserved data and code, the meta-analysis can be easily updated to account for new surveys and studies. This updated paper uses the same model as that of 1996, adds in a variable to test for a statistical difference between the new and old studies, looks at the "charisma" of a species, and delves deeper into the use of meta-analyses in benefit transfer models (Richardson & Loomis, 2009, p. 3). Richardson & Loomis concludes that benefit transfer values derived from such meta-analysis regressions will be important in measuring the benefits of rare and endangered species (2009, p. 33) as their value exposes a need for increased funding for conservation and recovery (2009, p. 34). Richardson & Loomis and gives evidence of WTP increasing over time, supporting calls for increasing funding (2009, p. 34).

Berstrom and Taylor devote a paper to the topic of Meta-Analysis usage in Benefit Transfer where they find that the strength in this approach is found in the summarizing of vast quantities of statistical information into one model. However, this also creates a weakness, in that details are lost in the merging, citing that benefit transfer is not the end-all-be-all for policy issues, but a tool within a kit. (2006, p. 1). Berstrom and Taylor note that there are two purposes to a meta-analysis in this field: To test variable influence on willingness to pay and to use the resulting model to estimate values for different species, locations, etc., (2006, p. 1). Their best practices advise on data collection, review, and coding, and acknowledge that there is no one "best way" to conduct a meta-analysis, but that there is the requirement of transparency in the decisions made, including in the potential for weakness or bias in the benefit-transfer (Berstrom and Taylor, 2006, p. 6). Berstrom and Taylor (2006), Rosenberger and Loomis (2003) and Stanley (2001), conclude that in a meta-analysis, all appropriate studies should be included, with variables in the regression to account for quality, instead of the researcher deciding which studies are and are not appropriate. Equally important is finding the gray literature to aid in preventing publication bias (Berstrom and Taylor, 2006). Where the researcher should make a judgement call is in “commodity consistency” (Berstrom & Taylor, 2006, p. 7), where all studies must be valuing the same thing.

Further issues for consideration are the spatial and temporal scale, range of quantity, framing effects, welfare change measure consistency. Welfare change measure consistency can be controlled for by separating meta-analysis for contingent valuation (stated preference) and travel-cost (revealed preference) studies, or by creating a dummy variable for the preference study type within one meta-analysis (Berstrom & Taylor, 2006, p. 12).

Study design variables should be included where available, such as: “WTP valuation method, WTP elicitation method, and WTP calculation method,” (Berstrom & Taylor, 2006, p. 14).

Berstrom & Taylor thus set forth a recommended list of considerations for Meta-Analysis Benefit-Transfer (MA-BT) work, to ensure accuracy (Berstrom & Taylor, 2006, p. 22). Thus, stating that MA-BT is best suited for bringing issues to the table, and minor decisions, but that then new studies must be conducted to confirm the MA-BT results.

Using the methods mentioned above, Johnston, Ranson, Besedin & Helm conducted A Meta-Analysis of Recreational Fishing Values (2006, p. 1). The goal is to determine if the differences in WTP are due to resource, context and demographics, that would allow for use of the resulting WTP in policy evaluation or if the variation is mostly due to study methodology (Johnston, Ranson, Besedin & Helm, 2006, p. 2-3). Building off of the work of previous meta-analyses, Johnston, Ranson, Besedin & Helm incorporate new statistical methods such as adjusting for heteroskedasticity using robust variance, and random effects in maximum likelihood. Additionally, as with Loomis & White, they choose the semi-log model to show how independent variables effect WTP and due to usage in past meta-analyses (e.g., Smith and Osborne 1996; Johnston, Besedin, and Wardwell 2003),” (Johnston, Ranson, Besedin & Helm, 2006, p. 18).

Finally, despite opposite approaches of handling weighting, which are referenced in Markowski et al. 2002 and Bateman and Jones 2003, Johnston, Ranson, Besedin & Helm choose a weighted model (those present both weighted and unweighted) with each study given a weight of one (Johnston, Ranson, Besedin & Helm, 2006, p. 18). This method of weighting gives each study equal weight within the model, instead of lending more weight to studies with more values, and follows the methodology of Poe, Boyle, and Bergstrom 2001 and Mrozek and Taylor 2002.

In summary, Johnston, Ranson, Besedin & Helm find that the WTP per fish varies with study method, resource, context and angler factors (2006, p. 27). As with previous studies, they note the importance of taking these methodological attributes into account when conducting welfare values in benefit transfer. Johnson, et al. finds similar issues in that welfare measures which are adapted to particular policy environments may lack reliability if there is too much variation in the study methodologies from the meta-analysis (2005, p. 221).

Johnson, et al. paints a similar warning tale, that policy adaptations should be used only if the variability is from observable variations in resources and study design, as opposed to "unexplained study-level effects" (2005, p. 221). However, where appropriate, benefit transfer may be conducted from a meta-analysis for providing insight into new phenomena where there are no other studies, or more general policy questions as a new issue is explored, as opposed to taking the values as hard and true facts for solidifying major policy decisions (Johnson, et al., 2005, 222). Johnson, et al. also settles on the semi-log model and finds that the model identifies systemic patterns that individual studies could not conclude alone (Johnson, et al., 2005, 244). And states that in matters such as model form, weighting decisions, and which variables for study methodology should be concluded, there is much literature, but few conclusive instructions, thus requiring each researcher to make their own one-off decisions to their best judgement (Johnson, et al., 2005, 244).

Given the variability in the literature, many decisions made in the following meta-analysis use advice from Benefit Transfer of Environmental and Resource Values (2015). Chapter 15 - Meta-analysis: Statistical Methods guides researchers through the quantitative analysis of a set of primary studies in the same area of work (Nelson, 2015, p. 329). Working through the issues of heterogeneity, multicollinearity, biases in publication, Nelson recommends fixed or random effect analysis that incorporates weighting and clustered standard errors (2015). This ensures correct effect size measurement and interpretation. Nelson explains that fixed-effects should be used in cases of studies sharing population effect size, while random-effects should be used in cases of between-study variation (Nelson, 2015, p. 333). As far as use in benefit transfer, Nelson recommends a sensitivity analysis for so to deal with issues that may arise from outliers, functional form, cases of missing data, and related metadata (Nelson, 2015, p. 346).

Chapter 16: “Meta-analysis: Rational, Issues and Applications” delves further into applications for benefits transfer involving a case study on river health using ordinary least squares and random effects (Rolfe, Brouwer, and Johnston, 2015, p. 357). Using a meta-analysis for benefit transfer is when WTP for something (such as river health) is explained by a variety of variables (such as population and site characteristics), and the results can be applied to other places of interest (Rolfe, Brouwer, and Johnston, 2015, 358). While OLS is presented in this case, it is for comparison and to show the inappropriate usage, for OLS does not properly deal with the issues of heteroskedasticity and weighting the articles. For these reasons, fixed or random effect models should be used, with robust standard error estimators, for which Rolfe, Brouwer and Johnston recommend White or Huber-White estimators (2015, p. 364). Rolfe, Brouwer, and Johnston also advise that pooling stated and revealed preference data requires comparing Hicksian and Marshallian measures, the method of handling which is disagreed upon within the field (2015, p.363). Common practices include a dummy variable to indicate which method an individual study (or data point from the study) employs, or running separate analyses for the two types.

In Chapter 17: “Meta-analysis: Econometric Advances and New Perspectives Toward Data Synthesis and Robustness” Boyle, Kaul, and Parmeter point out that meta-analysis cannot contain random samples, as they use every available study, and that the analyst will have to make decisions at their (informed) discretion for which studies to include, what variables to use, and the various corrections to make (2015, p. 383). Even this guide-book has no perfect guide, many decisions are ad-hoc. And despite this, Boyle, Kaul and Parmeter find that currently published meta-analyses often do not include discussion on result sensitivity to variable and model choices (2015, p. 384). As such, meta-analyses are a tool in a research toolkit, meant to help advance the field by summarizing the findings of existing studies, provide insight into the further research needed, and give perspective to how common problems are handled in the field (and whether or not these warrants changing). Meta-data may have issues of sample selection, influential studies, influential observations, and influential variables (Boyle, Kaul and Parmeter, 2015, 384). And while these can all be handled statistically via the methods prescribed in the previous chapters, they will occur in all meta-analyses.

Ecology

This ecological literature review was conducted to understand the implications and applications of this meta-analysis, as well as the details of the bird populations that were observed by the bird watchers.

Rosenberg et al. draws attention to the nearly 3 billion birds lost since 1970, a striking 29% of bird abundance (2019, p. 1). Particularly problematic is that this loss does not stop at rare and threatened species, but spreads into common species who serve keystone rolls in many ecosystems. These species are crucial players or “disproportionately influential components” for the functionality of the systems in which they reside. Loss in their abundance disrupts food webs and inhibits ecosystem functioning. (Rosenberg et al., 2019, p. 1). What is worse, these common species are not being replaced in human-created environments, as often human alterations make an ecosystem less habitable to many species.

What is the economic value of each bird lost? Furthermore, where are these losses occurring? And why? To understand these nuances, it is first important to understand population ecology. This is one particular area in which benefit transfer of the is meta-analysis will prove fruitful in policy prescription.

Population Ecology studies the population dynamics of a species and/or taxa, these dynamics involve factors such as births, deaths, immigration, emigration, migration, etc. However, they also incorporate the reasons behind such change - variation in food supply, competition, predation, disease, and ecosystem change. Traditionally, population dynamics involve the modeling of one season, but this misses key factors between seasons, especially considering the interregional effects of climate change (Hostetler, Sillett, & Marra, 2015). As Rosenburg, et al notes, the total impact is underestimated due to the loss of deceased breeders' potential reproduction (2019, pg. 3). As such, ecological models of population dynamics have begun to incorporate the annual cycle in order to capture the effects of and encourage analysis of breeding and non-breeding habitats and the effect of these sinks on avian populations.

"Full-annual-cycle population models for migratory birds" by Hostetler, Sillett, & Marra models the wood thrush population by incorporating demographic events whose effects carry throughout seasons, thus allowing for migratory connectivity between breeding and non-breeding areas and seasons (Hostetler, Sillett, & Marra, 2015). As traditional models focus on the breeding season of migratory birds, these FAC models incorporate important dynamic effects (Hostetler, Sillett, & Marra, 2015). As migratory birds spend much of the year in a variety of locations, FAC models provide the required understanding to the population dynamics throughout the entirety of the year (Hostetler, Sillett, & Marra, 2015).

Rushing, Ryder, & Marra form three recommendations: That particular winter locations and specific migration routes be linked, that inferences of demographic rates and the associated limiting factors must be found for range-wide spatial scales instead of deduced from local values, and that the environmental effects of the breeding and non-breeding seasons must be quantified throughout the full-annual-cycle (Rushing, Ryder, & Marra, 2016). The strength of this paper lies in the ability to conduct intense analysis of species-specific population dynamics and use the found effects in policy and management (Rushing, Ryder, & Marra, 2016). The weakness, or perhaps more frustration, is the understanding that this is more effective at the species level, rather than for avian populations on the whole. In summation: We have a future full of intense species modeling and the need for increased remote-sensing data.

“Dynamic Models for Bird Populations - A parameter-varying partial differential equation identification approach” by Ouvrard, Mercère, Poinot, Jiguet, & Mouysset studies the global decline of biodiversity via the dynamics of avian populations by suing the Galerkin method and proper orthogonal decomposition in a parameter-varying partial differential equation model. Here, they introduce information (like temperature) to study how biodiversity is impacted by global warming in specific land uses (such as agriculture) (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019). By modeling the European Stonechat with data from the French Breeding Bird Survey and CORINE Land Cover, they model one bird population to provide biodiversity goal data for public policy development (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019). These partial differential equations elicit area and country trends that incorporate temporal and spatial factors (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019). While this paper uses one bird species, it uses models from Mouysset (2012), Mouysset, Doyen, and Jiguet (2012) and Mouysset et al. (2016), where (contrary to the two previous papers suggestions), common bird species and agricultural patterns were used to develop dynamic models for overall bird populations in France (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019). The models referenced use logistic-growth models central to our knowledge of population dynamics with the addition of nonlinear ODE. Here, the partial differential equations present the spatial variations of the European Stonechat, with a diffusion equation, an advection equation, and a logistic growth equation (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019).While the paper applies broad-based bird models, it specifies one species for the partial differential equations in order to provide applicable information relative to policy needs in forming biodiversity goals (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019).

Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019 paper provides perhaps a currently more realistic generic model to populate with individual species data, as opposed to the FAC models which admit to being theoretical with difficulties in application. However, the FAC models of Rushing, Ruder, & Marra and Hostetler, Sillett, & Marra, will become crucial down the road with further remote-sensing data. The importance is to start somewhere, as biodiversity declines are dire today (Ouvrard, Mercère, Poinot, Jiguet, & Mouysset, 2019).

By combining population ecology and non-market valuation of bird watching, there will follow a fruitful relationship for stopping bird abundance loss, and using birds as an indicator for environmental and ecosystem health and wellbeing.

Conceptual Approach

This particular meta-analysis analyzes stated preference surveys (otherwise called “contingent valuation method”) to determine the willingness to pay by individuals for birds viewing/watching. Stated preference is the process of “developing a hypothetical market or referendum which an individual use to reveal or state his or her WTP for protection of a species in a particular location,” (Loomis & White, 1996, p. 198). In this case, the hypothetical market is for viewing the species (not protection of the species, as in the case of Loomis & White). The three components of the market used in Loomis & White are still the same: Description of the bird or wildlife species, form of eliciting stated preference response (open or close ended), and how survey respondents would pay for bird watching (for example a yearly park fee, a daily park fee, payment into a park fund, etc.). Open-ended questions ask survey respondents to come up with their own value, whereas close-ended (such as dichotomous choice, payment cards, iterative bidding, and referendum) ask respondents to circle one option within a set of dollar amounts, or respond “yes” or “no” to a stated amount. While there are critics of stated preference surveys and their reliability (Diamond & Hausman, 1994; Johansson-Stenman &Svedsäter, 2012) , the US District Court of Appeals and Department of the Interior still defend its' usage (Loomis & White, 1996, p. 199), and is used by the US Water Resources Council (Loomis & White, 1996). Additionally, a multitude of CVM studies have produced reliable results, and the resulting values pass "test-retest reliability studies" (Loomis & White, 1996).

In congruence with Loomis & White (1996) and Johnston, Ranson, Besedin & Helm (2006), this meta-analysis uses independent variables thought to influence WTP for bird watching, which are divided into: 1. Study method factors and 2. Demographics of survey respondents, resource characteristics, and context variables. These variables can all be found in Table 1.

Table 1

Meta-Analysis Variables

Meta-Analysis Variables			
Variable	Description	Units	For Dummy Variables - Comparing Against
ID	Each article is assigned an individual ID number so that weights can be assigned.	--	--
Weight	Each article is given a total weight of 1, so each data point has a weight of 1/n.	--	--
Title	Title of the article	--	--
Author	Authors of the article	--	--
YrPub	Year the article was published	Year	--
Location	Survey location	--	--
State	State that the survey was conducted in	--	--
SurveyCollxn	Survey collection method	--	--
DataYr	Year the data was collected	Year	--
VisitorType	Resident and/or nonresident	--	--
ResponseRate	Response rate to survey	%	--
SamplePop	Sample Frame	--	--
SampleSz	Sample Size	#	--
ElicMethod	Type of Stated Preference Elicitation Method	--	--
PmtVehicle	Type of Stated Preference Payment Vehicle	--	--
PmtType	Type of Stated Preference Payment Type	--	--
EcoServ	Ecosystem Service being valued	--	--
CS_PPPD	Consumer surplus (net willingness to pay)	Per Person, Per Day, 2020$	--
AvgAge	Average age of survey respondent	--	--
Percent_Male	Percent of survey respondents who identified as male	--	--
AvgEdu	Average education of survey respondent	--	--
HHIncome	Average household income of survey respondent	--	--
StdEr	Standard error of the estimate	Per person, per day, 2020$	--
Northeast	Dummy variable for studies in the northeastern region of the US.	--	To avoid the dummy variable trap, all remaining 0's are "All US" Studies.
Midwest	Dummy variable for studies in the midwestern region of the US.	--	
West	Dummy variable for studies in the western region of the US.	--	
South	Dummy variable for studies in the Southern region of the US.	--	
Canada	Dummy variable for studies in Canada.	--	
Southwest	Dummy variable for studies in the Southwestern region of the US.	--	
WestMidwest	Dummy variable for studies that include both the Western and Midwestern regions of the US.	--	
WMWS	Dummy variable for studies in the Western, Midwestern, and Southern regions of the US.	--	
NEWS	Dummy varaible for studies that include both the Northeastern, Western, and Southern regions of the US.	--	
NES	Dummy variable for studies that include both the Northeastern and Southern regions of the US.	--	
dIcon	Dummy for study using Iconoic bird species	0 = not iconic, 1 = iconic	To avoid dummy variable trap, comparing against studies that study all wildlife.
CommonBirds	Dummy for study about common bird species	0 = not common, 1 = common species	
Birds	Dummy for study about birds, but not further specified what bird species.	0 = not all birds, 1 = all birds	

Table 1, Cont'd.

Meta-Analysis Variables

Meta-Analysis Variables, Cont'd.			
Variable	Description	Units	For Dummy Variables - Comparing Against
BirdStudy	Dummy variable for a study containing only bird species.	0 = not only birds, 1 = only birds	To avoid dummy variable trap, comparing against wildlife.
NumSpecies	Dummy variable for number of species in a study.	0 = one species, 1 = multiple species.	To avoid dummy variable trap, comparing against studies surveying about one bird species only.
FillFWS	Dummy variable for a study that needed demographics filled in using US Fish and Wildlife Service Survey demographics for the corresponding year (because the individual study did not report their demographics).	0 = does not need USFWS demographics, 1 = uses USFWS demographics	To avoid dummy variable trap, comparing against studies that do not need USFWS demographics.
close	Dummy variable for close ended elicitation method.	0 = not close-ended, 1 = close-ended	To avoid dummy variable trap, comparing against open-ended elicitation methods.
unknown	Dummy variable for unknown elicitation method.	0 = not unknown, 1 = unknown elicitation method.	
Atlantic	Dummy variable for studies withing the Atlantic Flyway	0 = no, 1 = yes	To avoid dummy variable trap, comparing against studies that study the entirety of the United States.
Mississippi	Dummy variable for studies within the Mississippi Flyway	0 = no, 1 = yes	
Central	Dummy variable for studies within the Central Flyway	0 = no, 1 = yes	
Pacific	Dummy variable for studies within the Pacific Flyway	0 = no, 1 = yes	
CenPac	Dummy variable for studies within the Central Pacific Flyway	0 = no, 1 = yes	
AllCanada	Dummy variable for studies in Canada - not further specified to determine specific flyway.	0 = no, 1 = yes	
CandP	Dummy variable for Central and Pacific Flyways	0 = no, 1 = yes	
AMCP	Dummy variable for studies within all four flyways, but not studies that are the whole United States	0 = no, 1 = yes	
AMP	Dummy variable for studies within the Atlantic, Mississippi, and Pacific flyways.	0 = no, 1 = yes	
CPP	Dummy variable for studies within the Central Pacific and Pacific Flyways.	0 = no, 1 = yes	
MCP	Dummy variable for studies wihtin both the Mississippi and Central Flyways.	0 = no, 1 = yes	
MisCen	Dummy variable for studies within Mississippi and Atlantic Flyways.	0 = no, 1 = yes	
MisAt	Dummy variable for studies within the Mississippi and Atlantic Flyways.	0 = no, 1 = yes	
ACP	Dummy variable for studies within the Atlantic, Central and Pacific Flyways.	0 = no, 1 = yes	
logCS	log of CS_PPPD	--	--
logYr	log of DataYr	--	--
logSz	log of SampleSz	--	--
logAvg	log of AvgAge	--	--
logMale	log of Percent_Male	--	--
logInc	log of HHIncome	--	--
logEdu	log of AvgEdu	--	--
logW	log of Weight	--	--
logSE	log of StdEr	--	--

Data

This meta-analysis comprises stated preference studies in the United States and Canada found through database searches, and contacting prominent CVM researchers for the gray literature. Many of the papers (descriptive statistics in Table 2) report more than one value, for these, Table 2 reports the mean of all values to give an overview of the piece. The mean value per paper was not used in the regression because papers that reported multiple values were studying a variety of species and/or locations, and so an average was deemed inappropriate for more than a basic summary.

The starting point for the data was the USGS Benefit Transfer Toolkit (Loomis & Rosenberger, 2007). This toolkit provided Wildlife Viewing values (using both CVM and TCM), with each value converted into Per Person Per Day measures. Because of this, each value in our meta-analysis is also converted to match this unit. All values were inflated to 2020-dollar-values using an inflation calculator based off of inflation rates from the U.S. Department of Labor (Official Inflation Data, 2020).

The articles collected from the USGS Benefit Transfer Toolkit, database searches, and gray literature collection lead to 27 usable articles that measure bird and wildlife watching using stated preference methods. Wildlife watching studies specifically mentioned bird watching as a component.

For each article the title, author, year of publication, study location, species, survey type, year of data collection, visitor type, response rate, sample frame, stated preference valuation method, sample size, value per person per day, average age and education of respondent, percent of respondents that are male, average household income of respondent, and standard error of the estimate were collected (where available).

Table 2

Meta-Analysis Articles Summary

Title	Author	Year Published	Location	Species Studied	Multiple Species?	Group	Data Year	# Values in Article	Response Rate	Sample Size	Elicitation Method	Value Per Person, Per Day (2020$)	Avg Age	US FWS Demographics used?	% Male	Avg Edu	Avg HH income	Std Error
A Study of the Impact of Game and Nongame Species on Maine's Economy	Boyle, Kevin J., Stephen D. Reiling, Mario Teisl, and Marcia L. Phillips	1990	Maine	bald eagle	no	iconic birds	1988	1	73	2000	open ended	$1.27	45	no	70	13	73220.5	--
Analysis of the 1985 national survey of fishing, hunting, and wildlifeassociated recreation	Hay, M. J.	1989	United States	wildlife	yes	wildlife	1985	50	93.7	97	close ended	$48.80	34.5	no	49	14	65885.6	7.51
Economic Value of Wildlife Resources in the San Joaquin Valley: Hunting and Viewing Values.	Cooper J., Loomis J.	1991	California	birds	yes	birds	1987	4	44	104	close ended	$97.70	34.5	yes	49	14	65885.6	--
Economic Value of Wildlife Resources in the San Joaquin Valley: Hunting and Viewing Values.	Glen T. Hvenegaard, James R. Butler, & Doug K. Krystofiak	1989	Canada	birds	yes	birds	1987	4	96	603	close ended	$105.95	49.3	no	59	15.8	88645.2	--
Measuring the economic benefits of riparian areas	Crandall, K.	1991	Arizona	wildlife	yes	wildlife	1990	1	80.3	110	open ended	$132.32	48.6	yes	53	14	84814.6	--
Multicountry willingness to pay for transborder migratory species conservation: A case study of northern pintails.	Haefele, M., Loomis, J., Lien, A., Dubovsky, J., Merideth, R., Bagstad, K., . . . LópezHoffman, L	2019	United States and Canada	Northern Pintail	no	common birds	2016	8	--	850	close ended	$1.13	49.5	yes	67	14	93985.2	--
Value of Migratory Bird Recreation at the Bosque del Apache National Wildlife Refuge in New Mexico.	Huber, C., & Sexton, N.	2019	New Mexico	sandhill cranes and snow geese w/ other	yes	iconic birds	2010	2	76	191	close ended	$67.08	58.4	no	48	16	77933.1	1.07
The Economic Impact of Tourism Based on the Horseshoe Crab–Shorebird Migration in New Jersey. Fermata, Inc. Report to New Jersey Division of Fish and Wildlife.(11 December 2008.	Eubanks, T. L., Stoll, J. R., & Kerlinger, P.	2000	New Jersey	red knots and ruddy turnstones	yes	common birds	1998	3	63	602	close ended	$110.95	55	no	47.3	17	126526	--
FederalProvincialTerritorial Task Force on the Importance of Nature to Canadians, & Canada	FederalProvincialTerritorial Task Force	2000	Canada	wildlife	no	wildlife	1996	1	--	87000	unknown	$19.87	39.5	yes	50	14	53398.8	--
Platte River nature recreation study: The economic impact of wildlife watching on the Platte River in Nebraska	Eubanks, T., Ditton, R. B., & Stoll, J. R.	1998	Nebraska	sandhill cranes and other birds	yes	iconic birds	1996	1	69.56	1259	close ended	$45.04	53	no	48	16.54	98426.2	31.59
Platte River birding and the spring migration: Humans, value, and unique ecological resources	Stoll, J.R., R.B. Ditton and T.L. Eubanks.	2006	Nebraska	sandhill & whooping cranes	yes	iconic birds	1996	5	70	3054	close ended	$5.03	53	no	48	16	98426.2	0.0012
Use of dichotomous choice nonmarket methods to value the whooping crane resource.	Bowker, J. M., & Stoll, J. R.	1988	Texas, California, Illinois, and Georgia	whooping crane	no	iconic birds	1983	24	36	741	close ended	$12.62	34.5	yes	49	14	65885.6	--
Valuing wildlife in benefit-cost analyses: A case study involving endangered species.	Boyle, K. J., & Bishop, R. C	1987	Wisconsin	bald eagle and striped shiner	no	iconic birds	1984	14	--			$5.05	34.5	yes	49	14	65885.6	0.07
Birding in the United States: a demographic and economic analysis: addendum to the 2001 National survey of fishing, hunting and wildlifeassociated recreation	La Rouche, G. P.	2003	United States	wildlife	yes	wildlife	2001	4	90	45951	open ended	$22.20	49.5	yes	46	14.5	90977.9	1.535
Benefits of preserving old-growth forests and the spotted owl.	Haqen, D. A., Vincent, J. W., & Welle, P. G.	1992	Washington, Oregon, and California	Northern Spotted Owl	no	iconic birds	1992	8	46	409	close ended	$9.19	39.5	yes	53	14	56783.5	8.29
Measuring the existence value of wildlife: what do CVM estimates really show?	Echeverria, J., Glass, R. J., Hager, T., & More, T. A.	1991	Hampshire, Massachusetts, Connecticut and Rhode	us+A136:F143	no	iconic birds	1991	6	--	600	close ended	$3.03	39.5	yes	53	14	56783.5	--

Table 2, Cont'd.

Meta-Analysis Articles Summary

Title	Author	Year Published	Location	Species Studied	Multiple Species?	Group	Data Year	# Values in Article	Response Rate	Sample Size	Elicitation Method	Value Per Person, Per Day (2020$)	Avg Age	US FWS Demographics used?	% Male	Avg Edu	Avg HH income	Std Error
How much is that birdie in my backyard? A crosscontinental economic valuation of native urban songbirds.	Clucas, B., Rabotyagov, S., & Marzluff, J. M.	2015	Washington	house finch and common birds native songbirds	yes	common birds	2009	1	69.1	166	close ended	$1.50	49.64	no	40	15.74	105144	5.12
Net economic values of wildliferelated recreation in 2006: Addendum to the 2006 National Survey of Fishing, Hunting, and WildlifeAssociated Recreation	Aiken, R.	2009	United States	wildlife	yes	wildlife	2006	154	78	11279	open ended	$66.53	49.5	no	49	14.5	105144	--
Net economic values for wildliferelated recreation in 2001: Addendum to the 2001 National Survey of Fishing, Hunting and WildlifeAssociated Recreation.	Aiken, R. and G.P. la Rouche	2003	United States	wildlife	yes	wildlife	2001	70	--	21823	open ended	$95.79	49.5	no	46	14.5	90977.9	$37.15
1996 net economic values for bass, trout and walleye fishing, deer, elk and moose hunting, and wildlife watching: Addendum to the 1996 National Survey of Fishing, Hunting and WildlifeAssociated Recreation.	Boyle, K.J., B. Roach and D.G. Waddington.	1998	United States	wildlife	yes	wildlife	1996	19	80	624	close ended	$29.35	39.5	no	50	14	53398.8	8.35
Understanding the diversity of eight birder subpopulations: Sociodemographic characteristics, motivations, expenditures and net benefits.	Eubanks Jr TL, Stoll JR, Ditton RB.	2004	Nevada, New Jersey, California, Texas	birds	yes	birds	1998	1	64	859	close ended	$80.19	54.4	no	48.8	16.7	112483	13.52
Avitourism in Texas: Two studies of birders in Texas and their potential support for the proposed world birding center.	Eubanks, T. and J.R. Stoll.	1999	Texas	birds	yes	birds	1998	2	73	207.5	open ended	$3.76	58.21	no	49.65	16.955	102802	--
Wildlife associated recreation on the New Jersey Delaware Bayshore.	Eubanks, T.L, J.R. Stoll and P. Kerlinger.	2000	New Jersey and Nebraska	sandhill cranes and shorebirds	yes	common birds	1998	2	61.21	1525	open ended	$76.32	$54.18	no	47.65	16.725	112476	--
Measuring the recreational use value of migratory shorebirds on the Delaware Bay.	Myers, K.H., G.R. Parsons and P.E.T. Edwards.	2010	Delaware	birds	yes	birds	2008	8	65	155	close ended	$49.80	57.875	yes	49	16.92	136933	--
Economic amenity values of wildlife: Six case studies in Pennsylvania.	Shafer, E.L., R. Carline, R.W. Guldin and H.K. Cordell.	1993	Pennsylvania	falcons, osprey, eagles,	yes	iconic birds	1988	6	100	135	open ended	$22.97	34.5	yes	49	14	65885.6	--
Concepts of value, nonmarket valuation, and the case of the whooping crane.	Stoll, J.R. and L.A. Johnson.	1984	Texas	whooping crane	no	iconic birds	1983	1	67	508	close ended	$61.30	45.3	yes	68	14	65885.6	--
Platte River birding and the spring migration: Humans, value, and unique ecological resources.	Stoll, J.R., R.B. Ditton and T.L. Eubanks.	2006	Nebraska	birds	yes	birds	1996	1	70	3054	close ended	$21.99	53	no	48	16	98426.2	0.0008
1991 net economic values for bass and trout fishing, deer hunting, and wildlife watching.	Waddington, D.G., K.J. Boyle and J. Cooper.	1994	United States	wildlife	yes	wildlife	1992	47	93	187	close ended	$58.16	39.5	no	53	14	73497.9	82.23

Empirical Model

The present analysis's models are as follows:

Regions Models: log_CS = β0 - β1dIcon - β2CommonBirds - β3Birds + β4FillFWS + β5Northeast - β6Midwest + β7West - β8South + β9Canada + β10close + β11unknown - β12DataYr - β13SampleSz + β14AvgAge - β15Percent_Male + β16HHIncome - β17AvgEdu + β22StdEr

Model 1a: Fixed Effects. The full dataset is used, but due to collinearity with the fixed effects dIcon, CommonBirds, Birds, FillFWS, close, unknown, Percent_Male, HHIncome and AvgEdu are not included.

Model 1b: This model mimics Model 1a, but DataYr and AvgEdu are lost. StdError is added to explore study reliability and publication bias.

Model 2a: Fixed Effects. Only the six wildlife studies are used. Due to collinearity with the fixed effects dIcon, CommonBirds, Birds, FillFWS, close, unknown, DataYr, AvgAge Percent_Male, HHIncome and AvgEdu are not included.

Model 2b: This mimics Model 2a, but StdError is added.

Model 3a: Fixed Effects. Only the 13 birds-only articles are used. Due to collinearity with the fixed effects, effects dIcon, CommonBirds, Birds, FillFWS, close, unknown, DataYr, AvgAge Percent_Male, HHIncome and AvgEdu are not included.

Model 3b: This model mimics Model 3b, but adds in StdError. This model is not shown in results due to all variables except for StdError being eliminated for collinearity.

Model 4a: Fixed Effects. The full data set is used, but the dummy variables for Wildlife and Birds are left out to study the impact of CommonBirds and dIcon. The fixed effects would not allow for the inclusion of Birds. Close, unkown, DataYr, Percent_Male, HHIncome, and AvgEdu are also eliminated for collinearity.

Model 4b: This model mimics Model 4a, but loses AvgEdu for collinearity and adds in

StdError.

Model 5a: Least Squares. Includes all variables but StdError. As fixed effects would not permit inclusion, a least squares regression was run for comparison and exploratory purposes to understand the impact of study methodology, context, resource, and demographics.

Model 5b: This model mimics model 5a, but includes StdError.

Flyways Models: log_CS = β0 - β1dIcon - β2CommonBirds - β3Birds + β4FillFWS + β5Atlantic - β6Mississippi + β7Central - β8Pacific + β9CenPac + β10AllCanada + β11close + β12unknown - β13DataYr - β14SampleSz + β15AvgAge - β16Percent_Male + β17HHIncome - β18AvgEdu + β19StdEr

Model 6a: Fixed Effects. The full dataset is used, but due to collinearity with the fixed effects dIcon, CommonBirds, Birds, FillFWS, close, unknown, Percent_Male, HHIncome and AvgEdu are not included.

Model 6b: This model mimics Model 6a, but DataYr, AvgAge, and Canada are lost. StdError is added to explore study reliability and publication bias.

Model 7a: Fixed Effects. Only the six wildlife studies are used. Due to collinearity with the fixed effects dIcon, CommonBirds, Birds, FillFWS, close, unknown, DataYr, AvgAge Percent_Male, HHIncome and AvgEdu are not included.

Model 7b: This mimics Model 2a, but StdError is added.

Model 8a: Fixed Effects. Only the 13 birds-only articles are used. Due to collinearity with the fixed effects all demographics and half of the flyways are lost, so this model is left for full understanding, but not analyzed.

Model 8b: This model would have mimicked Model 3b, but add in StdError, however this model is not run due to the same collinearity issues found in Model 8a.

Model 9a: Fixed Effects. The full data set is used, but the dummy variables for Wildlife and Birds are left out to study the impact of CommonBirds and dIcon. The fixed effects would not allow for the inclusion of Birds. Close, unkown, Percent_Male, HHIncome, and AvgEdu are also eliminated for collinearity.

Model 9b: This model mimics Model 4a, but adds in StdError. However, the model cannot effectively be run and analyzed because with the decrease in data (as approximately ½ data does not have a reported standard error) dIcon and CommonBirds are colinear with the fixed effects.

Model 10a: Least Squares. Includes all variables but StdError. As fixed effects would not permit inclusion, a least squares regression was run for comparison and exploratory purposes to understand the impact of study methodology, context, resource, and demographics.

Model 10b: This model mimics model 5a, but includes StdError. Unknown and AllCanada are lost due to collinearity.

Models 1a-4b and 6a-9b are a fixed effect model (set to panel by Study ID) run using regions for location. Those including only studies that reported their standard error have approximately half the data, as not all papers reported these values. It is a semi-log model, with the CS_PPPD logged. Additionally, it reports robust clustered standard errors (clustered by the Study ID). Models 5a, 5b, 10a, and 10b are least squares regressions, as the fixed effects models yield more parsimonious results, and many variables are lost. The least squares regression gives us the flexibility to understand the depth of the workings of these studies, while the fixed effects allow for a more stringent set of statistical controls.

dIcon, CommonBirds and Birds are hypothesized to have a positive effect compared to generic Wildlife, because the birding population is known to spend money on bird watching specifically, whereas wildlife watching may be less economically fruitful, as many individuals see it as a byproduct of being outside, whereas bird watching is its' own activity/hobby. FillFWS is ambiguous, as the present study seeks to understand if needing demographics from the USFWS has any effect. Regions and Flyways are all ambiguous as well, part of what this study aims to determine is if certain regions and flyways have higher WTP, due to location, species, event, etc., or if it is irrelevant. Close and unknown are ambiguous compared to open-ended elicitation methods because the literature disagrees on whether open- or close-ended are likely to warrant higher consumer surplus. Boyle et al. (1994), Walsh et al. (1992), Loomis & White (1996), and Loomis & Richardson (2009) argue that close-ended elicits higher by providing an appropriate ballpark of values, while others may argue that birders know the worth of their hobby and so might answer higher than a researcher would assume. DataYr is hypothesized to have a positive effect, as birding value in the economy has increased over time. AvgAge, HHIncome, and AvgEdu are all hypothesized to have a positive effect as age tends to bring more financial stability and a higher disposable income. With higher incomes individuals have the ability to spend more on issues and hobbies they care about, and increased levels of education often lead to higher paying careers. Percent_Male is ambiguous because it is undetermined if male or female birders spend more, also birders often do not bird alone, frequently they go as retired couples. StdEr is proposed to have a positive value, because if studies with higher standard errors have a tendency to report larger values. This is often from small samples with lots of noise, and the inclination for only statistically significant studies to be published. It is important to note, that to combat this propensity in publishing, grey literature was gathered for the meta-analysis as well. By including the grey literature, we account for some of the publication bias. Not all studies should yield statistically significant results, but those published often do. With the grey literature, we control for those studies that were not published (due to purpose, desire, or rejection).

Methods

After determining the appropriate studies to include, each article's variables had to be pulled. These variables can be found in Table 1. The variables that required manipulation are as follows:

1. Observational Weights - Each article was assigned a weight of "1," lending equal weight to each individual study. This weight was then divided by the number of values (individual WTP) per study (aweight = 1/number of observations). (E.g.: If a study produced four consumer surplus

values, each individual value was assigned a weight of 0.25). This variable is not included in the regression, but is instead used to weight observations directly.

2. Species - While many studies looked at the values of different species, it was deemed inappropriate to create a dummy variable for each individual species. As such, species were broken into four groups: wildlife (including but not exclusive to birds), birds (just birds, but not further specified), common species, and iconic species.
3. Stated Preference Elicitation Method - For our purposes, this was divided into three categories: open-ended, close-ended, and unknown. Close-ended includes dichotomous choice, payment card, and iterative bidding.
4. Stated Preference Payment Vehicle and Payment Type were unable to be included in the regression as very few articles reported this information.
5. Consumer Surplus - Each reported value from every study was converted into per person, per day values and inflated to 2020$. Per person per day was chosen because it is how both the US Fish and Wildlife Service (USFWS) and the Benefit Transfer Toolkit report their values. For articles that presented yearly values, the USFWS average days spent per person wildlife watching (away from home) was used to calculate daily values. For articles that presented trip values, the average days per trip reported in the study (or if that was not reported, the USFWS) was used to calculate a daily value. When values were presented "per group" or "per household" the average number of people per group or household was used to determine per person values (this was often found in the study, but when unavailable USFWS data was used). When USFWS data was necessary, the closest year survey was employed (as the USFWS surveys every ten years).
6. AvgAge - The average age was either reported in the article, or taken from the closest year USFWS survey. Where a range was reported, the mean of the range was used. While some articles reported means and others medians, all information was included to paint the fullest picture and so as not to lose additional papers. Separate variables were created to indicate if the

AvgAge was pulled from the USFWS, and if USFWS was used for demographic information in general.

7. Percent Male - As with AvgAge, percent male was either reported in the article or pulled from the USFWS survey from the closest year.
8. Average Education - Reported in years of education. Follows the same methods as AvgAge.
9. HHIncome - Follows the same methods as AvgAge, the only change being inflating all average household incomes from the year of the data to 2020$.
10. Standard Error of the Estimate - Where reported, the standard error of the estimate was used. Because many studies did not report, the regression has to be run with and without it. As the studies did not all report in per person, per day values, the standard error also had to be divided into per person, per day, and inflated to 2020$.

Once all variables were found and appropriately formulated, methods follow Loomis & White (1996), Johnston, Ranson, Besedin, & Helm, E. C. (2006), and the procedures of Chapters 15-17 of Benefit Transfer of Environmental and Resource Values, The Economics of Non-Market Goods and Resources. This begins with running a traditional, linear OLS regression. The present analysis does this for two sets of empirical models, the first of which operates with regions, the second with flyways. This is intended to be a comparison for ecological consideration. Additionally, the regions and flyways regressions are both run with and without standard errors. A version without standard errors was run because 221 values did not report standard errors, which is approximately half of the data. A weighted and unweighted version are both run because the literature disagrees on whether or not this is necessary (Markowski et al. 2002, Bateman and Jones 2003, and Johnston, Ranson, Besedin, & Helm, E. C. 2006). For this analysis purposes, final analysis will be explained using the weighted regression, as it seems inappropriate to assign equal weight to each value, as opposed to each article. Following the advice of Loomis & White (1996), Johnston, Ranson, Besedin, & Helm (2006), (Nelson, 2015), (Rolfe, Brouwer & Johnston, 2015), and (Boyle, Kaul & Parmeter, 2015) semi-log (logging only the dependent) and double-log models (logging both dependent and independent variables) were estimated. Following the example of Johnston, Ranson, Besedin, & Helm, E. C. (2006), all models presented in this paper are in the semi-log form, as consumer surplus values have a tendency to be right skewed. Additionally, in the case of the studies used, the lower-bound is zero. There are instances of CS falling below zero for certain "pest" species, but this is in studies that measure WTP for increasing abundance, and thus a negative CS indicates WTP to decrease abundance.

It is at this point that the present analysis departs from Loomis & White (1996) and follows Johnston, Ranson, Besedin, & Helm (2006) due to statistically necessary developments within the realm of meta-analyses. From recommendations in (Nelson, 2015), (Rolfe, Brouwer & Johnston, 2015), and (Boyle, Kaul & Parmeter, 2015), modern meta-analyses need to employ fixed- and random- effect models for calculation of weighted means. The present analysis decides upon fixed effects at the study level, due to the strong assumptions of random effects models that do not hold here, and developments in the field of statistics since the publication of the above-mentioned meta-analyses.

Results

Table 3
Model 1a: Regions Full Data, no Species Variable

Model 1a. Regions Full Data, no species variables			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
Northeast	0.2924562	0.2679935	0.276
Midwest	0.1984065	0.2775714	0.475
West	0.5261842	0.2604724	0.044***
South	0.2395669	0.2477258	0.334
Canada	0.1595043	0.3125026	0.61
DataYr	1.194411	0.3754373	0.002**
SampleSz	0.0008744	0.0003376	0.01**
AvgAge	0.0010844	0.0375355	0.977
_cons	-2385.96	750.296	0.002
Denotes significance at the P ≤ 0.001 level	***		
Denotes significance at the P ≤ 0.01 level	**		
Denotes significance at the P ≤ 0.05 level	*		

# Obs.	434
R-Squared	0.8243
Adj. R-Sq	0.8131
W/in R-Sq	0.0464
Absorbed FE	19 categories

Table 4

Model 1b: Regions Full Data, no species variable, w/ StdError

1b. Regions Full Data, no species variables, w/ StdError			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
Northeast	0.1000651	0.3647478	0.784
Midwest	-0.1264726	0.3769568	0.738
West	0.1735101	0.3519522	0.623
South	-0.0671096	0.3371314	0.842
SampleSz	-0.0012462	0.0006863	0.071
StdError	0.0043911	0.0024681	0.077
_cons	12.82669	5.695847	0.025
Denotes significance at the P ≤ 0.001 level		***	
Denotes significance at the P ≤ 0.01 level		**	
Denotes significance at the P ≤ 0.05 level		*	

# Obs.	218
R-Squared	0.73
Adj. R-Sq	0.7114
W/in R-Sq	0.0403
Absorbed FE: ID	9 categories

Table 5

Model 2a: Regions Wildlife Data

2a. Regions Wildlife Data			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
Northeast	0.0306787	0.164693	0.852
Midwest	-0.1086423	0.171698	0.527
West	0.222533	0.1616457	0.17
South	-0.0566964	0.1539974	0.713
SampleSz	-0.0011351	0.0003399	0.001***
_cons	18.71683	4.562716	0.000
Denotes significance at the P ≤ 0.001 level		***	
Denotes significance at the P ≤ 0.01 level		**	
Denotes significance at the P ≤ 0.05 level		*	

# Obs.	343
R-Squared	0.4023
Adj. R-Sq	0.3843
W/in R-Sq	0.0657
Absorbed FE: ID	6 categories

Table 6

Model 2b: Regions Wildlife Data, with StdError

2b. Regions Wildlife Data with StdError			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
Northeast	0.1000459	0.2171648	0.646
Midwest	-0.1265017	0.2244338	0.574
West	0.1735436	0.2095465	0.409
South	-0.0670578	0.2007225	0.739
SampleSz	-0.001246	0.0004086	0.003**
StdError	0.0043865	0.0014695	0.003**
_cons	20.49412	5.65145	0.000
Denotes significance at the P ≤ 0.001 level	***		
Denotes significance at the P ≤ 0.01 level	**		
Denotes significance at the P ≤ 0.05 level	*		

# Obs.	189
R-Squared	0.4771
Adj. R-Sq	0.4478
W/in R-Sq	0.1188
Absorbed FE	6 categories

Table 7

Model 3a: Regions Birds Data

3a. Regions Birds Data			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
Northeast	4.528636	1.580883	0.005**
Midwest	0	(omitted)	
West	1.269336	1.031581	0.222
South	0	(omitted)	
Canada	0.3661901	0.6012652	0.544
SampleSz	0.0019817	0.0008	0.016*
_cons	-0.5476149	1.161484	0.639
Denotes significance at the P ≤ 0.001 level	***		
Denotes significance at the P ≤ 0.01 level	**		
Denotes significance at the P ≤ 0.05 level	*		

# Obs.	91
R-Squared	0.8561
Adj. R-Sq	0.825
W/in R-Sq	0.1034
Absorbed FE: ID	13 categories

Model 3b is not presented due to collinearity with the Fixed Effects that results in an absence of all variables but StdError.

Table 8
Model 4a: Regions Full Data with Species

4a. Regions Full Data with Common and Iconic			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
CommonBirds	-1.606779	0.3739746	0.000***
dIcon	-0.6252359	0.3739504	0.095
Northeast	0.2673805	0.2591371	0.303
Midwest	0.1689943	0.2684155	0.529
West	0.4970974	0.2518884	0.049*
South	0.2111878	0.2395659	0.379
Canada	0.1235716	0.3022097	0.683
DataYr	1.499604	0.3691076	0.000***
SampleSz	0.0006819	0.0003291	0.039*
AvgAge	0.0080373	0.0363187	0.825
_cons	-2994.091	737.5984	0.000
Denotes significance at the P ≤ 0.001 leve		***	
Denotes significance at the P ≤ 0.01 level		**	
Denotes significance at the P ≤ 0.05 level		*	

# Obs.	434
R-Squared	0.8366
Adj. R-Sq	0.8253
W/in R-Sq	0.1131
Absorbed FE: ID	19

Table 9
Model 4b: Regions Full Data with Species and StdError

4b. Regions Full Data withCommon, Iconic and StdError			
Fixed-Effects Regression			
logCS	Coef.	Std. Err.	P>|t|
CommonBirds	-1.509049	0.3811218	0.000***
dIcon	-0.7250999	0.3810693	0.058
Northeast	0.1523669	0.2549298	0.55
Midwest	-0.2748585	0.244624	0.262
West	0.1512493	0.2249074	0.502
South	-0.0944426	0.2254697	0.676
Canada	0.148726	0.2455237	0.545
SampleSz	-0.0003852	0.0001902	0.043*
_cons	5.162789	0.9586829	0.000***
Denotes significance at the P ≤ 0.001 level		***	
Denotes significance at the P ≤ 0.01 level		**	
Denotes significance at the P ≤ 0.05 level		*	

# Obs.	434
R-Squared	0.8289
Adj. R-Sq	0.8179
W/in R-Sq	0.071
Absorbed FE	19

Table 10

Model 5a: Regions Least Squares

5a. Regions Full Data			
Least Squares Regression			
logCS	Coef.	Std. Err.	P>|t|
dIcon	-2.762756	0.3270263	0.000***
CommonBird	-2.460532	0.3578914	0.000***
Birds	-1.524216	0.4487456	0.001**
FillFWS	0.6399863	0.2811485	0.023*
Northeast	0.0722854	0.1505225	0.631
Midwest	-0.2655176	0.1525794	0.083
West	0.2367964	0.1564141	0.131
South	-0.1520986	0.1493915	0.309
Canada	0.3789911	0.5008631	0.45
close	0.0931764	0.308926	0.763
unknown	1.807072	1.413396	0.202
DataYr	-0.1089631	0.0211516	0.000***
SampleSz	-0.0000357	0.0000147	0.016*
AvgAge	0.1339101	0.0445349	0.003**
Percent_Mal	-0.0808529	0.0262224	0.002**
HHIncome	0.0000169	5.21E-06	0.001**
AvgEdu	-0.34214	0.274446	0.213
_cons	223.396	43.85926	0.000***
Denotes significance at the P ≤ 0.001 le	***		
Denotes significance at the P ≤ 0.01 lev	**		
Denotes significance at the P ≤ 0.05 lev	*		

# Obs.	442
R-Squared	0.54
DF Model	17
DF Total	441

Table 11

Model 5b: Regions Least Squares with StdError

5b. Regions Full Data with Std Error			
Least Squares Regression			
logCS	Coef.	Std. Err.	P>|t|
dIcon	-5.937757	0.6694914	0.000***
CommonBirds	-13.22138	1.863426	0.000***
Birds	-4.294017	0.7885273	0.000***
FillFWS	3.929278	0.559349	0.000***
Northeast	0.2727355	0.2000231	0.174
Midwest	0.0448104	0.210651	0.832
West	0.3128636	0.2042358	0.127
South	0.1114047	0.1923603	0.563
close	1.584713	0.3221036	0.000***
DataYr	0.0958378	0.109291	0.382
SampleSz	-0.0002151	0.0000276	0.000***
AvgAge	-0.034344	0.1773755	0.847
Percent_Male	-0.4387103	0.0527419	0.000***
HHIncome	0.0001136	0.0000224	0.000***
AvgEdu	-0.5494045	0.5928908	0.355
StdError	0.0068897	0.0014264	0.000***
_cons	-163.6786	219.4131	0.457
Denotes significance at the P ≤ 0.001 level	***		
Denotes significance at the P ≤ 0.01 level	**		
Denotes significance at the P ≤ 0.05 level	*		

# Obs.	222
R-Squared	0.721
DF Model	16
DF Total	221

Results for Models 6a-10b are not shown or analyzed here, as they are similar in nature to their Regions counterparts (1a ~ 6a, 1b ~ 6b, etc.). The purpose of modeling both is to have Regions models for understanding in people-oriented policy and Flyways models for ecological purposes. Our hope is that the two will be compared down the road for true socio-ecological coupling and understanding. For the purpose of this first paper however, it would add too much detail.

The only significant regions are West (Model 1a and Model 4a) and Northeast (Model 3a). This requires a deep dive into the locations present, potential events that would pull bird-watchers to the area, and ecological perspective.

DataYr is significant and positive in Models 1a and 4a, and significant and negative in 5a.

SampleSz is significant in Models 1a, 2a, 2b, 4b, 5a, and 5b.

Of the four models that included StdError, it is only significant in 2b and 5b, both positive, but also very small coefficients.

Of the species variables, CommonBirds was significant and negative in 4a, 4b, 5a, and 5b. dIcon was only significant (and also negative) in 5a, and 5b. Birds was negative significant in 5a and 5b (the only models in which it was included).

In Models 5a and 5b, which included all possible variables, HHIncome and FillFWS were significant and positive and Percent_Male was significant and negative. In 5a, AvgAge was also significant and positive. And in 5b, close was also significant and positive.

Discussion

The results of this meta-analysis lead to some interesting findings.

We expected to see SampleSz significance lead to interpretation and discussion of publication bias, especially as it is significant in six models (two positive, four negative). However, each coefficient is so miniscule, that it is much more of a precise zero than a measure to interpret. This could be due to the small nature of the field (only 27 studies of Stated Preference WTP for Bird Watching). Similarly, StdError was only significant in two of the Regions models. These small coefficients indicate that if a studies StdError increases by 1, the CS_PPPD would increase by $0.44 (Model 2b) or $0.69. This lends evidence to the idea that higher standard errors, from noisier studies, can lead to larger results, but not by as much as would have been expected.

DataYr is significant and positive in Models 1 and 4a, but significant and negative in Model 5a. This difference could be due to the fixed-effects nature of 1 and 4a, but least squares approach of 5a. The negative relationship observed in Model 1 could be evidence of a decreased value by humans on the environment, or a decreased quality of birdwatching experience as bird abundance and biodiversity has decreased rapidly since the 1970s (Rosenberg et al, 2019). However, the coefficients in Models 1a and 4a do seem rather large, and there may be other issues at play that need to be explored here. For reference, studies range from 1983 to 2016.

Table 11

Number of Studies by Year

Year	# of Studies
1983	1
1984	2
1985	1
1987	1
1988	2
1990	1
1991	1
1992	2
1996	6
1998	3
2001	2
2006	1
2008	1
2009	1
2010	1
2016	1

In models 4a, 4b, 5a, and 5b, the negative significance of CommonBirds (compared against Wildlife and Birds studies in 4a/b and Wildlife in 5a/b) indicates that the sole presence of CommonBirds is worth less than the ability to view all wildlife (including birds) or any/all birds. However, this could also be because of the small number of studies that specifically indicated the species. dIcon was only significant (and also negative) in 5a, and 5b, indicating that iconic birds are valued less than wildlife as a whole. It is important to note that these were least-squares, not fixed-effects, models, but this could also be because avid-birders have a tendency to look for iconic birds, whereas casual birders tend to look for biodiversity and abundance, Birds was negative significant in 5a and 5b (the only models in which it was included), indicating that wildlife watching (including birds) is valued more than bird watching specifically. This could, again, be due to the least squares nature of the regression, the small number of studies, or the ability/sample size of the studies that studied wildlife as a whole.

In Models 5a and 5b, HHIncome was significant, but at such a small coefficient that it is effectively zero. FillFWS was also significant and positive, indicating that articles that needed USFWS demographics data were associated with higher WTP. Percent_Male was significant and negative, meaning that a percent increase in males surveyed was associated with a lower CS. This could be indicative of men valuing nature less than women, but more evidence would be needed for this claim. It will be interesting to compare with hunting values, which is stereotypically a male-dominated field. In 5a, AvgAge was also significant and positive, indicating that an increase in the average age of the person survey of 1 year leads to a $13.39 higher CS. This could be due to (often) increased income as we get older, or a higher value for leisure activities as we age, but it would be interesting to see if there is a tipping point (perhaps after retirement). Finally, in 5b, close was also significant and positive. This suggests that close-ended question sequences elicit higher WTP than open ended questions (which is supported by Loomis, 2016). The mentality behind this is that people will choose a higher value when presented with a range, than when asked to come up with a value off the top of their heads, however this dichotomy is still up for debate in the field and evidence has been brought on both sides.

On the whole, this Meta-Analysis looked at 27 stated preference WTP surveys to measure consumer surplus per person, per day in 2020$ for bird watching. The mean was $56.74 with a standard deviation of $70.31. The minimum CS_PPPD is $0.29, indicating a low value, but positive and existing value. As the US FWS reports an average of 16 days spent wildlife watching per participant in 2016, and 86,042,000 individuals over 16 years old who participated, this could amount to $399,234,880 (US Fish and Wildlife Service, 2016). Following this logic, but using the mean CS_PPD, the potential generation is $7,812,369,280. Because this is a measurement of consumer surplus (the value of the enjoyment gained by individuals from bird watching above and beyond what they pay), this would be an additional economic value that could be put towards policy, notwithstanding the “47 million people spend U.S.$9.3 billion per year through bird related activities in the United States” (Rosenberg, et al., 2019, p. 3). The maximum CS_PPPD is $824.53 (Out-of-state visitor to Iowa), which while likely unrepresentative of the country as a whole, was left in because it is an important benchmark of the value of out-of-state bird watching. Understanding the consumer surplus placed on bird watching and wildlife watching helps us to understand what individuals would be willing-to-pay in benefit transfer areas of environmental public policy.

Table 12

Summary Statistics of CS_PPPD

Summary	# Obs.	# Articles	Mean	Std. Dev.	Min.	Max.
CS_PPPD	442	27	56.74	70.31	0.29	824.53

Implications

With this meta-analysis in hand, and those to be conducted down the road, we can value birds by region, flyway, type of bird (common, iconic, any bird), and provide values across the US and Canada. Maps created highlighting these values, while simultaneously making note of different areas of environmental concern, would find a Benefit Transfer Value useful in crafting climate change public policy for conservation, restoration, adaptation, and mitigation. This could prove particularly fruitful in areas of water and air quality, as birds are useful indicators of both.

In the era of climate change, which is arguably the most pressing issue facing today’s generations, ecosystem assessments and sustainability goals are the framework by which humans must make policy decisions.

The Millennium Ecosystem Assessment (MEA) looks at ecosystem services, otherwise known as the benefits we derive from the environment. According to the analysis, approximately two-thirds stem services measured are being used in an unsustainable (Millennium Ecosystem Assessment, 2005, 1). The potential loss will likely be seen in nonlinear changes that occur suddenly and in steps (Millennium Ecosystem Assessment, 2005, 6) due to decreased biodiversity (Millennium Ecosystem Assessment, 2005, 12).

Biodiversity is where birds enter the picture, as wild birds are often used as a measurement of biodiversity in assessing ecosystem services (Bateman, et al., 2013, 45). But according to the MEA, 10-30% of bird species face possible extinction (Millennium Ecosystem Assessment, 2005, 35), in part from human activity. The United Nations' International Panel for Biodiversity and Ecosystem Services' (IPBES) chair, Sir Robert Watson, reports that ecosystem health, on which humans, animals, and plants alike depend, is rapidly degrading due to our own actions, our relentless drive for growth at the detriment to quality of life around the globe (United Nations, 2019, 2).

This is increasingly problematic as developing substitutes for ecosystem services is costly, and sometimes impossible, especially in the case of biodiversity (Millennium Ecosystem Assessment, 2005, 19), for how do you manufacture biodiversity? Biodiversity has been called our "most important life-supporting 'safety net'" (United Nations, 2019, 8), fundamental to a sustainable future, but it is rapidly declining as species and population numbers dwindle, fall apart, or go extinct, with Professor Josef Settele (A United Nations panelist for IPBES, from Germany) explaining that this is a problem of our own design, and to our intense detriment (United Nations, 2019, 11). IPBES reports that approximately one-quarter of threatened bird species, an indicator species for biodiversity levels, may already be experiencing negative impacts from climate change (United Nations 2019, 42). Using the models of this meta-analysis, we can begin to calculate values for this lost biodiversity, the loss of our safety net. With economic costs in hand, climate change policy can be more accurately crafted.

Birds are considered a flagship species because they easily attract public support, due to their looks and charisma, thus providing a rallying point or symbolic representation of initiatives for conservation (Egwumah et al., 2017, 195), and have been monitored by organizations since 1900 with the introduction of National Audubon Society's annual Christmas Bird Temple et al., 1989, 262). Additionally, bird species are diverse, and found in most habitats across the globe, and each species is fairly specialized in their own right (BirdLife International, 2013, 3). As “flagships for nature,” the popularity of birds holds public and policy-makers attention, particularly due to the economic value of their services (such as pest control, which can be quantified with the mitigated costs of alternative pest management) (BirdLife International, 2013, 3). Furthermore, birds are sensitive to changes in their environment - both climate and land use, and their population trends and distribution often reflect those of many other species (BirdLife International, 2013, 3). Birds are subject to their environment, which experiences seasonal changes, but also unexpected catastrophes, and we can predict and monitor the population response (Temple et al, 1989,260). Sensitive to strenuous environmental conditions, bird species will demonstrate the effect of this strain (Egwumah et al., 2017, 195). And, as birds often are in high trophic levels, they provide a look into the health of the system as a whole, because their species health encompasses effects of those at lower trophic levels (O’Connell, et al., 2000, 1706).

Birds as environmental monitors is a concept as old as time, Aristotle cited cranes as signals of bad weather, flying down from the clouds and holding still, where still others cited the fall arrival of cranes as a sign of a harsh winter, or the arrival of geese as a sign spring was on the horizon (Furness & Greenwood, 1993, 3), and then there’s the old adage “canary in the coal mine,”. These days, they are not mere symbols of the coming seasons or storms, but indicators of biodiversity, a changing climate, and a motivator for policy prescriptions to handle the ramifications of such. And now, there is a monetary value attached. Ecosystem services have three-fold values: Economic - monetary expression, Ecological - how the ecosystem service is measured as a contribution by the ecosystem, and Socio-Cultural - socially derived values from ethics, spirituality and religion, and intergroup dialogue (Hattam, et al., 2015). Valuation of ecosystem services, currently within the economic wheelhouse, links ecosystem services with human well-being in a more explicit manner. This knowledge should influence decision-making for environmentally-minded policy, by motivating both people-minded and pocket-minded policy-makers (Hattam, et al., 2015). With this multi-method valuation, we can analyze the trade-offs between the supplies and demands for different ecosystem services, and incorporate them into climate change modeling, natural resource management, and public policy (Hattam, et al., 2015).

While this meta-analysis is a good jumping-off point for such Benefit-Transfer, there are a variety of further studies to be conducted. Our next step is to analyze the revealed-preference (travel-cost method) studies in the field. From there, a world of valuing biodiversity saving awaits.

Conclusion

Birds, given their prominence and visibility, geographic reach, and the wide range of studies done on their taxonomy and ecology, are in a unique position to perform as indicators of environmental issues. In many cases, specific species are used as indicators of local issues such as air and water quality. On a larger scale, birds are used as a measure of biodiversity to represent the general health and well-being of the ecosystem, and to help validate the particular ecosystem service of inherent value.

Ecology has provided population dynamic models for understanding intertemporal and interregional flows of species and populations, which are used in natural resource management and as dire warnings for climate change. Economics has determined the process for nonmarket valuation of ecosystem services, which is used for policy prescriptions and budgeting. The natural next step is to merge the two together. Population dynamics as production functions, ecosystem services valued, policy created, actions taken, paradigms shifted.

According to Rosenberg, et al. biodiversity conservation is the challenge of today (2019) due to extreme habitat loss, crisis-level anthropogenic climate change, and a whole host of other issues. This challenge is not insurmountable, but only if the correct measures are taken quickly as too much time and precious biodiversity has already been lost (Rosenberg, et al., 2019, pg. 3). Ecologists and economists need to join forces and tool kits, and this meta-analysis provides the beginnings of models and values with which to do so.

Environmental problems are economic problems, and environmental solutions can be economic solutions - when the analysis is deliberate, accurate, inter -regional and - temporal workshopping at the interdisciplinary level. Many have previously defined the biodiversity crisis with extinction, but that starts with the loss of abundance, both of which functionally change ecosystems (Rosenberg, et al., 2019), and fundamentally affect the economy. Together, ecology and economics can take the chaos of the climate crisis and model a series of pathways and solutions to mitigate further damage and adapt to this reality. This potential for Benefit Transfer applications, is the crucial reason why these meta-analyses must be conducted. With stated-preference methods yielding consumer surplus values, there is the ability to present economic values of each bird lost, and what environmental policies could help us gain.

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