LETTER

National valuation of monarch butterflies indicates an untapped potential for incentive-based conservation

Jay E. Diffendorfer[1], John B. Loomis[2], Leslie Ries[3,4], Karen Oberhauser[5], Laura Lopez-Hoffman[6], Darius Semmens[1], Brice Semmens[7], Bruce Butterfield[8], Ken Bagstad[1], Josh Goldstein[2], Ruscena Wiederholt[6], Brady Mattsson[9], & Wayne E. Thogmartin[10]

[1] United States Geological Survey, Geosciences and Environmental Change Science Center, Denver, CO 80225, USA
[2] Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO, USA
[3] Department of Biology, University of Maryland, College Park, MD 20742, USA
[4] The National Socio-environmental Synthesis Center, 1 Park Place, Annapolis, MD, 21401, USA
[5] Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St Paul, MN, USA
[6] School of Natural Resources and the Environment and Udall Center for Studies in Public Policy, The University of Arizona, Tucson, AZ 85721, USA
[7] Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla CA 92093, USA
[8] National Gardening Association, Po Box 4515, Burlington, VT 05406, USA
[9] Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna, Austria
[10] United States Geological Survey, Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI 54603, USA

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Correspondence
Jay Diffendorfer, United States Geological Survey, Geosciences and Environmental Change Science Center, Denver, CO, 80225, USA. Tel: +011–303–236–5369.
E-mail:jediffendorfer@usgs.gov

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Abstract

The annual migration of monarch butterflies (*Danaus plexippus*) has high cultural value and recent surveys indicate monarch populations are declining. Protecting migratory species is complex because they cross international borders and depend on multiple regions. Understanding how much, and where, humans place value on migratory species can facilitate market-based conservation approaches. We performed a contingent valuation study of monarchs to understand the potential for such approaches to fund monarch conservation. The survey asked U.S. respondents about the money they would spend, or have spent, growing monarch-friendly plants, and the amount they would donate to monarch conservation organizations. Combining planting payments and donations, the survey indicated U.S. households valued monarchs as a total one-time payment of $4.78–$6.64 billion, levels similar to many endangered vertebrate species. The financial contribution of even a small percentage of households through purchases or donations could generate new funding for monarch conservation through market-based approaches.

Introduction

The multigenerational migration of North American monarch butterflies (*Danaus plexippus*) between breeding grounds in the northern U.S. and southern Canada and wintering grounds in central Mexico and coastal California is one of the world's most spectacular natural events (Figure 1). People's interest in monarchs and their fascinating, visible biology is obvious. They are the official insect or butterfly of seven U.S. states; celebrated via festivals in Mexico, the United States, and Canada; the focus of science curricula; and the subject of multiple citizen-science projects that track juveniles, adults, and disease dynamics.

Since 1999, the size of the overwintering colonies in Mexico and California have declined (Brower *et al.* 2012; Xerces 2013), and the 2012 survey in Mexico showed

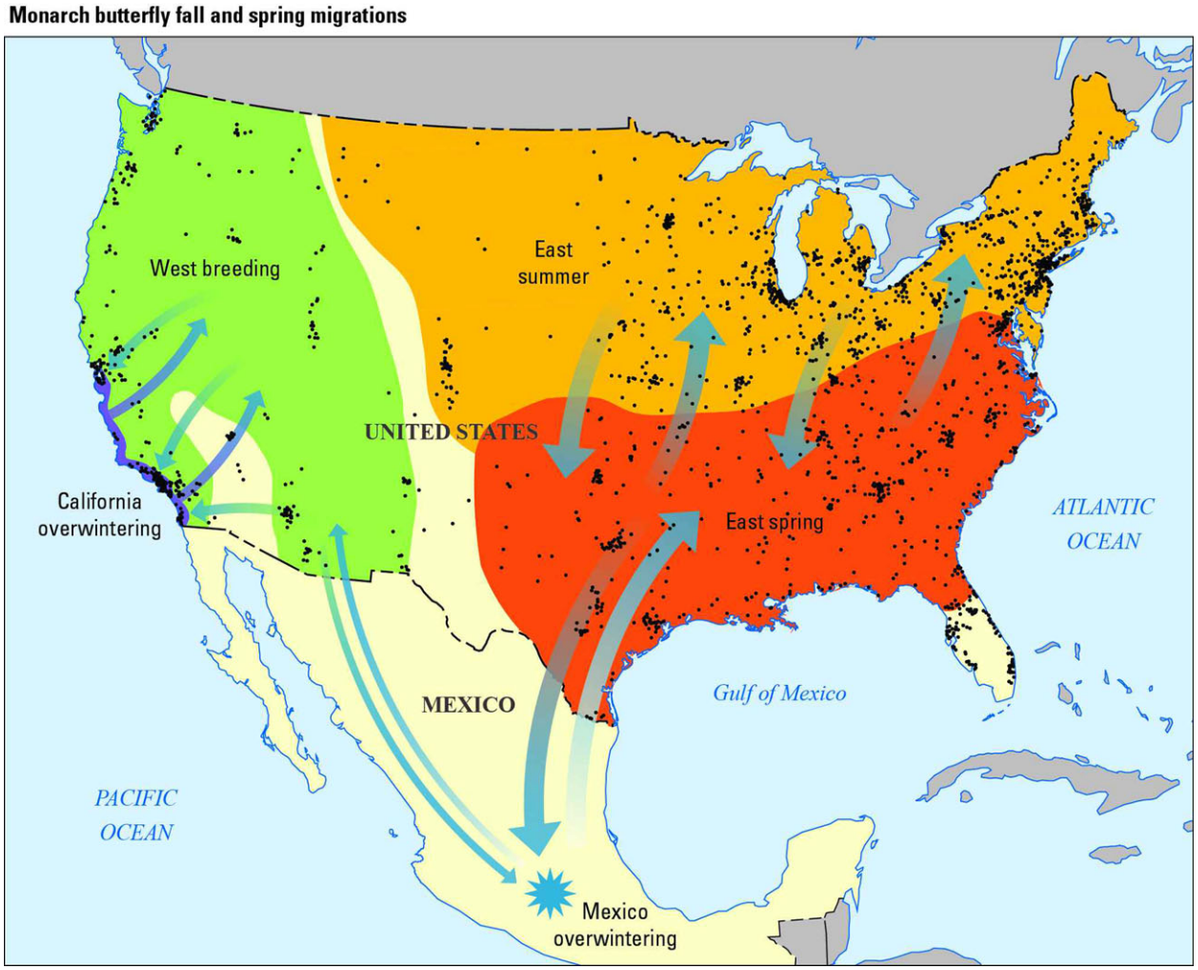

Figure 1 Fall (southward) and spring (northward) migrations of the monarch butterfly (blue arrows), the four monarch regions used in the study, and location of respondents to the national survey (black dots).

the lowest colony size yet recorded, which prompted wide-scale media reports (Wines 2013). Habitat loss in the overwintering sites in Mexico and California is well-documented (Brower *et al.* 2002; Ramirez *et al.* 2006), although no direct empirical link between declining overwintering habitat and monarch numbers exists. In addition, the growing use of glyphosate-tolerant genetically modified crops has reduced larval host plant (milkweed, *Asclepias* spp) abundances in farm fields across United States and Canada. Increasing acreage of glyphosate-tolerant corn and soybeans are negatively correlated to monarch numbers, with the area of milkweed in farm fields in the United States declining from an estimated 213,000 to 40,300 ha (Pleasants & Oberhauser 2012).

Monarchs represent one of many migratory species whose complex annual cycle requires conservation actions across diverse stakeholders and countries (Behrens *et al.* 2008; Skagen & Knopf 1993). Developing conservation strategies for migratory species requires a blend of approaches, such as spatial models of habitat use, tracking individuals to identify stopover locations, and prioritizing funding for conservation actions across multiple locations or countries (McCarthy *et al.* 2010; Miller 2011). One growing conservation strategy develops economic incentive-based, market-oriented mechanisms for conservation practices (Kinzig *et al.* 2011). Examples of such approaches include ecotourism, public or private payments for ecosystem services or the conservation practices that produce them, and tax incentives (Salzman

2005). For monarchs, funds generated in one region, for example the United States, could be spent locally, or transferred to support conservation in other parts of their range, such as overwintering locations. Currently, ecotourism in the Monarch Butterfly Biosphere Reserve in Mexico and a fund compensating landowners who have lost their rights to log overwintering forests are key methods for conserving overwinter habitat (Missrie 2004; Honey-Rosés *et al.* 2009).

Monarch ecology creates unique opportunities for market-based conservation approaches because many households can plant nectar plants and milkweed to offset ongoing losses in the breeding habitat. For example, the Monarch Waystation program asks participants to plant monarch friendly gardens on their property and has more than 6,000 registered habitats (MonarchWatch 2013). Monarch-focused plantings may produce significant income for the horticultural industry, creating a potential for market-based monarch conservation. Thus, understanding the geographic patterns of community support is keenly important for successful conservation of migratory species. For example, if residents will only support local conservation efforts, but the critical conservation need is elsewhere, incentive-based programs will not function efficiently. The main goal of this article is to use the economic tool of contingent valuation to assess the value that people across the United States place on monarchs, and on conserving and restoring their habitat.

Economists use contingent valuation methods to assess the value society places on ecosystem goods and services that cannot be bought and sold. In contingent valuation, surveys elicit how much value people have for conserving a species or protecting its habitat. These methods estimate the "nonuse" value of a species, such as existence and bequest values, in addition to traditional "use values" such as viewing, hunting, or fishing. Like any survey-based research method, there are limitations to contingent valuation, and development of the general approach continues to be refined and debated. It has been suggested that some contingent valuation studies violate one or more economic principles put forward to test the method (Hausman 2012). However, reviews and meta-analyses suggest assessments of the public's willingness to pay for species or habitat conservation generally follow expectations from economic theory (Carson 2012; Kling *et al.* 2012), show predictable results, and enable hypothesis testing (Lindhjem and Tuan 2012; Morse-Jones *et al.* 2012). Despite the scholarly discussion over contingent valuation, it is a legally accepted method for valuing species and other environmental goods and services (Portney 1994). To date, species valuation based on this approach has informed resource management decision making (Chichilnisky 1998), allowed comparisons of potential monetary investments across endangered species (Loomis & White 1996; Lindhjem & Tuan 2012), and aided in assessing the costs of species conservation relative to their societal value (Rubin *et al.* 1991). Estimating the value of migratory species in different parts of their range allows decision makers to structure economic incentives across the various geographic regions and jurisdictions involved in management.

We examined the potential to develop economic incentives for monarch conservation by assessing the amounts and regional patterns of money Americans might be willing to pay to plant monarch friendly gardens and donate to groups that conserve and restore monarch habitat. We also investigated whether there are regional differences in willingness to pay. Previous studies reported a distance-decay function exists for willingness to pay, with higher payments when the focus of the survey is closer to where respondents live (Pate & Loomis 1997; Morse-Jones *et al.* 2012). Thus, we expected respondents to show a preference for conserving monarchs closer to where they lived, and that there would be broad geographic patterns in donations across regions important to monarch biology. We report a surprisingly high economic value for monarchs based on contingent valuation as well as geographic patterns in willingness to pay.

Methods

We analyzed willingness to pay data from a national survey commissioned by the National Gardening Association (NGA) via Harris Interactive, an international polling company. In 2012, NGA included six questions regarding knowledge, attitudes, and willingness to pay for monarch conservation to its annual survey of U.S. households. Though commissioned by a gardening association, the survey was sent to a random selection of *all* US households; participation in gardening was not a factor in selecting respondents. The online survey was designed to provide a stratified random sample that was demographically and economically representative of all U.S. households (see Supporting Information). The survey asked questions about willingness to pay for planting nectar or milkweed plants and donating to conserve monarch habitat in five regions across their range (Figure 1). The survey did not include respondents in Mexico or Canada, so it does not estimate the value residents of these countries place on monarchs. Of the 2,290 respondents, 2,132 lived within regions where monarchs were common, not surprising given the widespread distribution of monarchs in the United States (Figure 1). Monarch's general ubiquity coupled with extensive media attention suggests respondents were likely familiar with the species they were being asked to value. One respondent was

removed from the survey because the value they entered was so large we suspected a typographical error (they reported having invested $2,344 planting milkweed vs. a survey mean of $44). The final sample size was 2,289 individuals.

We estimated mean values of the amount respondents had spent or would spend planting nectar plants and milkweeds directly from the values respondents entered in the survey. The calculated means included payments of zero. To estimate the potential interest in planting nectar plants and milkweed, we first took the average willingness to pay for future plantings of nectar and milkweed and multiplied by 118 million households (United States Census Bureau 2012). We then corrected this estimate by multiplying it by the proportion of respondents that would plant and had space. We note that the survey may overestimate willingness to pay for planting nectar plants specifically to help monarchs because these plants attract other species and are themselves attractive.

After describing two organizations supporting overwintering habitat conservation in Mexico (the Monarch Butterfly Fund) and breeding, migratory, and overwintering habitat conservation in the United States (the Monarch Joint Venture), the survey asked "What is the one time amount you would donate to the Monarch Butterfly Fund and/or the Monarch Joint Venture described earlier, to support each of the following efforts to stop the loss of monarchs?" Respondents were presented with conservation actions in the five regions illustrated in Figure 1, and nine discrete categories of monetary donations ($0, $10, $20, $30, $40, $50, $75, $100, and $150), for each of the five regions (see Supporting Information).

Respondents indicating zero willingness to pay required additional investigation to uncover if these were "valid zeros", or what economists call "protest zeros." For valid zeros, respondents gave reasons for not donating to monarch conservation that clearly indicated the respondent did not value monarch butterflies enough to donate (e.g., they selected "protecting areas for this species is not worth the money to me"; "I do not believe protecting the monarch butterfly is important"; and "I live outside the range of monarch butterflies"); these $0 responses were included in our analyses and are considered nonprotest responses as their zero willingness to pay response was consistent with their statements that they get no benefits from monarchs.

However, some of the respondents selecting $0 for a donation value also indicated that they received some benefits from the species because they answered either "very important," "important," or "somewhat important" to the question "How important to you is helping to save monarchs?" These respondents were opposed to the particular way in which conservation was to be financed ("I do not trust that the money spent will result in protecting areas"), or the idea that they are responsible for paying for conservation ("It is unfair to expect me to pay for monarch conservation"). Such responses (24.2% of all respondents), called "protest bids" by economists, indicated the respondent may not have approved of the hypothetical payment approach of donating to the conservation organizations, despite valuing monarchs enough to want to save them. It is standard practice in contingent valuation to drop respondents who do not accept the premise of the valuation question as their responses are not indicative of their values (Halstead & Luloff 1992). However, to ensure the broadest interpretation of our results, when estimating mean values of donations at regional or national scales, we calculated and report the analyses both with and without protest votes.

We used these data to explore geographic patterns in donations. Our goal was to understand first if regions showed different patterns of donations, and second if respondents were more likely to donate, and more likely to donate higher amounts, to areas close to their region or to their region itself. To examine these patterns we fit ordered categorical models to the data and compared models using Akaike's Information Criterion adjusted for finite sample sizes (AICc) (Burnham & Anderson 2002). We present differences in AICc between models, and interpret differences >2 as strong support for the model with the lowest score. We also present model likelihoods and model weights, which provide information on the support of a model relative to other candidate models.

The donations data were categorical with unequal intervals between the categories and highly skewed, with large donations rare, and donations of zero common (Figure 1). We initially attempted to use all nine categories of donations in the models, but these failed to converge given small sample sizes or no data at the larger donation values. The data generally grouped around donations of zero, donations between 1 and 50, and donations >50 (Figure S1), so we pooled responses into these three categories to allow model convergence. We estimated both national and regional mean donations from the categorical donations data conservatively, by using the dollar value of the box selected by a respondent as the lower bound for their donation to a region, rather than assuming the dollar value lies in the midpoint of the interval between the dollar value checked and the next highest dollar amount (Cameron & Huppert 1989). The model selection approach contrasted a model in which the proportion of respondents donating to the three categories varied across all five regions (a full model), a model where proportions of donations varied across larger areas (the western United States, eastern United States, and Mexico), and a null model with no spatial variation in

donations. We performed this model selection approach for respondents residing in each of the four monarch regions in the United States.

To understand spatial patterns in donations, we estimated the total willingness to pay between all possible combinations of individual regions and mapped this. We first estimated the average donation per respondent between all combinations of regions (excluding protest votes) directly from the survey data. The survey included the respondents Zip Code, so we categorized the region of residence for each respondent, and used this to estimate average donations from one region to another. We then multiplied this average by the number of households in a region, calculated as the sum of household numbers by Zip Code from the 2010 U.S. Census.

Results

More than half (55%) of the respondents were "not aware" monarch butterfly populations are believed to be declining, whereas 39% were "somewhat aware," "aware," or "very aware." Nevertheless, 70% indicated conserving monarchs was "important" or "very important" to them whereas 3% indicated it was "not important." Small percentages of American households currently grow nectar plants (13%) or milkweed (4%), but as much as a quarter of American households would like to grow nectar plants (29%) and milkweed (24%). An additional 19% did not have space and 18% were not interested in growing plants beneficial to monarchs.

We estimated both the current expenditures of U.S. households and their willingness to spend in the future by asking "What is the one time amount you would spend, or have spent, to grow flowering nectar plants or milkweed that benefit monarchs at your home?" (see Supporting Information). These values are one-time payments and represent the total value a person would pay at the time of the survey. Responding U.S. households have already spent an average of \$7.36 ± 0.79 (mean ± standard error) for nectar plants and \$2.22 ± 0.26 for milkweed. When multiplied by 118 million U.S. households (United States Census Bureau 2012), the national amounts already spent were \$868 (\$685–\$1050, 95% confidence interval) and \$262 (\$201–\$322) million, for nectar plants and milkweed, respectively.

Respondents' interest in growing monarch-friendly plants appears to be as large as the existing expenditures. We estimated a one-time willingness to pay of \$933 (\$861–\$1,004) million for nectar plants and \$473 (\$432–\$513) million for milkweed across U.S. households after excluding respondents who indicated they had no space to plant or no interest in doing so. A different method, based on respondents' interest in growing plants in the future, produced similar results. Based on answers to the survey, 16% more households may grow nectar plants in the future than currently do (29% who answered they would grow-13% who answered they currently grow). If these households spent the same amount as those who currently grow these plants (\$40.39 ± 4.79), this would result in \$762 million of one-time nectar plant purchases. For milkweed, households spent \$20.37 ± 4.7 and 20% more households may grow milkweed, resulting in \$480 million for new purchases.

The data on willingness to donate for protecting monarch habitat showed two main trends First, people were willing to donate to both the region where they lived and other regions that monarchs use. For those respondents willing to make donations, 50% would donate to all five regions, 8% to four regions, 10% to three regions, and 15% to two regions. Just 17% would donate to only one region. Second, as we expected based on previous studies (Pate & Loomis 1997; Morse-Jones *et al*. 2012), where people lived affected their willingness to pay. In general, respondents were more likely to donate, and had higher proportions of large donations, to the region or area of the United States where they lived (Table 1; Figure 2). Model selection indicated respondents from three of four regions (CA overwintering,

Table 1 Modeling results for willingness to donate data by region[a]

Model	AICc	ΔAICc	Log-likelihood	Model weight
Respondents from California overwintering				
Full	658.23	0.76	−322.73	0.41
East versus west	657.47	0.00	−323.74	0.59
Null	709.46	51.99	−351.73	0.00
Respondents from western breeding				
Full	1083.56	25.29	−534.78	0.00
East versus west	1058.27	0.00	−524.13	1.00
Null	1188.84	130.57	−591.42	0.00
Respondents from eastern spring				
Full	2231.84	0.00	−1108.92	1.00
East versus west	2246.13	14.29	−1117.06	0.00
Null	2363.21	131.37	−1178.61	0.00
Respondents from eastern summer				
Full	4282.97	0.00	−2134.48	1.00
East versus west	4378.75	95.78	−2184.37	0.00
Null	4659.77	376.80	−2285.01	0.00

[a]Results from ordered-categorical model selection to determine if willingness to donate across three donation categories (\$0, \$10–50, and >\$50), was a function of the region where respondents lived. "Full" = a model in which the proportion of donations to each category varied across five regions, df = 7; "Area" = a model with donations varying between the Eastern and Western U.S., df = 5, "Null" = a model with no spatial variation in donations, df = 3. Delta AICc is the difference between the model in that row, and the model with the lowest AICc value.

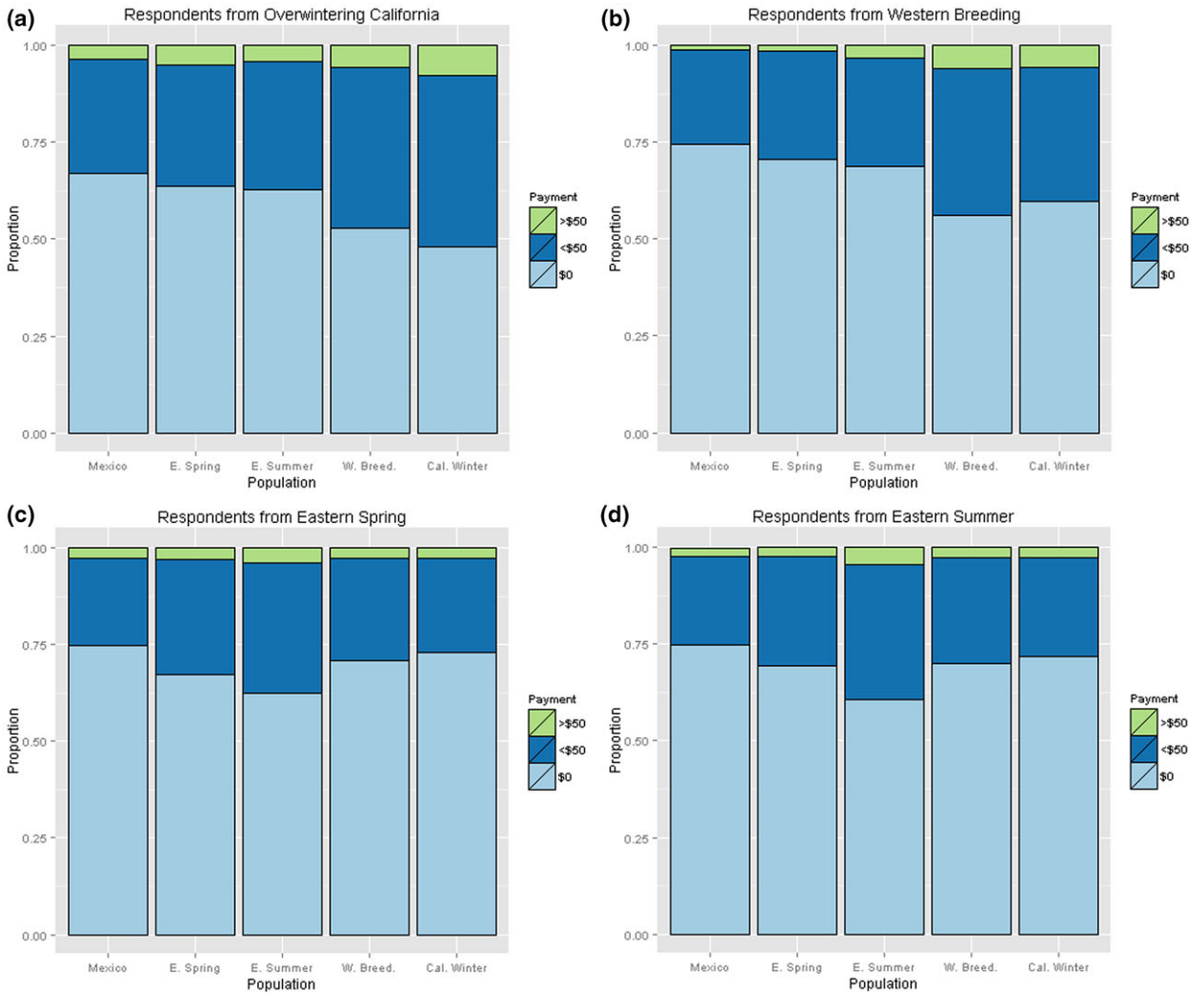

Figure 2 The proportion of respondents living in a particular region not donating, donating $1–$49, and ≥$50 to either the same, or a different, region.

Western breeding and Eastern spring) were more likely to support habitat conservation in the large areas of the United States where they lived (Table 1; Figure 2a–c) and respondents in the Eastern Summer region showed a preference to support habitat conservation primarily within the east summer region itself (Figure 2d). Eastern Spring respondents had the highest proportions of both donations and large donations to the Eastern summer region, followed by their own region. In all cases, the proportion of respondents donating, and the proportion of large donations to Mexico were lower than to the U.S. regions (Figures 2 and 3).

The geographic patterns associated with respondents' donations resulted in differences in the mean donations to a region. Though respondents were willing to donate to all regions, they were willing to donate more to the east summer region and less to Mexico (Table 2), though these differences (∼$1–$3.00) were small relative to the mean regional donations (∼$5.00–$9.00). Respondents in both the east summer and east spring region, 82% of respondents living in any monarch region, were more likely to donate, and more likely to donate larger amounts to the east summer region (Figure 2c and d), which drove the observed higher mean donations to this region. Likewise, patterns of relatively lower proportions of respondents donating, and lower proportions of large donations, explain the lower mean value of donations to Mexico.

Summing across regions, the mean household one-time donations varied from $31–$41 depending on the inclusion or exclusion, respectively, of protest votes. Multiplying the lower confidence interval for our low

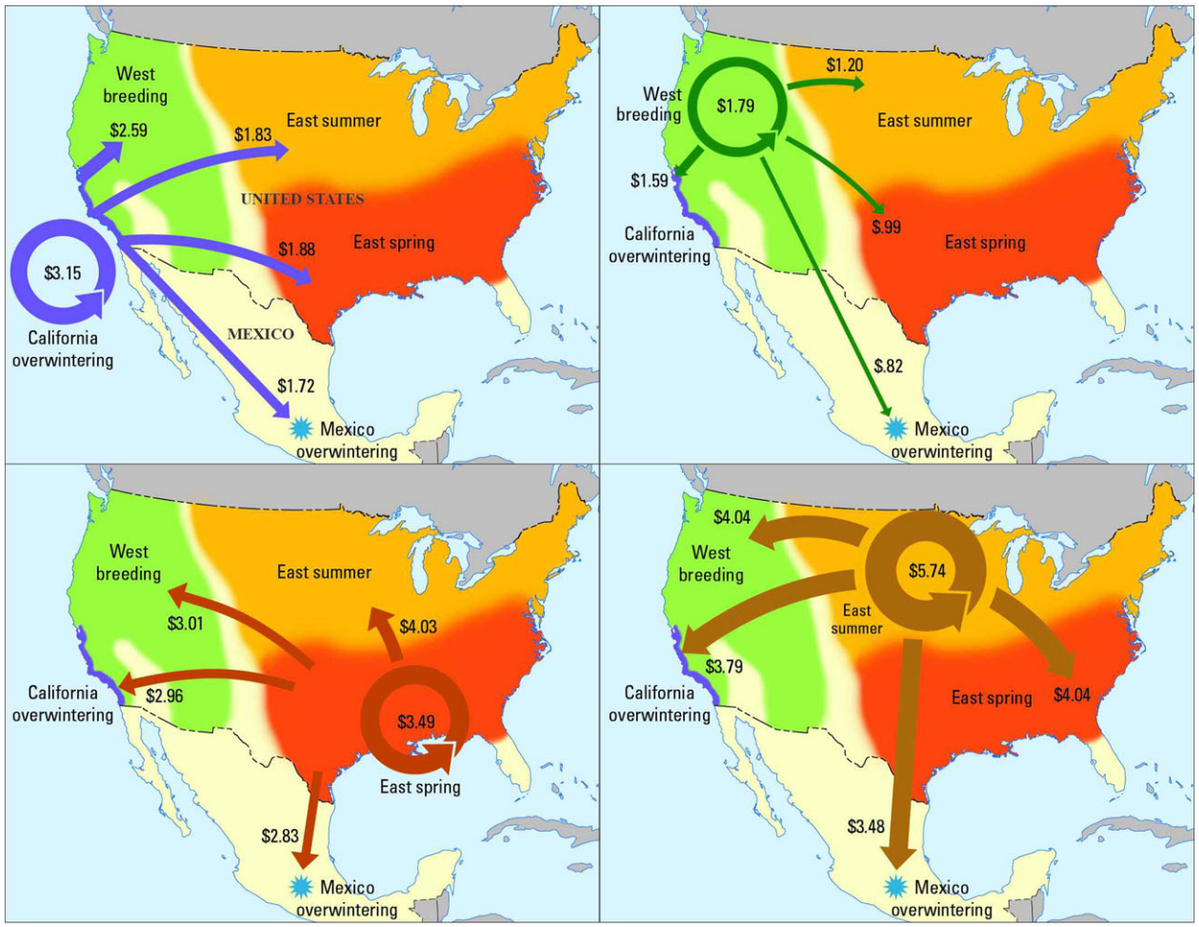

Figure 3 The estimated one-time transfer of donations between or within regions. Arrows, and their width, represent the amount of the donation from residents in a region to conservation groups working in a different region. Circular arrows represent the amount of the donation from residents to the region where they live. Wider arrows represent larger one-time donations. Arrows are labeled with the donation in 100 millions of U.S. dollars.

estimate (protest votes included, $28.52) and the upper confidence interval from our high estimate (protests excluded, $44.23) by 118 million households, we estimate a nationwide one-time willingness to donate between $3.37 and $5.22 billion to maintain monarch butterfly habitat. Adding one-time purchases for plants and donations, U.S. households would be willing to spend from $4.78 to $6.64 billion to support monarch butterfly conservation.

Discussion

Our results suggest the majority of U.S. households believe monarchs and their conservation are important. The results further suggest U.S. households might support a more sizeable market focused on monarch friendly plants. Some studies indicate the charisma of a species affects its perceived value (Metrick & Weitzman 1996; Richardson & Loomis 2009) whereas others suggest the degree of endangerment matters more (Tisdell *et al.* 2007). In general, insects have lower perceived values than other animals (Coursey 1994). For monarchs, the range of willingness to pay per respondent for monarchs ($53.89–$74.03) was within the range of those reported for endangered vertebrate species in Asia, Oceania, and the United States, but lower than values for other well-known and culturally iconic species such as elephants, bald eagles, pandas, and gray whales (Loomis & White 1996; Richardson & Loomis 2009; Lindhjem & Tuan 2012).

Monarch popularity, as shown by the survey results, could become an advertising focus for butterfly-supporting products that tap into the large, existing, gardening market in the United States. In the 2012 NGA

Table 2 Regional willingness to donate per household[a]

	Mexico	East spring	East summer	Total east	West breeding	California overwinter	Total west	Total United States
Protest votes included (n = 2,289)	$5.07 ± 0.28 (0.26)	$6.08 ± 0.28 (0.32)	$7.41 ± 0.32 (0.38)	$18.56 ± 0.82	$6.39 ± 0.30 (0.33)	$6.21 ± 0.29 (0.31)	$12.6 ± 0.57	$31.16 ± 1.35
Without Protest votes (n = 1,733)	$6.65 ± 0.36 (0.33)	$7.97 ± 0.36 (0.42)	$9.72 ± 0.40 (0.49)	$24.34 ± 1.04	$8.38 ± 0.38 (0.42)	$8.14 ± 0.38 (0.40)	$16.53 ± 0.73	$40.87 ± 1.71

[a]Means ± standard errors in U.S. dollars represent the amount respondents were willing to donate for conserving monarch habitat in each region. The proportion of respondents with donations >$0 are in parentheses. Estimates are shown with and without protest respondents.

survey, households identified as "do-it-yourself lawn and gardeners" generated $29.1 billion of retail sales on all aspects of their lawns and gardens (NGA 2012). Our survey suggests consumers might pay more for monarch friendly milkweeds and nectar plants grown without systemic insecticides in the potting soil. The use of systematic insecticides, such as neonicotinoids, is standard practice for many nursery-grown plants. These insecticides target a wide diversity of insects, including Lepidoptera (moths and butterflies), are present in the tissue and nectar of plants, and can kill feeding caterpillars and adults (Goulson 2013). In addition, given respondents willingness to support monarch habitat conservation or restoration, consumers might be more interested in buying nectar-producing plants or milkweeds if they indicate a small percentage of sales will be donated to habitat conservation. These funds could support restoration programs in the United States, Mexico, and Canada, including areas where monarch habitat has, or will be, impacted by climate or land use change.

Our survey of public interest in monarch butterflies may reflect a more general interest in pollinators which are in decline globally (Burkle *et al.* 2013). As an example of public interest, a recent Time magazine cover was dedicated to the decline of honeybees (Walsh 2013). Similar to monarchs, market-based conservation practices could be highly effective for pollinators. For example, a percentage of revenue from honey sales going to habitat conservation could act synergistically with monarch habitat conservation. Indeed, many policies discussed by Garibaldi *et al.* (2013) as methods to maintain effective pollination for crops would also enhance nectar plant availability for monarchs. Monarch reliance on milkweed for reproduction, however, will require a species-specific approach, although milkweed will benefit a wide range of pollinators.

Public interest in monarchs and pollinators could be considered a potential source for innovative conservation practices. Funding could be used to conserve and restore existing habitats, plant monarch-supporting plants, and on education programs for the public and growers that discuss trade-offs between herbicide-tolerant crops and monarch populations. Care should be taken to avoid perverse outcomes such as planting invasive plants or those requiring unsustainable levels of water, or buying captive bred monarchs that may not survive.

The spatial patterns of payments suggest U.S. households will support habitat conservation in all parts of the monarch range, but have a preference for programs that generally benefit the region or area of the country where they live. These regional preferences are not large relative to the general willingness to support conservation in all parts of the monarchs range. These results suggest support for both the development of market-based approaches to generate funding for activities designed to increase local monarch habitat, as well as national and international conservation activities. Contingent valuation studies, such as this one, are a critical step toward not only understanding how the general public values migratory species but also to provide insights in how to align conservation and economic values for migratory species protection across their range.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Figure S1(a–d). Frequency histograms of the check box values selected by respondents living in a particular region. Values on the survey were $0, $10, $20, $30, $40, $50, $75, $100, and $150.

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