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The Steller's Sea-Eagle in North America: An economic assessment of birdwatchers travelling to see a vagrant raptor

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Abstract

1. Birdwatching—a cultural ecosystem service—is among the most popular outdoor recreational activities. Existing economic valuations of birdwatching typically overlook the economic contributions of birdwatchers travelling to see vagrant (out-of-range) birds.
2. Economic valuations of vagrant birdwatching are few, and to date, no valuation of a large, charismatic vagrant species—or of a recurring individual vagrant bird—has been reported.
3. During 2020–2022, a vagrant Steller's Sea-Eagle (*Haliaeetus pelagicus*) was reported in several locations in North America, representing the first record of this species in these locations. In Winter 2020–2021, the eagle spent nearly a month on the eastern seaboard of the United States, and thousands of people travelled to see it.
4. We conducted an online survey of individuals who travelled to see the eagle to estimate the individual and collective non-consumptive use value of this vagrant birdwatching event. Using individual travel cost methodology, we estimated an average individual expenditure and, together with estimates of the total number of birdwatchers, we estimated non-consumptive use value of the vagrant birdwatching event. Finally, we used a willingness to pay framework (via hypothetical donations to view the eagle) to evaluate the non-consumptive use consumer surplus of the event.
5. We estimated that, on average, individual birdwatchers spent $180 USD (95% CI = $156–$207) ignoring travel time—or $277 (95% CI = $243–$314) when accounting for travel time—to view the eagle. Furthermore, we estimated between 2115 and 2645 individuals travelled to see the eagle during December 2021 to January 2022. Thus, we estimated that the eagle generated a total expenditure between $380,604 and $476,626, or between $584,373 and $731,809 when accounting for travel time. Finally, based on travellers' willingness to pay, we estimated a non-consumptive use consumer surplus of the event between $139,036 and $174,114.

6. Assigning economic value to nature gives policymakers and business leaders footing to advance conservation in decision-making. Although often overlooked in these decisions, vagrant birds supply ephemeral ecosystem services that might bolster community development efforts, particularly if vagrancy events occur with some predictability (e.g. recurring annually).

KEYWORDS
birdwatching, ecological economics, ecosystem services, recreational tourism, vagrant birds

1 | INTRODUCTION

Ecosystem services—the benefits humans receive from nature—are recognized as life-supporting processes that improve human well-being, support economic development, and reduce global poverty (Braat & De Groot, 2012; Carpenter et al., 2009; Daily, 1997; Reid, 2005; Turner & Daily, 2008). Conservation scientists and policymakers have emphasized the role of *natural capital*, which provides ecosystem services, to integrate these services into decision and policy contexts (Guerry et al., 2015). For example, financial capital can be derived from tourism and outdoor recreation (natural capital), which can then be used to support ecosystem restoration and wildlife management, generating additional natural capital (Costanza et al., 1997; Daily & Matson, 2008). Ecosystem services are provided by many taxa and ecosystems globally, but birds—as a widespread and charismatic taxon—play an especially important role in each of the four ecosystem services categories defined by the United Nations Millennium Ecosystem Assessment: provisioning, regulating, cultural and supporting services (Reid, 2005; Wenny et al., 2011; Whelan et al., 2008, 2015). For example, domestic fowl and wild game birds provide provisioning services as major sources of nutrition globally, while scavengers (e.g. vultures, corvids) provide regulating services by consuming carcasses (Whelan et al., 2008). Birds also provide cultural services, or non-material benefits to humans through activities such as recreation, which in turn can generate large economic contributions (Sekercioglu, 2002). Birdwatching, a major cultural service, has long been among the most popular outdoor recreational activities in the United States, with an estimated 46 million birdwatchers generating $85 billion (USD) per year in overall economic output (La Rouche, 2003).

Assessing the economic value of ecosystem services provides a foundation for policymakers and business leaders to include conservation actions in land-use and development decisions (Wenny et al., 2011). While land managers frequently compare the costs and benefits of alternative land-use decisions for avian populations (e.g. Nichols & Williams, 2006), the valuation of birdwatching is often overlooked in such decisions. Additionally, birdwatching valuations often do not focus on specific geographic locations or species, and moreover fail to account for the ephemeral cultural services provided by vagrant species (species found outside of their typical geographic range; Lees & Gilroy, 2022). Travelling to see vagrant species is highly valued by birdwatchers, and recent evidence suggests that such activities generate considerable economic value that could be leveraged in land-use planning decisions (Callaghan et al., 2020; Lees & Gilroy, 2022; Schwoerer & Dawson, 2022). Importantly, vagrant birds often appear in locations (e.g. rural towns) and/or seasons that do not receive much tourism, providing a novel—although typically ephemeral—source of economic activity. These *ephemeral* ecosystem services—short-lived and often unpredicted services—may become more permanent if the location develops a reputation for attracting vagrant species (Laney et al., 2021), if a high-profile vagrant returns in successive seasons, or if birdwatchers return to the location for non-vagrant birdwatching or other activities (Lees & Gilroy, 2022). Nonetheless, economic valuations of vagrant birdwatching are few and have been limited to esoteric species that are of interest primarily to dedicated subsets of the birdwatching community (Callaghan et al., 2018, 2020). To date, no valuation of large, charismatic vagrant species has been reported. We seek to fill this gap by performing an economic valuation of a Steller's Sea-Eagle (*Haliaeetus pelagicus*; hereafter 'eagle') that appeared in the United States in 2020 (Figure 1).

During August 2020, one observer photographed a Steller's Sea-Eagle near the Denali Highway, Alaska, USA (Figure 1). The report caused a considerable stir in the birdwatching community but was not unprecedented. The species, which has a global population of only 3000–5000 individuals (BirdLife International, 2021), had been observed in Alaska several times previously, although its typical geographic range comprises northeast Asia along the Kamchatka Peninsula of Russia and the Sea of Okhotsk (BirdLife International, 2021). The same individual eagle was photographed in March 2021 in Victoria, Texas, United States—more than 5000 km from the original sighting and 8000 km from its typical range—a first record for the lower 48 contiguous states. The eagle reappeared some 3500 km away in June 2021 in New Brunswick, Canada, representing the first record for Canada (Figure 1). Throughout the remainder of the summer of 2021, the eagle was sporadically seen in the Atlantic provinces of Canada before moving south to the New England seaboard of the United States, being seen in Massachusetts in December 2021, and then lingering for weeks along coastal Maine in early 2022 (Figure 1). The various sightings have been confirmed as the same individual bird through careful inspection of plumage patterns on the bird's wings from photos (Bretagnolle et al., 1994).

The vagrant eagle's story is unprecedented in birdwatching history. The duration of the eagle's wanderings (and known whereabouts) allowed for birdwatchers and wildlife enthusiasts to attempt to see the eagle at various locations and times of the year, which is uncommon

FIGURE 1 The Steller's Sea-Eagle's (*Haliaeetus pelagicus*) journey across North America during August 2020–January 2022. Each black pin-drop represents the location of reporting for the individual eagle along with the date of the observation. The colour of the transition line matches the colour of the marker on the timeline.

for many vagrant sightings. Additionally, the charisma of the eagle attracted national media attention, creating widespread interest in the location and well-being of the individual bird (Gamillo, 2021; National Public Radio, 2022). The uniqueness of this event provided an opportunity to explore the role of charismatic vagrant birds in conservation, land-use planning and local economies. Here, we surveyed individuals who travelled to see the eagle to (1) understand sociodemographic drivers of travelling birdwatchers, (2) estimate the total number of individuals attempting to see the eagle and (3) estimate the individual and collective non-consumptive use value as well as the non-consumptive use consumer surplus of this event.

2 | METHODS

2.1 | Questionnaire

Our study focuses on birdwatchers who travelled to see the eagle between December 2021 and January 2022 in Massachusetts and Maine, USA. In Massachusetts, the eagle was reported on 12 December and stayed for 8 days on the Taunton River near Dighton Rock State Park. Then, following 10 days of no reports, the eagle was reported in Maine on 30 December 2021 and was present for just over 3 weeks, being reported primarily near Georgetown, Southport and the Maine State Aquarium, Boothbay Harbor and Ocean Point Preserve.

We used Survey Monkey (SurveyMonkey, Inc.) to collect anonymous survey responses from individuals who attempted to see the eagle during December 2021–January 2022 in the United States. All individuals consented to participating and the questionnaire was reviewed and approved by a university ethics committee for human subjects research. We focused on this period because the eagle stayed in several nearby locations for an extended period of time, allowing individuals to plan trips to see the eagle; this time period also coincided with the height of the media attention, potentially further motivating individuals to see the eagle. Survey responses were collected for 2 weeks from 26 January to 9 February 2022; we shared our survey on social media platforms (e.g. Twitter, Facebook, GroupMe) and email listservs (e.g. Ecolog). We increased reach by directly sharing with established birdwatching communities, state and regional birdwatching organizations, and discussion threads of the eagle. However, no in-person, on-site surveys were conducted.

Questions were adapted from previous research that assessed non-consumptive use value of vagrant bird events to enhance direct comparisons (e.g. Callaghan et al., 2020; Czajkowski et al., 2014). Our survey was developed to elicit responses on (1) timing, location and effort of an individual's attempt(s) to see the eagle, (2) expenditures associated with their effort, (3) the individual's birdwatching habits and motivations, (4) sociodemographic variables, (5) the number of other birdwatchers they observed on-site and (6) non-consumptive use consumer surplus. The full questionnaire is available as a Supporting Information.

We asked individuals about their visit details including the date and location of visit, amount of time they spent observing the eagle, and whether they made multiple trips. We also asked individuals to estimate the number of other birdwatchers observed during their trip; this information was used to estimate the total number of individuals who travelled to see the eagle (details below). For each trip, we also asked individuals to estimate all expenditures including fuel, airfare, meals (e.g. prepared, dining out, fast food), and lodging. Furthermore, we asked whether the individual carpooled and, if so, how many individuals were in the vehicle; this information was used to apportion travel costs across the number of individuals in the vehicle. Next, we asked the individuals to describe their birdwatching habits, including (1) number of years birdwatching, (2) whether or not they kept bird lists, (3) whether they were a member of birdwatching organizations, (4) whether they reported their eagle observation to the eBird database and (5) whether they posted about their trip on Twitter. Survey responses were used to describe birdwatching behaviour, estimate the number of visitors to the eagle, and estimate the economic impact of the vagrant event.

Finally, we estimated the non-consumptive use consumer surplus of the event by measuring visitors' willingness to pay to view the eagle through hypothetical monetary donations. Non-consumptive use consumer surplus refers to the non-consumptive use value beyond trip expenditures and builds upon economic theory suggesting that expenditures plus consumer surplus equals total willingness to pay (Boyle, 1998; O'Donnell, 2016). Previous vagrant bird studies have referred to this value as the *conservation potential* of the event, assuming that the donations would support conservation through protection efforts (e.g. land purchases; Callaghan et al., 2020). We asked whether individuals would be willing to pay a fee of \$5, \$25, \$50, \$75, \$100 or \$200 to view the eagle, using the same wording for each amount. For example, we asked, 'Would you be willing to pay \$5 to view the eagle?'. To calculate overall non-consumptive use consumer surplus, we used the proportion of respondents in each willingness to pay level (e.g. \$5, \$100) to sum the product estimated funds at each level and the estimated number of visitors.

2.2 | Visitor estimation

Estimating the total expenditure by birdwatchers attempting to see the eagle (i.e. beyond those who responded to our survey) required estimating the total number of birdwatchers who attempted to see the eagle. To account for uncertainty, we used three approaches to estimate the total number of visitors: (1) eBird records, (2) Twitter data and (3) responses from our survey.

First, we queried the eBird database through the eBird Basic Dataset for observations of Steller's Sea-Eagles in North America from 1 December 2021 to 9 February 2022 (Cornell Lab of Ornithology, 2022). Once downloaded, we used the R package *auk* (Strimas-Mackey et al., 2018) to filter observations to a bounding box encompassing northeastern United States (−98.26, 31.63, −50.12, 50.19). From this, we stored the total number of unique users rather than the total number of observations, since some individuals made multiple reports of the eagle. We then divided the total number of users by the proportion of survey respondents who stated that they submitted their observation of the eagle to eBird to estimate p, which we can view as 'reporting proportion'. Then, borrowing from the wildlife population literature, we can assume that the population size (i.e. total number of birders) follows the relationship of $N = \frac{c}{p}$, where c represents the count of eBird users reporting a Steller's Sea-Eagle, p is the proportion of individuals reporting to eBird and N being the total number of individuals visiting the eagle. For example, if 400 individuals reported on eBird and our survey indicated that 80% of respondents reported to eBird, then we would estimate a total of 500 birders attempted to see the eagle. We used this same logic and approach for the following two datasets.

Second, we applied the same approach to Twitter data, using survey responses to calculate a proportion of visitors reporting on Twitter to the number of tweets indicating visitation to the eagle. To access Twitter data, we used the Academic Research developer access and the R package *academictwitteR* (Barrie & Ho, 2021) to query the API. We used the *get_all_tweets* function with the following arguments: query = "Steller's Sea Eagle" OR "stellers sea eagle" OR "#StellersSeaEagle", start_tweets at 2021-12-01, end_tweets at 2022-02-09, n = 10,000, and FALSE for is_retweet, is_reply and is_quote. From these results, we then searched the tweet strings for "we", "chase", "chased", "saw", "seeing", "see", "finding", "find", "drive", "travel*", where * indicates a wild card ending. Using these tweets, we calculated the number of unique users and compared this against the proportion of survey respondents who indicated that they tweeted about their attempt. Again, this resulted in an estimate of the total number of individuals visiting the eagle.

Finally, we used the counts of birdwatchers reported by our survey respondents in the survey question, 'Approximately many other birdwatchers did you see while observing the eagle?'. Using the date supplied by the respondents, we grouped across days to identify an average number of birdwatchers reported for each day. That is, on a given day (e.g. 10 January) we may have had several survey respondents report the number of other birders they saw while attempting to see the eagle. This, for example, could have been '40' and '200', in which we would have applied an average value of '120' birders for 10 January. We did not use the maximum number of birdwatchers reported each day to avoid bias from overcounts by respondents; by doing so, we believe that our estimates from this data source are conservative. Finally, we summed the average daily values (e.g. 120 birders) across the range of dates of interest (i.e. December 2021 and January 2022) to estimate a total number of visitors to the eagle.

2.3 | Non-consumptive use value

Vagrant birdwatching requires indirect market-price analyses, such as revealed preference valuation techniques, since the value of this ecosystem service must be indirectly estimated because the experience of viewing a vagrant bird is not directly bought or sold in a market (Field, 2008). The travel cost approach has traditionally been applied to estimate the value of recreation because it is based on observed market behaviour of a cross-section of users in response to direct out-of-pocket and time cost of travel (Englin & Cameron, 1996; Field, 2008; Parsons, 1991; Willis & Garrod, 1991). This non-market approach assumes that the sum of travel-related expenses associated with a recreation experience represents the minimum amount an individual values the recreation experience. We used the *individual* travel cost method to evaluate the average total costs incurred by individuals (or groups of individuals, e.g. carpooling) attempting to see the eagle (Willis & Garrod, 1991). We estimated two measures of individual expenditure: direct monetary costs of the trip (e.g. fuel, food) and direct monetary costs plus the opportunity cost of travel time to see the eagle.

For estimating direct monetary costs, we used questionnaire responses about total expenditures (e.g. fuel, food and lodging) and travel points of origin. We first calculated road distance travelled between respondents' home zip code and the eagle's zip code using the *gmapsdistance* (Melo & Zarruk, 2022) package; *gmapdistance* also gives estimated driving times between two locations which is how we calculated travel time. In processing distance, all zip codes needed to be geocoded to return the latitude and longitude of the zip code centroid; this was completed using the R packages *opencage* (Possenriede et al., 2021) and *zipcodeR* (Rozzi, 2021). Once the distance was calculated, we then calculated an automobile operating cost, which was the product of the round-trip travel distance and the standard operating cost of an automobile, excluding fuel ($0.396/km; National Transportation Statistics, 2021). For estimating the opportunity cost of time, in addition to the expenditures listed above, we included an average hourly wage rate using values supplied in the questionnaire. For individuals who did not report their hourly wage or reported an imprecise value (e.g. '<$500'), we applied the federal average hourly wage rate which was based on the 2020 median household income and the federal average number of work hours a year ($68,703 / 2087 h = $32.92/h; Semega et al., 2020, U.S. Office of Personnel Management, 2022). We used this wage value and accounted for the amount of travel time, estimated in the *gmapdistance* package, required between the respondent's and the eagle's zip codes. Thus, the opportunity cost of time was a product of the hourly wage and the time spent travelling. For individuals who reported air travel as their primary mode of transportation, we calculated flight time between the nearest international airport to the respondent's home zip code and Boston International Airport; given that no details were provided on departure and arrival airports in the questionnaire, we assumed these locations, which, although potentially inaccurate (e.g. landing at a different airport), the time difference associated with different departure and arrival locations is likely minimal.

We used a Bayesian linear model to estimate an adjusted mean individual expenditure to facilitate predictions across a larger population of birdwatchers. We modelled a respondent's expenditure (log transformed) as a linear function of (1) whether the respondent took an overnight trip, (2) gender, (3) marital status, (4) employment status, (5) highest level of education, (6) whether the respondent carpooled and (7) age group. We included the former six variables as factors in the model but included age as a monotonic effect (i.e. an ordered categorical variable) to reflect the sequential nature of age (Bürkner & Charpentier, 2020; McElreath, 2020). We used standard weakly informative priors for all model parameters (McElreath, 2020). Within the model, we computed the mean predicted expenditure and multiplied it by the estimates of the total number of birdwatchers who attempted to see the eagle (three estimates: from eBird, Twitter and the respondents' estimates) to produce a posterior distribution for the estimated collective non-consumptive use value. We implemented the model in Stan using the *rstan* package (Carpenter et al., 2017). Data and code are available at https://github.com/BrentPease1/sea_eagle.

3 | RESULTS

3.1 | Survey responses and sociodemographic characteristics

We received 680 responses during a 2-week period (48 responses/day); 70% of the responses were complete, resulting in 469 usable responses for analyses. Over half of the respondents were above the age of 55 and the majority (92%) were white or Caucasian (Table 1). Respondents were more commonly women (57%) than men, most were married (60%), either employed full-time (40%) or retired (34%), and college educated (87%; Table 1). Forty-five per cent of respondents reported being a birdwatcher for 10 years or less (Table 1), but most self-identified as expert birdwatchers with over 80% keeping a bird list (e.g. life list, county list).

3.2 | Trip details

Twenty-four respondents (5%) reported travelling by air with the remaining 95% travelling by vehicle. The mean one-way driving distance between a respondent's home zip code and the eagle viewing location was 548 km (SD = 593 km), with a maximum reported one-way distance of 2354 km (Figure 2). Eighty-two respondents (17%) reported a one-way driving distance of less than or equal to 100 km, with just 5% of respondents reported staying in their home zip code to view the eagle. The most common (16%) round-trip driving distance was 400–600 km, but only 34% of respondents reported an overnight stay during their trip. Nearly 72% of respondents reported food expenses; 28% indicated bringing food with them and not purchasing while on the trip. Most respondents (95%) reported the eagle as their sole reason for taking the trip and were primarily motivated by the rarity of the species and the unlikely event of encountering the species again. Approximately 67% of respondents reported successfully seeing the bird.

TABLE 1 Sociodemographic characteristics of 469 respondents to a survey of vagrant birdwatching in the United States during December 2021–January 2022. For each characteristic, we report the per cent of respondents in a given category such that each characteristic sums to 100.

Characteristic	% Respondents
Age	
18–24	6
25–34	13
35–44	13
45–54	14
55–64	28
65+	27
Gender	
Man	40
Woman	57
Other	3
Race	
Asian or Pacific Islander	2
Hispanic or Latino	<1
Biracial or Multiracial	1
Native American or Alaskan Native	<1
White or Caucasian	92
I would rather not say	3
Not reported	<1
Marital status	
Married	60
Single	33
Other	7
Employment status	
Employed full-time	40
Employed part-time	7
Retired	34
Self-employed	11
Student	5
Unemployed	4
Education	
High school	9
Bachelor's degree	39
Master's degree	34
Doctoral degree	14
Other	3
Years birdwatching	
0–10	45
11–20	17
21–30	12
31–40	8
41–50	12
50+	6

3.3 | Number of visitors

The three approaches to estimating the total number of visitors—eBird, Twitter and respondents' counts—produced similar estimates of the number of birdwatchers. For eBird, 44% of respondents reported submitting their observation to the database, resulting in an estimated 2112 birdwatchers visiting the eagle. With 10% of respondents posting observations to Twitter, the greatest estimate of visitors resulted from this database at 2645 visitors. Using respondents' estimates of the number of other birdwatchers present during their visit resulted in an estimated 2303 visitors. Averaging across the methods, we conservatively estimate that 2350 visitors attempted to see the eagle in Massachusetts and Maine during December 2021 and January 2022.

3.4 | Non-consumptive use value

Using the number of visitors and respondents' reported expenses, we estimated individual and collective non-consumptive use value of the eagle. First, we estimated adjusted mean individual expenditure of \$180 (95% CI = \$156–\$207) ignoring travel time and \$277 (95% CI = \$243–\$314) when accounting for travel time. Multiplied by the three estimates of the number of birdwatchers, we estimated that the eagle generated a total expenditure between \$380,604 and \$476,626 when not including travel time and between \$584,373 and \$731,809 when accounting for travel time (Figure 3). Allowing for uncertainty and including the cost of travel time, the non-consumptive use value could be as high as \$830,499 (Figure 3). Respondents reported an average of \$84 spent on food (SD = \$88; n = 336) and \$261 on lodging (SD = \$201; n = 130). Additionally, respondents reported spending an average of \$68 on fuel (SD = \$83; n = 428) and 24 respondents spent an average of \$619 on airfare (SD = \$342).

Respondents additionally reported on their willingness to pay to view the eagle (i.e. their non-consumptive use consumer surplus). The majority (92%) of respondents indicated that they would be willing to donate at least \$5 dollars to view the eagle, with 34% willing to donate \$100 and still 16% willing to donate \$200 to view the eagle (Figure 4). Expanding this across the estimated number of individuals visiting the eagle, and assuming this behaviour is consistent across all visitors, we estimate a non-consumptive use consumer surplus ranging between \$139,036 and \$174,114.

4 | DISCUSSION

Here, we estimated the economic activity generated from birdwatchers travelling to see a rare, charismatic vagrant bird—the Steller's Sea-Eagle—to be between \$380,000 and \$732,000 during a 2-month period in the United States. This is significant because, although traditionally an area of frequent nature-based tourism (e.g. visitation to National Parks), December through January is the

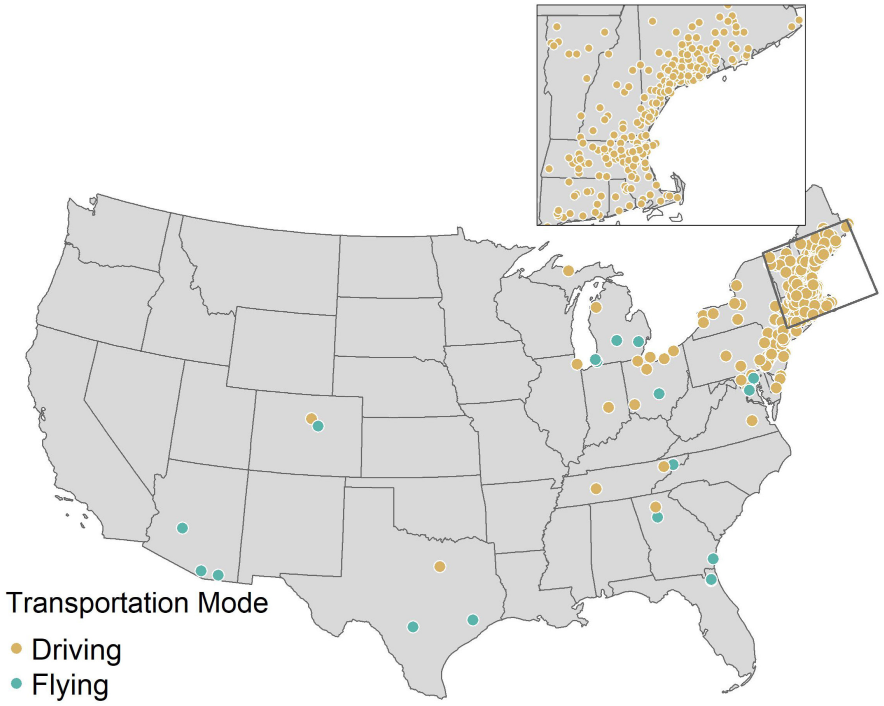

FIGURE 2 A map of the home zip code of 469 respondents to a survey of vagrant birdwatching of a Steller's Sea-Eagle (*Haliaeetus pelagicus*) in the United States during December 2021–January 2022. The inset within the figure is a zoomed-in view of the Northeast United States where a majority of respondents started their trip. We additionally differentiate between individuals who reported flying versus driving.

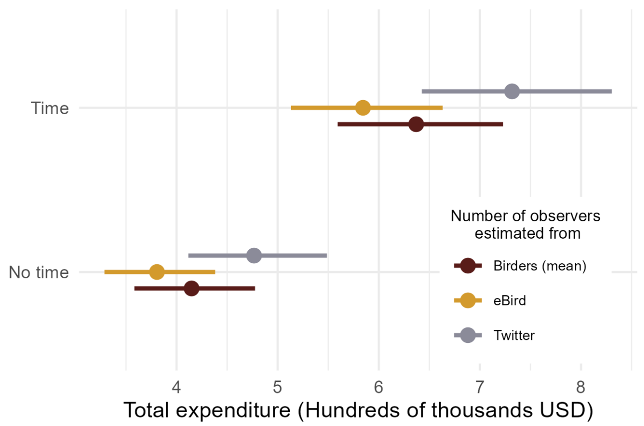

FIGURE 3 Estimated total economic expenditure of a vagrant birdwatching event of a Steller's Sea-Eagle (*Haliaeetus pelagicus*) in the United States during December 2021–January 2022 using individual travel cost methodology combined with estimates of the total number of individuals travelling to see the bird. We used three sources of information to estimate the total number of birdwatchers: eBird, Twitter and survey questions prompting estimates of the number of birdwatchers present during their visit.

off-season, thus providing a surge in economic activity. Additionally, through self-reported hypothetical donations, we estimated the non-consumptive use consumer surplus of this event between $139,000 and $174,000. Importantly, these values reflect only non-consumptive use, which is a subset of overall total economic value which is presumed to be much higher than our estimates (Barbier et al., 1997). No other documented single event of vagrant birdwatching has generated this level of economic activity, highlighting a potential and hitherto largely unrecognized role of bird vagrancy as an ephemeral ecosystem service. At the current writing (February 2023), the eagle has returned to within several kilometres of its previous haunts in coastal Maine, once again attracting hundreds of visitors (Maine Audubon Society and Hitchcox, 2023). Given that eagles are long-lived (e.g. the longevity record from banding records for Bald Eagle is 38 years; United States Geological Survey, 2022), it is thus possible that birders will travel to see the eagle for years to come should it stay on the Atlantic seaboard.

Recent decades have seen considerable growth in birdwatcher interest in vagrant bird discovery and chasing, likely a result of increasingly rapid dissemination of vagrant bird information, heightened attention to biodiversity loss and a growing global community of birdwatchers (Howell et al., 2014; Lees & Gilroy, 2022). Continued studies of vagrancy are incrementally demystifying its biological drivers (Tonelli et al., 2023) and ecological implications, and we emphasize that understanding the socioeconomic effects of vagrancy can support decision-making in land-use planning (Elix & Lambert, 2007; Istomina et al., 2016; Underwood et al., 2011), improve local community ecotourism (Biggs et al., 2011; Schwoerer & Dawson, 2022; Sekercioglu, 2002; Wenny et al., 2011) and encourage species conservation (Ocampo-Peñuela & Winton, 2017).

Most of the survey respondents were 55 and over, white, married with secure employment, and well-educated. Overall, the socio-demographic make-up of our respondents was characteristic of the birdwatching community (Callaghan et al., 2018; Sekercioglu, 2002). However, unlike typical vagrant birdwatchers, most of the respondents reported relatively less experience and commitment to birdwatching (Brock et al., 2021). For example, most respondents reported less than 10 years of birdwatching experience, and 60% of the respondents reported having a membership in a birdwatching group, which is markedly lower than previous studies evaluating economic potential of vagrant birdwatching (Callaghan et al., 2018).

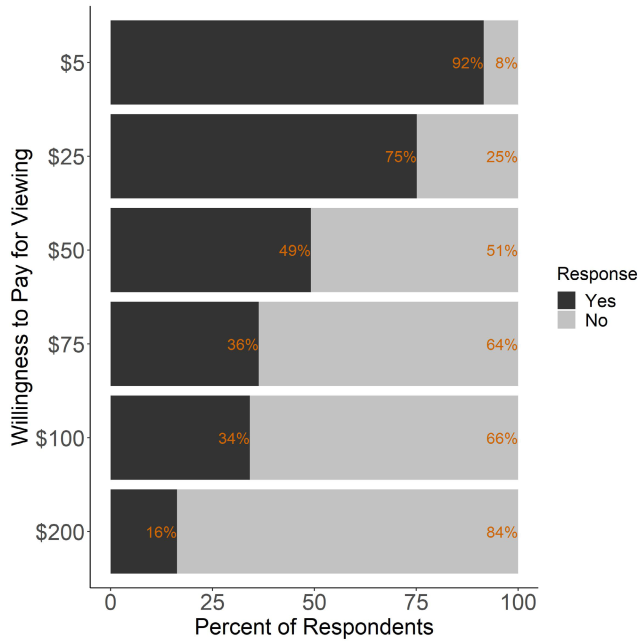

FIGURE 4 The theoretical donation values (y-axis) and the proportion of survey respondents willing to pay the values to view a Steller's Sea-Eagle (*Haliaeetus pelagicus*) in the United States during December 2021–January 2022. These values represent a species' conservation potential (non-consumptive use consumer surplus) as donations may be given to a non-governmental organization for land protection and species conservation.

In contrast, 80% of respondents kept some bird list (e.g. county, life) and reported vagrant birdwatching outside of their home zip code five or more times per year, suggesting that species rarity, vagrant bird watching and building life-lists were important contributions to the economic valuation of this event.

Recreation and tourism attributed to the eagle made a notable economic contribution ($381,539–$477,799) to local communities throughout Maine and Massachusetts, USA, which was substantially larger than previous estimates of the economic contributions of other vagrant birdwatching events (Brock et al., 2021; Callaghan et al., 2018, 2020). The magnitude of this economic contribution was primarily a result of the total number of visitors rather than individual expenditures. In our study, mean individual expenditures and the categorical breakdown of these expenditures were comparable to other documented events. For example, trips to see a vagrant Black-backed Oriole (*Icterus abeillei*) in Pennsylvania, USA generated an average individual expenditure of $69–$75 (Callaghan et al., 2018), while a vagrant Aleutian Tern (*Onychoprion aleutica*) in Australia generated an average individual expenditure between $371 and $435 (Callaghan et al., 2020). In comparison, general birdwatching trips (i.e. not targeting an individual bird) in Alaska, USA during 2016 resulted in average individual expenditures of $1694 (Schwoerer & Dawson, 2022). While this and some previous studies accounted for the opportunity cost of travel time from their home zip code to see the bird, additionally accounting for the length of trip and return travel time would have been needed to fully characterize this cost. We chose to focus explicitly on this event rather than total travel time because several respondents reported engaging in other activities while on their travel to see the bird, and any expenses and/or time associated with those activities fell into a 'non-birdwatching' category, which would have inflated the value of the event. Although recreation and tourism activities generated by vagrant species have the potential to contribute to community socioeconomic development, they are irregular events that may be poorly predicted (but see Tonelli et al., 2023), and realization of these benefits requires investments in the capacity of communities for sustainable tourism development. This calls for policies aimed at building community resilience through the development of community capital assets and local institutional capacity (Akamani, 2012; Bennett et al., 2012).

We also evaluated the non-consumptive use consumer surplus of this event, conceptualized as the theoretical donation that visitors would be willing to pay to view and protect the eagle, to replicate previous research who sought to quantify the *conservation potential* of vagrant birdwatching. Results from our study were nearly identical to previous efforts (Callaghan et al., 2020), despite the vagrant birdwatching events taking place on different continents (North America vs. Australia), suggesting broad consistency in birdwatcher behaviour and willingness to protect and conserve bird species. For example, 34% of our respondents indicated that they would be willing to pay $100 USD to view the eagle, while 35% of respondents reported a willingness to pay $100 AUD to view a vagrant Aleutian Tern in Australia, demonstrating that vagrant birdwatching may be an important source of future fundraising for bird conservation agencies across the world if implemented (Steven et al., 2013). Practical implementation of this approach might entail local birdwatching organizations supporting 'rare bird ambassadors' who coordinate with birdwatchers and local communities to identify fundraising goals and mechanisms for collecting donations (Ontario Field Ornithologists, 2022). While employing this approach allowed for direct result comparison, it may have introduced additional hypothetical bias compared to more updated contingent valuation approaches such as double-bounded dichotomous choice. Future studies should seek to improve their estimates of non-consumptive use consumer surplus using these updated methods, thus improving point estimates, and allowing for cross method comparisons.

Vagrant birdwatching can be a high-carbon hobby, especially when individuals use air travel as their primary form of transportation. That is, individuals engaging in vagrant birdwatching often need to leave their primary home zip code via some mode of transportation, usually other than walking or biking (Lees & Gilroy, 2022). Within this case study few individuals booked airfare to see the eagle, whereas almost 95% of individuals reported taking a personal vehicle, many of whom carpooled with friends and family. Previous research evaluating carbon emissions from nature-based recreation has several recommendations for reducing emissions, including increasing vehicle occupancy, using newer cars with higher fuel efficiency, and using public transportation when available (Grizane & Blumberga, 2020). As the excitement around vagrant events grows, the carbon-cost associated with travelling to see the species may eventually offset the ecosystem services generated from the event, and future research should evaluate benefit–cost ratios of economic activity to carbon emissions in the pursuit to see vagrant bird species. Although it may generate less economic activity, low-carbon forms of travel (e.g. biking) should be considered by the birdwatching community as they consider whether to chase a vagrant bird. As we continue to see impact of global climate change, changing the ways in which birdwatchers travel to see birds and define species rarity may be a solution. Although birdwatchers who stay local will likely encounter fewer continental-scale vagrants, local rarities can still provide excitement and birdwatching motivation.

Birdwatching will continue to be an important ecosystem service provided by birds so long as species and places are protected. Vagrant species are an exciting part of birdwatching and can raise the profile of birdwatching, species conservation and outdoor recreation to the general public. Our research contributes to the increasing evidence that vagrant birdwatching is valuable and should be considered in the context of ecosystem services, land-use planning and conservation decision-making. While circumstances around this vagrant event allowed for a prolonged opportunity for birdwatchers across the United States to attempt to see the eagle, resulting in significant economic activity, future research might attempt to estimate economic value of all vagrant birdwatching. For example, estimating the total economic value associated with all vagrant birds for a given year could contribute to large-scale ecosystem service modelling and mapping. Another important question pertains to the ephemeral nature of the services provided by vagrant birds: since the occurrence of vagrant birds is temporary and unpredictable in space and time, the capacity of local communities to capitalize on vagrant birdwatching as a source of revenue may be limited unless vagrant events alter the behaviour of birdwatchers. Moreover, expanding the scope of ecosystem services research to include vagrant birdwatching—often an ephemeral activity—may motivate development in research on and capture of dynamic ecosystem services. Most research on ecosystem services focus on static snapshots of ecosystem service supply and demand (Rau et al., 2018, 2020; Renard et al., 2015); a recent literature review noted that only 2% of studies engaging with the ecosystem services concept considered temporal changes in ecosystem services (Rau et al., 2020). As vagrancy in birds is expected to increase with global change (Lees & Gilroy, 2022), continued study of the social and ecological implications of this phenomenon will support the conservation of places and species.

AUTHOR CONTRIBUTIONS

Brent S. Pease conceived the idea and led the writing with edits from all co-authors; Brent S. Pease, Neil A. Gilbert, William R. Casola and Kofi Akamani designed the study and supported the data collection; and Neil A. Gilbert and Brent S. Pease analysed the data. All authors gave final approval for publication.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All data, R code and survey questionnaire are available at https://github.com/BrentPease1/sea_eagle and a release is archived at https://zenodo.org/badge/latestdoi/462378107.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Full survey questions used for estimating travel expenditures.

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