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Willingness to Pay for Conservation of Transborder Migratory Species: A Case Study of the Mexican Free-Tailed Bat in the United States and Mexico

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Abstract
We estimated U.S. and Mexican citizens' willingness to pay (WTP) for protecting habitat for a transborder migratory species, the Mexican free-tailed bat (*Tadarida brasiliensis mexicana*), using the contingent valuation method. Few contingent valuation surveys have evaluated whether households in one country would pay to protect habitat in another country. This study addresses that gap. In our study, Mexican respondents were asked about their WTP for conservation of Mexican free-tailed bat habitat in Mexico and in the United States. Similarly, U.S. respondents were asked about their WTP for conservation in the United States and in Mexico. U.S. households would pay $30 annually to protect habitat in the United States and $24 annually to protect habitat in Mexico. Mexican households would pay $8 annually to protect habitat in Mexico and $5 annually to protect habitat in the United States. In both countries, these WTP amounts rose significantly for increasing the size of the bat population rather than simply stabilizing the current bat population. The ratio of Mexican household WTP relative to U.S. household WTP is nearly identical to that of Mexican household income relative to U.S. household income. This suggests that the perceived economic benefits received from the bats is similar in Mexico and the United States, and that scaling WTP by relative income in international benefit transfer may be plausible.

Keywords Bats · Contingent valuation · Habitat · Mexico · United States · Willingness to pay

Introduction

Transborder migratory species (birds, mammals, and some insects) often depend on habitat in one country for part of their life cycle (e.g., breeding) and habitat in another country for a different phase (e.g., overwintering). Migratory species often provide benefits such as ecosystem services, in certain parts of their ranges while receiving habitat support in other portions of their range (López-Hoffman et al. 2017). Successful management of such species

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requires conservation of habitat throughout all countries on which the species depend. In some instances, however, one country might provide relatively more support for a species while another country might receive relatively more of the species' benefits. Sometimes the range of a species includes countries with different standards of living.

Previous research suggests that households in a higher-income country such as the United States would pay to protect a migratory species in their own country (Richardson and Loomis 2009). However, a scarcity of literature exists about the relative willingness to pay (WTP) of households in a higher-income country to protect the habitat in a lower-income country upon which the migratory species depends for part of its life cycle. No literature of which we are aware has estimated what low-income countries would pay for protection of habitat in high-income countries.

Some have suggested that, because of differences in ability to pay, higher-income countries should pay lower-income countries to protect their environment and biodiversity (Balmford and Whitten 2003; Ferraro 2001; Ferraro and Kiss 2002). The assumption here is that individuals in lower-income countries may not be able to pay the monetary cost or may be unwilling to bear the opportunity cost to protect habitat for a species that also provides benefits elsewhere. This assumption of lack of commitment would seem even more pronounced for a migratory species that requires habitat in both lower-income and higher-income countries during its life cycle, or that provides more benefits in higher-income countries than in the lower-income countries.

In this situation, if individuals in the lower-income country believe that the majority of the benefits from habitat conservation go to the higher-income country, they may be less willing or even unwilling to contribute money to protect the habitat even in their own country (Balmford and Whitten 2003, p 241). In this case, residents of the lower-income country may view protection to be the responsibility of the higher-income country since people in the higher-income country receive benefits of conservation and are better able to afford the cost of conservation than they are. If this view of individuals in lower-income countries is correct, then certainly individuals in these lower-income countries would not be willing to contribute to efforts to protect the migratory species habitat in the higher-income country, even though the cross-boundary species requires habitat in both countries for survival. There is some support for this view of lack of WTP in the apparent necessity of payments from international donors to landowners in lower-income countries such as Costa Rica (Ferraro 2001, p 994) and to landowners of habitat of another transboundary species, the Monarch Butterfly in Mexico (Kido and Seidl 2008). The necessity of these payments suggests not only might those residents not be willing to pay, but that some residents may feel they should be entitled to compensation from the higher-income countries in order to provide habitat in their country for a species enjoyed in a higher-income country. In this paper, we test these hypotheses for households in Mexico and the U.S. regarding maintaining and improving habitat for the Mexican free-tailed bat (*Tadarida brasiliensis mexicana*), hereafter MFTB.

A related hypothesis that underlies international benefit transfers that infer WTP of citizens in lower-income countries based on WTP in higher-income countries is that the amount households would pay may be proportional to their income (Ahtiainen et al. 2015). Chestnut et al. (1997) used this approach for valuing reduction in air pollution in Bangkok. Hammitt and Robinson (2011) estimated the value of statistical life (VSL) for lower-income populations using values from higher-income populations in this manner. However, as Hammitt and Robinson (2011) and Czajkowski and Scasny (2010) noted, there need not be a proportional relationship between WTP and income. For example, the VSL literature supports an income elasticity of 0.40 (Hammitt and Robinson 2011). As Ahtiainen et al. (2015) noted, assuming an income elasticity of one for WTP is equivalent to assuming that a respondent's WTP is a constant share of their income, something we can evaluate with our data. While this assumption seems somewhat restrictive, Ahtiainen et al. (2015) and Czajkowski and Scasny (2010) both found empirical support for this assumption.

Research Hypotheses

Our study allows us to test the hypotheses discussed above using WTP for protection of habitat of the transboundary MFTB in a lower-income country (Mexico) and a higher-income country (U.S.). Specifically:

Hypothesis 1 The average WTP per household in the lower-income country (L) to protect a portion of the habitat of a migratory species in its own country is statistically greater than 0:

$$H0_1 : \mathrm{WTP_L}(\mathrm{Habitat_L}) = 0 \quad (1)$$

$$HA_1 : \mathrm{WTP_L}(\mathrm{Habitat_L}) > 0 \quad (2)$$

Hypothesis 2 The average WTP per household in the lower-income country (L) to protect a portion of the habitat of the migratory species in a higher-income country (H) is

statistically greater than 0:

$$H0_2 : WTP_L(Habitat_H) = 0 \quad (3)$$

$$HA_2 : WTP_L(Habitat_H) > 0 \quad (4)$$

Hypothesis 3 The average WTP per household in the higher-income country (H) to protect a portion of the habitat of a migratory species in its own country is statistically greater than 0:

$$H0_3 : WTP_H(Habitat_H) = 0 \quad (5)$$

$$HA_3 : WTP_H(Habitat_H) > 0 \quad (6)$$

Hypothesis 4 The average WTP per household in the higher-income country (H) to protect a portion of the habitat of the migratory species in a lower-income country (L) is statistically greater than 0:

$$H0_4 : WTP_H(Habitat_L) = 0 \quad (7)$$

$$HA_4 : WTP_H(Habitat_L) > 0 \quad (8)$$

If we reject the null hypothesis for H_1 through H_4 (that is, we find that there is a positive WTP to protect migratory species habitat in one's own country and in the other country the species depends on), the next step is to test whether WTP to protect habitat within one's own country is equal to the WTP to protect habitat in the other country.

Hypothesis 5 The average WTP per household in the lower-income country (L) to protect habitat within the lower-income country is equal to the average WTP per household in the lower-income country to protect habitat in the higher-income country (H):

$$H0_5 : WTP_L(Habitat_L) = WTP_L(Habitat_H) \quad (9)$$

$$HA_5 : WTP_L(Habitat_L) > WTP_L(Habitat_H) \quad (10)$$

Hypothesis 6 The average WTP per household in the higher-income country (H) to protect habitat within the higher-income country is equal to the average WTP per household in the higher-income country to protect habitat in the lower-income country (L):

$$H0_6 : WTP_H(Habitat_H) = WTP_H(Habitat_L) \quad (11)$$

$$HA_6 : WTP_H(Habitat_H) > WTP_H(Habitat_L) \quad (12)$$

Hypothesis 7 To investigate whether WTP is a constant share of income in the lower-income and higher-income countries, we test whether the ratio of WTP to income in the lower-income country is equal to the ratio of WTP to income in the higher-income country:

$$H0_7 : (WTP_L/HHinc_L) = (WTP_H/HHinc_H) \quad (13)$$

$$HA_7 : (WTP_L/HHinc_L) \neq (WTP_H/HHinc_H) \quad (14)$$

Valuation Methodology and Empirical Case Study

The economic benefits of non-market goods such as maintaining and improving wildlife habitat are measured using one of several techniques that are generally divided into revealed or stated preference methods. Revealed preference methods use individuals' or households' purchases of market goods to infer how they value non-market goods. Revealed preference methods are appropriate when the value of a non-market good is largely or wholly use value (e.g., hunting a particular species or other onsite recreational use of the species).

For many species, the bulk of the anthropocentric benefits are non-use values or passive-use values (Richardson and Loomis 2009). These values are made up of existence value (the benefit associated with knowing that the species continues to exist in the wild) and bequest value (the benefit of knowing that protection today will ensure these species will be provided to future generations). In such cases, it is necessary to use stated preference methods, which rely on surveys asking households their WTP for protection of a non-market resource to estimate non-use values (Champ et al. 2017).

The contingent valuation method (CVM) is a stated preference method commonly used throughout the world to estimate the WTP for non-market goods (Champ et al. 2017). CVM studies are conducted using a survey questionnaire that includes several elements: (a) description of the public good to be valued; (b) description of the program for maintaining or improving the public good; (c) the means by which respondents would pay for the program, called the payment vehicle; and (d) the response format of the question used to elicit the respondent's WTP. These elements of our CVM survey are described below.

Public Good Being Valued

The public good in our study is the population of MFTB in the United States and Mexico. The survey included a map illustrating the annual MFTB migration between the United States and Mexico, showing the summer habitat in northern Mexico and the southwestern United States, and the winter

habitat in central and southern Mexico. In the text of the survey, respondents were told that female MFTB migrate in the spring from wintering sites in central and southern Mexico to give birth in "maternity roost" caves in northern Mexico and southwestern U.S. In the fall, the female bats and their pups return to winter sites in Mexico. Survey recipients were also informed that MFTB provide the following benefits to people:

1. MFTBs eat insects, including insects that damage agricultural crops. In doing so, the bats reduce the need to spray pesticides, which prevents potential pesticide contamination and saves farmers money (Cleveland et al. 2006; Federico et al. 2008; Lee and McCracken 2005; López-Hoffman et al. 2014).
2. Viewing of MFTBs at caves and bridges is a popular summer activity. Often, large crowds of people gather in the evenings to watch thousands or even millions of MFTBs emerge for their nightly insect feeding (Bagstad and Wiederholt 2013).
3. MFTBs' droppings, or guano, are used for fertilizer and in many other products (Kaya et al. 2014).

Survey recipients were also informed that, though rare, MFTB might transmit rabies.

All of this text and the map may suggest to some respondents that more than half of the year of the MFTB's migratory cycle is spent in Mexico, and thus may have influenced their WTP for habitat protection in Mexico and the U.S. While we ran a focus group on the survey, we did not specifically probe on this point, so we are uncertain as to exactly what respondents were thinking about this particular point. Ecologically speaking, the relative time a species spends in each geographic area is not necessarily perfectly correlated to species survival, i.e., one type of habitat may have a greater influence on species survival and population size than another. As such, ecologists have developed several metrics to measure the contribution of migratory species habitats to their populations (Nicol et al. 2016; Wiederholt et al. 2017). Likewise, the ecosystem services provided by a species (especially if it involves viewing value as compared to non-use, or involves insect control on crops) are a function of specific timing of activities (i.e., the crops need to be to the point where insect damage would, in the absence of the bats, require spraying), rather than just the total amount of time the species spends in each habitat. It would be useful in future research to explore whether respondents could make such fine distinctions when forming their valuations if they were provided this more detailed information.

The survey also explained that due to the past use of dichloro-diphenyl-trichloroethane (a pesticide now banned in the U.S.) and land development (Betke et al. 2008; McCracken 2003), the population of MFTB dropped from approximately 125 million in the 1950s to the current estimate of under 23 million. Respondents were also informed that due to expected impacts from changes in weather patterns and increasing numbers of wind turbines (Boyles et al. 2011), that without additional habitat conservation efforts, the size of the MFTB population is projected to decline further. These trends were illustrated in the survey with a figure showing just the lower dark dashed line labeled No Additional Conservation Efforts in Fig. 1.

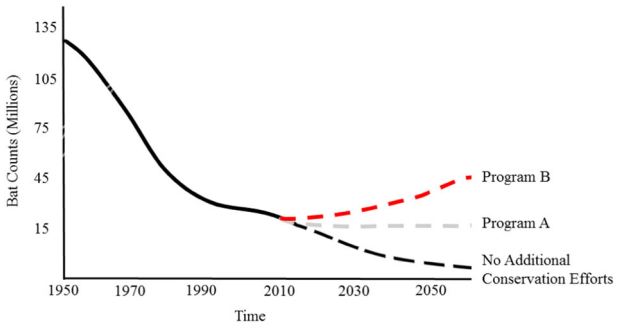

Fig. 1 Trend in MFTB population and future population under three alternative scenarios

In CVM, as in most environmental and economic analyses, there is a comparison of the likely future without to a future with one or more alternative programs. In our survey, two program levels were proposed to address the MFTB population decline. The first would stop the continued decline in MFTB population size, stabilizing the population at its current level (Program A). The second program (Program B) would double the population size of MFTB. These are illustrated in Fig. 1, that was shown in the survey.

The programs to conserve MFTB habitat described in the survey involved the establishment of a North American international wildlife conservation organization to work with private landowners and public land managers to provide funds or payments to protect habitat where there are bat roosts, prevent vandalism of roosts, and ensure that some MFTB habitat is protected from development. Respondents were informed that Program B (to increase the size of the MFTB population) would cost more than Program A (to just stabilize the MFTB population at the current level).

How Households Will Pay for Habitat Protection

When a public good provides both use and non-use or passive-use values, the method of payment must be one that can be readily paid by both users and non-users—usually some type of tax. But taxes can sometimes elicit a high degree of protest responses where people indicate that they will not pay at all, not because they do not value the public good, but because they have a general anti-tax sentiment (Boyle 2017) or because of a concern for government

corruption or past poor performance of government. In situations like this, a donation payment vehicle is often used to reduce the instance of such protest responses (Gonzalez-Caban and Loomis 1997; Shah et al. 2016). For this reason, and because our survey was conducted in two countries with differing taxation systems, we chose a donation payment vehicle where the money collected would go into a fund to be used by an international wildlife conservation organization to support protecting habitat for MFTB.

WTP Question and Response Format

The WTP question for Program A was:

> What is the largest amount you would donate each year to fund Mexican free-tailed bat habitat conservation that keeps the number of Mexican free-tailed bats stable at the current level? There are no right or wrong answers. We are just interested in your honest response.
>
> Please answer for each geographic area. If you would not spend any money, please check '$0'.

Similar wording was used for Program B. Response options to the WTP question utilized a payment card format. This format lists a range of alternative monetary amounts from which respondents select the specific monetary amount that represents their maximum WTP. This format is more statistically efficient than other formats since the monetary amount indicated by the respondent provides a relatively precise estimate of the respondent's WTP and avoids the issues with other WTP question formats. For example, respondents sometimes find answering an open-ended WTP question a difficult task especially for goods they are unaccustomed to paying for, inducing some respondents to leave the question blank (Arrow et al. 1993). The dichotomous-choice WTP question format is the simplest for the respondent to answer, but does not yield a great deal of information because all that we can learn from a single response is whether the respondent's WTP is greater than or less than the bid amount they were asked to pay.

Our payment card included an explicit zero WTP response for those who would be unwilling to pay, and a fill-in-the-blank option for respondents with a WTP greater than the highest monetary amount shown on the payment card (Fig. 2 illustrates the payment card using the U.S. version for Program A). The same payment card layout was used for Program A and Program B, and the payment card shown to Mexican households used monetary amounts in Mexican pesos (based on average excahnge rates, October 11, 2017, ONDA).

We also provided respondents with reminders about their budget constraint and substitutes (Arrow et al. 1993). Specifically, survey recipients were informed that the MFTB was one of about 150 bat species that occur in North America (Loeb et al. 2015), and that 20 of these bat species are migratory (Fleming and Eby 2003). While the specific ecosystem services provided by different bat species may differ, we did not want survey recipients to assume that MFTB are the only bat species in North America and value them as such. The survey also requested survey recipients to consider their household income and whether they can afford to make the payment they selected when answering the WTP questions. Finally, respondents were advised at the beginning of the WTP section that they would be asked about their WTP for programs in both Mexico and the United States, and for stabilizing and increasing the MFTB population.

Survey Mode and Sample Sizes

Several modes for conducting surveys include mail, in-person, internet, phone, and mixed modes. The selection of the best survey mode must consider the content of the

Annual donation for Mexican free-tailed bat habitat conservation **in the United States:**											
Indicate the highest annual donation you would make →	US$0	US$5	US$10	US$20	US$30	US$40	US$50	US$75	US$100	US$150	>US$150
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This question shown only to respondents who selected >US$150 above What is the largest amount you would donate each year to fund Mexican free-tailed bat habitat conservation **in the United States** that keeps the number of Mexican free-tailed bats stable at the current level? US$_____											
Annual donation for Mexican free-tailed bat habit conservation **in Mexico:**											
Indicate the highest annual donation you would make →	US$0	US$5	US$10	US$20	US$30	US$40	US$50	US$75	US$100	US$150	>US$150
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
This question shown only to respondents who selected >US$150 above What is the largest amount you would donate each year to fund Mexican free-tailed bat habitat conservation **in Mexico** that keeps the number of Mexican free-tailed bats stable at the current level? US$_____											

Fig. 2 U.S. household payment card for Program A

survey. Our survey has several visual aids including two color photos of MFTB and a color map of their migration patterns. The survey also includes several places with diverging response paths. Given the complexity of the survey and the visual aids, we chose an internet survey mode administered by Survey Sampling Inc. (SSI), a company with 40 years of experience providing survey research services, including international surveys. We worked with SSI to verify that the programming and translation followed our design.

SSI's initial sample frame was a panel that was demographically representative of the U.S. population and to the extent possible of the Mexican population. Members of these panels have the necessary hardware and internet connections to complete online surveys for SSI. The questionnaire administered in Mexico was translated into Spanish and the monetary amounts shown in pesos. We collected 1000 responses in each country. Half of the respondents from each sample were from states where MFTB are found, and half from the remaining states. As is often the case (Mitchell and Carson 1989, p 226), approximately 2% of the WTP responses were determined to be outliers, defined as WTP greater than 3 standard deviations from the sample mean (Howell et al. 1998). After removing these responses, the final sample was 986 in the United States and 980 in Mexico.

Statistical Analysis Methods for Hypothesis Testing

To test Hypotheses 1 through 4—whether WTP of households in both countries is statistically different from zero—we calculated the confidence interval around the mean WTP:

$$\text{Mean WTP} \pm 1.960\,\text{SE}, \tag{15}$$

where 1.960 is the *t*-statistic for a 5% significance level and SE is the standard error of the mean, calculated as standard deviation/$\sqrt{n}$ where n is the sample size. We do this calculation for both U.S. and Mexican households' WTP for protecting MFTB habitat in both countries. To test Hypothesis 5—whether Mexican households' WTP for protecting MFTB habitat in Mexico is greater than Mexican households' WTP for protecting MFTB habitat in the United States—we conduct a paired *t*-test between each household's WTP. We repeat this test for Hypothesis 6—whether U.S. household's WTP for protecting habitat in the U.S. is greater than their WTP for protecting MFTB habitat in Mexico. A two-sample *t*-test was used to test Hypothesis 7—whether Mexican household WTP relative to their income (Mexican household WTP/Mexican household income) is equal to U.S. household WTP relative to their income. We use multiple regression analyses to examine the determinants of respondents' WTP in each country.

Results of Survey

Respondent Characteristics

Because the survey was administered by SSI, it was possible for them to monitor responses and adjust the final sample to be demographically representative for the United States and to the extent possible for Mexico. Therefore, the demographic characteristics of the final sample correspond more closely to the general populations of each country than if the survey had been randomly applied (Table 1). Nevertheless, there are some differences. Respondents in Mexico have substantially lower income (by about 20%) than the average in Mexico. Respondents are older than the averages in their respective countries. The percentage of male respondents in the United States closely matches the U.S. population, but there is a higher proportion of male respondents in the Mexican sample than in the population.

About half the respondents in both countries have viewed bats around their home (Table 2). Roughly one-third of Mexican and U.S. respondents who viewed bats at home believe they have seen MFTB (about 15% of the combined sample). About one quarter of the respondents in both countries have taken a trip away from home to view bats, and about half of them did so to view MFTB (about 14% of the overall sample).

There is a great deal of variability in respondents' familiarity with and attitudes toward MFTB in both countries (Table 3). Despite about half the sample being concerned that MFTB may spread rabies, they also feel that MFTB "provide benefits to people like me". Much of the perceived benefits of MFTB stem from non-use or passive-use value. Most respondents in both countries are neither

Table 1 Comparison of sample demographic characteristics with those of the general population

Mexico	Survey respondents	General population
Median household income	9000 (US$)	11,940 (US$)[b]
Median age[a]	39	28[c]
Percent male[a]	52.04%	44.8%[c]
United States		
Median household income	55,000 (US$)	56,516 (US$)[d]
Median age[a]	45	37[d]
Percent male[a]	49.9%	49.2%[d]

[a]Comparisons include only population over 18 years of age

[b]Riner (2015)

[c]Index Mundi, Mexico Demographics Profile 2016 (http://www.indexmundi.com/mexico/demographics_profile.html)

[d]U.S. Department of Commerce, Census Bureau, American Fact Finder (https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml)

Table 2 Response to questions regarding bat viewing

		Yes	No	Not sure
Have you ever viewed bats around your home or community?	U.S.	47.7%	52.3%	–
	Mexico	50.2%	49.8%	–
If yes, have you ever viewed Mexican free-tailed bats around your home or community?	U.S.	31.1%	31.3%	37.7%
	Mexico	37.3%	12.4%	50.4%
Have you ever traveled away from home (either on day trips or overnight) to view bats?	U.S.	26.1%	73.9%	–
	Mexico	29.7%	70.3%	–
If yes, have you ever traveled away from home (either on day trips or overnight) to view Mexican free-tailed bats?	U.S.	53.6%	26.1%	20.3%
	Mexico	45.5%	22.2%	32.3%

Table 3 Response to attitude and familiarity questions

		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am familiar with the Mexican free-tailed bats	U.S.	22.6%	23.5%	22.7%	23.6%	7.6%
	Mexico	14.8%	22.7%	36.4%	23.4%	2.7%
I would enjoy knowing that Mexican free-tailed bats are protected throughout their full range of habitat even if I never see them	U.S.	4.7%	3.5%	19.9%	42.6%	29.3%
	Mexico	2.7%	1.7%	6.0%	40.3%	49.3%
I would enjoy knowing that habitat for Mexican free-tailed bats is protected wherever the species occurs, including in other countries	U.S.	4.1%	3.5%	19.5%	43.8%	29.1%
	Mexico	2.5%	1.3%	4.6%	39.8%	51.8%
I believe that Mexican free-tailed bats provide benefits to people like me	U.S.	4.9%	6.0%	27.3%	38.1%	23.7%
	Mexico	2.3%	2.7%	27.7%	37.1%	30.2%
I am concerned that Mexican free-tailed bats may spread rabies	U.S.	8.5%	17.6%	28.8%	30.3%	14.8%
	Mexico	4.8%	11.4%	26.3%	36.0%	21.5%

members of an environmental group nor donate to such groups (Table 4).

It is possible that respondents who completed the entire survey were more concerned about or familiar with MFTB or may be more environmentally concerned in general than those respondents who started the survey but never finished. To check for the possibility of such sample-selection effects, we compared responses to the initial questions for those who completed the entire survey (in Tables 2–4) with those who started the survey but never finished. We found that there were no statistically significant differences in responses between these two groups (details of these *t*-tests available upon request from the senior author).

Table 4 Response to questions about environmental membership/donations

		Yes	No
Are you a member of any organizations that work to protect wildlife and wildlife habitat?	U.S.	16.3%	83.7%
	Mexico	6.6%	93.4%
In the past year, have you donated money to an organization that works to protect wildlife or wildlife habitat?	U.S.	36.0%	64.0%
	Mexico	32.3%	67.7%

WTP Results

We first compare WTP for habitat conservation in respondents' own country with WTP for habitat conservation in the other country. Then, we compare WTP for programs that would stabilize the MFTB population with programs that would increase the population (Table 5). As is clear from Table 5, we can reject null Hypotheses 1–4: the WTP in each country for their own habitat and the other country's habitat is significantly different from zero (i.e., the confidence interval around the mean WTP does not include zero). WTP in one's own country is statistically higher than WTP in the other country ($P = 0.000$) for both U.S. and Mexican households. However, the WTP to protect habitat in the other country is still substantial, in the range of 60–80% of what Mexican and U.S. respondents, respectively, would pay in their own country, and the confidence interval on the mean WTP does not include zero in any case. Thus, we reject the null Hypotheses 1–6 in favor of a non-zero WTP to protect habitat in one's own country and also to protect habitat in the other country in both the

Table 5 Mean willingness to pay (WTP) for MFTB habitat conservation ($USD, 2016)

	Habitat in the U.S.		Habitat in Mexico		*t*-test: WTP (own country) >WTP (other country)
WTP to stabilize populations (Prog. A)	Mean	Std. err.	Mean	Std. err.	*t*-statistic
U.S. households	30.48	1.47	23.99	1.27	7.165***
(95% confidence interval)	(27.60–33.35)		(21.50–26.47)		
Mexican households	5.05	0.27	8.25	0.32	13.718***
(95% confidence interval)	(4.37–5.40)		(7.38–8.60)		
WTP to increase populations (Prog. B)					
U.S. households	36.56	1.79	29.65	1.66	6.403***
(95% confidence interval)	(33.06–40.07)		(26.39–32.90)		
Mexican households	5.53	0.28	8.65	0.35	13.403***
(95% confidence interval)	(4.83–5.88)		(7.72–9.05)		
t-test: WTP (Prog. B) > WTP (Prog. A)	*t*-statistic	*t*-statistic			
U.S. households	2.680***	1.745*			
Mexican households	2.857***	1.741*			

***, **, and * indicates statistically significant differences at 0.01, 0.05, and 0.10 levels, respectively

higher-income and lower-income countries. This implies that residents of the lower-income country are willing to pay for habitat in the higher-income country. Further, as the last two rows of Table 5 indicate WTP to increase the MFTB population is statistically larger than WTP to stabilize the population at current levels. Thus, our CVM WTP estimates pass an internal scope test as laid out by Giraud et al. (1999).

Analysis of Zero WTP and Protest Responses

Respondents have valid economic reasons for indicating a zero WTP. In our survey, responses such as "I cannot afford to pay anything" for the program (the most common response for a zero WTP), followed by "protecting habitat for MFTB is not important to me" are valid zero WTP responses. But it is common in CVM studies that a fraction of respondents indicate a zero WTP not because they cannot afford to pay or because protecting MFTB habitat is unimportant, but because they reject some feature of the scenario presented in the survey. In our survey, responses such as "I do not believe protecting habitat will stabilize (Program A) or increase (Program B) MFTB populations" or "I do not trust that the money collected will be used for protecting habitat areas" or "It is unfair to expect me to pay for MFTB conservation" are protest responses. Table 6 provides a summary of the number and percentage of protest responses for Programs A and B for Mexican and U.S. households. Table 6 illustrates an interesting pattern: the relatively low rate of protest responses of U.S. households for protecting habitat in the U.S. is similar to the relatively low rate of protest responses of Mexican households for protecting habitat in Mexico. The protest rate for paying for habitat protection in the other country is higher among both U.S. and Mexican households, but in the case of Mexican households, this discrepancy is much larger.

Table 6 Percentage of respondents whose zero WTP is a protest response

	Program A		Program B	
	Habitat in U.S.	Habitat in Mexico	Habitat in U.S.	Habitat in Mexico
U.S. households	71	129	83	147
	7.20%	13.08%	8.42%	14.91%
Mexican households	179	77	214	99
	18.27%	7.86%	21.84%	10.10%

Per the suggestion of the NOAA Blue Ribbon Panel on CVM (Arrow et al. 1993) to be conservative in calculating estimates of WTP, we have retained all the zero WTP responses regardless of whether they are protests. However, we performed all our hypotheses tests with protest zeros removed (e.g., paired *t*-tests) and in no case did the results of the hypothesis tests change (these results are available from the senior author).

Relationship of WTP to Income across Countries

Our data provide us with an opportunity to evaluate a commonly used approach in international benefit transfer. Specifically, we can evaluate the practice of calculating the lower-income country's WTP by scaling down a higher-income country's WTP using the ratio of the two countries'

incomes. In our study, the mean sample household income in Mexico is USD $14,329 and the mean U.S. sample household income is USD $65,246, a ratio of 22% (this is close to the income ratio for the populations which was 21%). Mexican household WTP for Program A in Mexico is 27% of the U.S. household WTP for Program A in the United States. Further, Mexican household WTP for Program B in Mexico is 24% of U.S. household WTP for Program B in the United States. Thus, if an analyst were to apply a 21% income adjustment to U.S. household WTP for MFTB habitat to calculate Mexican households' WTP for MFTB habitat in Mexico, they would be slightly underestimating the benefits to Mexican households. To test this more formally, we performed two-sample *t*-tests of the ratio of WTP to household income, and found that for both programs in both countries, this ratio was statistically significantly higher for Mexican households. Thus, we reject null Hypothesis 7 and conclude that Mexican households' WTP reflects a statistically significant higher proportion of their income than that of United States households.

Multiple Regression Analysis of the Variation in WTP within a Country

We evaluate the relationship between attitudes, preferences, experience, and demographic variables and WTP. Overall, our results suggest that WTP is systematically related to these variables in a way that is consistent with economic principles. For example, we would expect WTP to increase with income if species conservation is what economists call a "normal good" with respect to income. We find this to be the case, with the exception of U.S. respondents' WTP for Program B in Mexico (Tables 7a and 7b). Respondents in both countries who indicated they agree with the statement that "Mexican free-tailed bats benefit people like me" had higher WTP. Membership in environmental groups and donations to environmental causes is positively and significantly related to WTP. While those who view bats receive both use and non-use value for bats and hence would be expected to have greater WTP, this variable is not statistically significant in most models (Tables 7a and 7b). U.S. respondents with higher education levels have higher WTP, but the relationship between education and WTP is not statistically significant for Mexican respondents. We tested whether there was a difference in WTP of households living in a region containing MFTB vs. not containing MFTB. That variable was not a statistically significant predictor of WTP and, in a few cases, was negatively related to WTP.

Discussion

This research is part of by a broader body of work examining the interconnections across great distances between

Table 7a Willingness to pay for Program A—stabilize MFTB population at current level

Variable	Program A in the U.S.				Program A in Mexico			
	U.S. respondents		Mexican respondents		U.S. respondents		Mexican respondents	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Education level[a]	3.260673***	3.79	−0.07576	−0.44	2.036822***	2.66	0.191967	0.97
Age	−0.48689***	−7.32	−0.06995***	−3.58	−0.42625***	−7.2	−0.07487***	−3.34
Gender[b]	−8.01223***	−3.45	0.32118	0.55	−7.53091***	−3.64	0.934457	1.4
Annual income	0.000135***	5.06	9.56E-05***	4.22	5.81E-05**	2.44	0.000153***	5.85
Participates in viewing bats	5.55124**	2.22	0.95018	1.58	3.463036	1.56	0.49664	0.72
Benefit personally from MFTB[c]	2.80711**	2.51	0.703185**	2.28	2.5416**	2.55	1.718106***	4.85
Member of environmental group	16.9528***	4.65	1.25806	1.09	15.8050***	4.87	2.21312*	1.66
Donates to environmental causes	24.2794***	8.45	2.3829***	3.77	20.9585***	8.2	3.47604***	4.78
Constant	17.6718**	2.49	2.81891	1.16	21.10576***	3.34	−2.2704	−0.81
Number of obs.	948		867		948		867	
F-statistic	68.7		9.68		55.01		18.33	
Probability > *F*	0.0000		0.0000		0.0000		0.0000	
R^2	0.3692		0.0828		0.3191		0.146	
Adjusted R^2	0.3638		0.0742		0.3133		0.138	

[a]Education level ranged from 1 = completed some high school to 7 = Doctorate, law or professional degree for U.S. respondents and from 1 = no schooling to 13 = Doctorate for Mexican respondents

[b]Male = 1, Female = 2

[c]Responses ranged from 1 = strongly disagree to 5 = strongly agree

*** Coefficient is significant at $\alpha = 0.01$, ** coefficient is significant at $\alpha = 0.05$, * coefficient is significant at $\alpha = 0.10$

Table 7b Willingness to pay for Program B—increase MFTB populations (coefficients and *t*-statistics)

Variable	Program B in the U.S.				Program B in Mexico			
	U.S. respondents		Mexican respondents		U.S. respondents		Mexican respondents	
	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Education level[a]	2.944487***	2.78	−0.14901	−0.84	2.127893**	2.17	0.131174	0.6
Age	−0.635303***	−7.76	−0.10538***	−5.24	−0.54574***	−7.2	−0.12208***	−4.93
Gender[b]	−9.16798***	−3.2	−0.70784	−1.18	−11.0263***	−4.16	0.185054	0.25
Annual income	0.000139***	4.22	9.13E-05***	3.91	4.23E-05	1.39	0.000156***	5.44
Participates in viewing bats	10.14742***	3.3	0.746619	1.2	7.589763***	2.67	1.421115*	1.86
Benefit personally from MFTB[c]	4.52315***	3.28	1.25938***	3.97	3.14931**	2.47	2.12354***	5.43
Member of environmental group	13.28332***	2.96	1.53844	1.29	17.91353***	4.31	1.914343	1.3
Donates to environmental causes	26.87423***	7.61	2.29886***	3.53	24.5426***	7.51	2.88454***	3.6
Constant	23.68667***	2.71	5.140682**	2.05	31.40863***	3.88	−0.18641	−0.06
Number of obs.	948		867		948		867	
F-statistic	56.92		11.95		49.72		17.8	
Probability > *F*	0.0000		0.0000		0.0000		0.0000	
R^2	0.3266		0.1002		0.2975		0.1424	
Adjusted R^2	0.3209		0.0918		0.2916		0.1344	

[a]Education level ranged from 1 = completed some high school to 7 = Doctorate, law or professional degree for U.S. respondents and from 1 = no schooling to 13 = Doctorate for Mexican respondents

[b]Male = 1, Female = 2

[c]Responses ranged from 1 = strongly disagree to 5 = strongly agree

*** Coefficient is significant at $\alpha = 0.01$, ** coefficient is significant at $\alpha = 0.05$, * Coefficient is significant at $\alpha = 0.10$

human and natural systems (Lopez-Hoffman et al. 2009, 2010, 2017). From the human perspective, these coupled natural-human systems both impact human well-being and are impacted by human actions. In the case of species that provide benefits to humans and migrate across international borders, the benefits derived from and costs to preserve such species may not fall equally on the human populations on different sides of these borders. The research findings reported here begin to address the value of one species, the MFTB, in two of the countries that provide habitat necessary for MFTB survival and therefore continued ability to produce benefits for humans.

Our findings indicate that residents of both the United States (a higher-income country) and Mexico (lower income) are willing to pay to protect MFTB habitat in their own country and are willing to pay to protect habitat in the other country where the migratory species spends part of its lifecycle. This indicates that households in both countries recognize the importance of protecting habitat throughout the entire range of the MFTB. This suggests that it is important for analyses of migratory species management to recognize the benefits realized more broadly than just in one's own country and to acknowledge the importance for international collaboration in protecting habitat across borders.

In addition, our results indicate that WTP is higher for management actions that increase the size of the population (Program B) vs. actions that just stabilize the MFTB population size (Program A). This is sometimes referred to as passing an internal scope test, and indicates that the results are consistent with economic principles (Giraud et al. 1999).

It is often useful to compare new research results with similar findings. However, in this case there are few studies with which we can compare our WTP estimates, as most studies estimate values for higher-profile species such as bald eagles, salmon, or wolves (Richardson and Loomis 2009).

We found that respondents living in states/regions where MFTB occur do not appear to have WTP that is any higher than people who live in regions where MFTB does not occur. We also found that in some cases people living in a region where the species occurs have a lower value for additional conservation. The first result suggests that the benefits of MFTB are largely non-use or passive-use values —consistent with our finding in Table 3. The second result may suggest that those living in states where MFTB occur may see these animals frequently enough that they are not willing to pay for additional conservation efforts. New surveys may be needed to explore this issue further.

Another interesting result is the level of environmental concern expressed in the attitude questions and in the WTP itself, especially in Mexico. Prior research has examined the differences in environmental concern between the U.S. and

Mexico. Schultz and Zelezny (1999), Bechtel et al. (1999), and Corral-Verdugo Armendáriz (2000) all apply the Human Exception Paradigm and the New Environmental Paradigm, or both, to examine differences in environmental beliefs between the two countries. Schultz and Zelenzy (1999) conclude that U.S. respondents showed lower levels of environmental concern than most of the 14 countries they studied, one of which was Mexico (the countries scoring lower than the United States were the Dominican Republic, Ecuador, and Peru). Bechtel et al. (1999) conclude that while the U.S. and Mexico differ in the degree of this dichotomy, they share a similar view of nature as separate from human culture. However, Corral-Verdugo and Armendáriz (2000) conclude that Mexicans are less likely to see humans as separate from nature than those in more industrialized countries. Our results showing that Mexican household WTP as a percentage of income is slightly higher than the U.S. ratio, along with the responses to the attitude and familiarity questions are consistent with these previous findings.

Conclusions

The MFTB requires habitat in both the United States and Mexico during its lifecycle. Our contingent valuation WTP survey administered to households in the United States and Mexico indicated that households in each of the countries were willing to pay to protect the habitat not only in their own country but also in the other country upon which the species relies. In both countries, WTP is significantly higher for increasing the MFTB population size compared to stabilizing the population size at its current level. We also found that the ratio of Mexican respondents' WTP to U.S. respondents' WTP was roughly equal to the ratio of household incomes between the two countries. This suggests that scaling household WTP by relative income when making international benefit transfers may be plausible.

This study has important implications for conducting economic analyses of habitat protection for transborder migratory species. Such protection provides benefits throughout a species' range and these benefits need to be taken into accounted when performing benefit-cost analyses and wildlife management analyses of habitat conservation. International agreements and their associated funding mechanisms should incorporate the relative benefits received throughout the entire range of a migratory species into wildlife management decision making.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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