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Valuing wildlife sightings at the species-wide and individual animal levels: an approach and application to bear viewing in Yellowstone National Park

Leslie Richardson[a] and Aaron J. Enriquez[b]

[a]National Park Service, Social Science Program, Fort Collins, Colorado, USA; [b]U.S. Geological Survey, Fort Collins Science Center, Fort Collins, Colorado, USA

ABSTRACT

Wildlife viewing is a popular recreation activity in parks and protected areas around the world, yet information on the nonmarket value that visitors derive from viewing specific species, and how that value is affected by small-scale population changes, is lacking. We devised an approach to fill the gap. First, we applied the travel cost method to obtain the value of a wildlife viewing trip. Next, we estimated a value per animal sighting, which we aggregated by the number of visitors who experienced and valued a sighting. Finally, we incorporated the probability of viewing an animal to determine an individual animal's contribution to sighting value, which varies by species type, visibility, and seasonality. We examined bear viewing in Yellowstone National Park. For grizzly and black bears, respectively, per-sighting values are $16 and $14, aggregate annual sighting values are $6.9 and $9.7 million, and annual per-bear viewing values are $46,000 and $15,000.

KEYWORDS

Bear viewing; consumer surplus; nonmarket value; travel cost method; wildlife sightings

Introduction

Wildlife viewing is a primary draw at national parks and protected areas around the world, with many tourists seeking opportunities to view high-profile, charismatic wildlife species (Anderson et al., 2010; Skibins et al., 2012; Verbos et al., 2017). Wildlife sightings can have a significant effect on both visitor satisfaction and broader species conservation (Mariyam et al., 2022; Skibins et al., 2012, 2013; Walpole & Leader-Williams, 2002). Numerous studies have quantified the value that visitors derive from wildlife viewing opportunities. For instance, Oregon State University's Recreation Use Values Database (2016) provides a comprehensive summary of nonmarket valuation studies conducted in the United States and Canada that quantify the value of a day spent viewing wildlife. Interestingly, the vast majority (~95%) of the included value estimates focus on birdwatching or general wildlife viewing, as opposed to sightings of a particular species, and just a small fraction of the estimates (~1%) are based on studies conducted in national parks. There is thus a surprising lack of information about the value

CONTACT Leslie Richardson leslie_a_richardson@nps.gov National Park Service, Social Science Program, 1201 Oakridge Dr., Fort Collins, CO 80525, USA

recreational visitors derive from viewing a specific wildlife species, especially in certain protected areas. Further, aside from Kubo and Shoji (2016) and McCollum et al. (1998), few studies have attempted to determine how an individual wildlife sighting affects the overall value of the visitor experience or how changes in sightings are linked to recreational viewing values.

Our study sought to answer three general questions that integrate the human dimensions of wildlife, the quality of the visitor experience, and the value of passive wildlife observation. First, what is the monetary value of a visitor's experience spent viewing a specific wildlife species? Second, how do changes in a species' population size, which could in turn influence a visitor's likelihood of seeing that species and potentially the quality of their experience, affect aggregate sighting value? Third, how does the expected value of an individual animal depend on factors such as seasonality and proximity to visitor use locations? Attributes such as the number or frequency of wildlife seen can affect a visitor's wildlife viewing experience (Manfredo et al., 2002; McCollum et al., 1998; Skibins et al., 2012), yet these relationship can be challenging to characterize. In this paper, we introduced a novel approach that allows for estimating expected changes in value over small-scale changes in wildlife population sizes, including the loss of an individual animal.

Our work is motivated by two main factors. First, there is greater recognition that sustainable wildlife management strategies should consider visitors' desired experiences, often referred to as experience-based management (EBM) (Manfredo et al., 2002; Skibins et al., 2012). Economic measures of value in particular help translate the public's preferences for wildlife resources and visitor experiences into a common metric of dollars. Such values can help demonstrate the benefits of EBM, inform management tradeoffs associated with competing recreational uses of wildlife, and elucidate societal losses following incidents such as oil spills (NPS, 2005; Unsworth & Petersen, 1995).

Second, incidents that affect a single or small number of animal(s) likely do not have population-level effects nor affect overall visitation, but such small-scale changes can still affect the probability of a wildlife sighting and the value of the visitor experience. Per-animal values, while largely absent from the existing literature, are increasingly important for wildlife management. For example, a park manager may be tasked with assessing damages from illegally poached wildlife and seeking dollar-valued compensation from the responsible party for the loss of that individual animal. The more closely this compensation reflects the value of that wildlife to the public, the more likely the public will be made whole for the loss of wildlife held in trust on their behalf. As another example, a management action may affect the harvest of a particular wildlife species in an effort to maintain hunter satisfaction (Gigliotti, 2000; Heberlein & Kuentzel, 2002). Even if that increased harvest is small and not expected to meaningfully affect the size of the species' population, visitors may still experience decreased viewing opportunities (Borg et al., 2016). Comparing changes in the quality of both the hunting and viewing visitor experiences using a consistent metric can help managers determine whether the action generates positive net benefits to society.

To address gaps in the wildlife valuation literature, we devised a four-step approach that incorporates basic information on visitor recreation behavior, wildlife sightings, and wildlife populations. First, we applied the travel cost method to determine how recreational visitors value a trip spent viewing wildlife. Second, we converted the value per trip to a value per animal sighting (in the context of the quality of a wildlife-based experience), using information on the average length of time visitors spend engaged in a sighting. Third, we multiplied the value per animal sighting by the expected number of visitors who both experience and value a sighting. This yields the species-specific share of aggregate value associated with time spent viewing a particular wildlife species. Finally, we expanded our specification such that a visitor's average probability of seeing the species is a function of the species' population size. This allowed us to determine how the loss of one animal affects aggregate value.

Methods

Study Site

We applied our approach to bear viewing in Yellowstone National Park for several reasons. First, Yellowstone is iconic as the first designated national park. It is among the top 10 most-visited national parks in the United States, with more than four million visitors annually. Second, wildlife viewing consistently ranks among the top visitor activities in the park (Kulesza et al., 2012; Otak, 2019; RSG, 2017). Bear viewing, which is a highly-demanded activity across the globe (Penteriani et al., 2017; Skibins et al., 2012), is a particularly popular draw in Yellowstone (Gunther et al., 2018; Haroldson & Gunther, 2013). Excluding winter months, approximately 70 to 80% of visitors report that seeing American black (*Ursus americanus*) or grizzly bears (*Ursus arctos horribilis*) is one of the reasons they come to the park (Duffield et al., 2006). Sightings for many visitors occur in "bear jams," which are traffic jams caused by visitors stopping to observe or photograph bears on or near park roads (Haroldson & Gunther, 2013). Third, bears in the Greater Yellowstone Ecosystem are subject to a wide range of human-caused mortalities, including management removals, self-defense kills, and motor vehicle collisions (Enriquez & Finnoff, 2021; Gunther et al., 1998; NPS, 2011; van Manen et al., 2021). Bear viewing in Yellowstone National Park thus made a good case study for our analysis.

Data

To determine the value of bear viewing opportunities, we relied on an existing survey of Yellowstone National Park visitors conducted by the Yale School of Forestry and Environmental Studies (summarized in Richardson et al., 2014, 2015). The visitor survey was conducted from May through September of 2009. The survey included numerous questions specific to bear viewing, including the number of trips visitors took to the park in the past 12 months to view bears, preferences for bear species visitors would like to see (grizzly or black), and the type of bear viewing experience visitors would prefer (e.g., seeing a habituated bear close up, a wary bear far away, or no preference). The survey also included key questions about respondents' visits to Yellowstone, including the amount of time they spent in the park, the travel time and distance from their home to the park, mode of travel, trip expenditures, and demographic information. Visitors were contacted at a variety of locations throughout the park. At each intercept location, every third visitor, aged 18 or older, was intercepted while exiting. Overall, 1,048 visitors were intercepted with 978 agreeing to participate and 70 declining. Those agreeing were handed a cover letter, survey packet, and postage paid return envelope. A total of 663 visitors mailed a completed survey back, for an overall response rate of 63% when taking the initial refusals into account.

Although the data are now more than a decade old, this visitor survey was unique in that it included targeted questions about viewing specific species – bears. Further, several meta-analyses and evaluations of recreation values have found that estimates are temporally stable, even across periods of economic recession (Huber & Richardson, 2016; O'Donnell, 2016; Rosenberger, 2012). Findings by Rosenberger (2012) suggest that the Consumer Price Index captures most changes in recreation values over time. As a result, we confidently relied on the 2009 survey data.

Analysis

We took four steps to estimate the wildlife viewing value associated with black bears and grizzly bears, based on visitor sightings at Yellowstone National Park (see Table 1 for modeling details).

Step 1

We applied the travel cost method to determine how recreational visitors value a bear viewing trip. The travel cost method is commonly used to estimate the net economic value (also called consumer surplus) associated with recreation activities. The basic premise is that the time and money spent traveling to a recreation site represents the "price" of accessing that site (Parsons, 2017). Using information from a sample of visitors regarding the number of trips taken to a recreation site in the past year, along with the travel and time costs required to reach the site, a demand curve can be estimated and used to calculate the consumer surplus that visitors gain from having access to the site. The demand curve is expected to be downward sloping: the higher the costs, the lower the number of trips taken, all else equal. By focusing on trips taken to Yellowstone National Park for the primary purpose of bear viewing, we specifically estimate the value of a bear viewing trip to the park (rather than the value of a general trip to the park).

Because the dependent variable in a travel cost model is a count (number of trips), we estimated both a Poisson and negative binomial regression model. The latter accounts for the possibility of overdispersion, which is when the variance of trip counts exceeds the mean (Cameron & Trivedi, 1998; Greene, 1992). We used a likelihood ratio test to determine whether the Poisson or negative binomial model is more appropriate. This is a test that alpha (the overdispersion parameter in the negative binomial model) is equal to zero.

The existing literature has developed various approaches to overcome common limitations of on-site travel cost modeling. We focus on four such limitations. First, in on-site samples, the number of visits to the site is always greater than zero, which is referred to as truncation. Second, there is endogenous stratification: visitors taking more trips to the recreation site are more likely to be sampled. We corrected our Poisson and negative binomial models for both truncation and endogenous stratification (Englin & Shonkwiler, 1995; Haab & McConnell, 2002; Shaw, 1988). Third, if the amount of time visitors spend on-site is chosen, with its own "price" that affects this choice, on-site time should be treated as endogenous. We estimated a linear regression model where on-site time is a function of both trip costs and on-site costs per unit of time to determine if the cost coefficients are significantly different from zero, in which case on-site time is endogenous and a separate variable for on-site costs should be included in the travel cost model (McConnell, 1992; Pokki et al., 2020). Fourth,

Table 1. Detailed description of the four-step general approach used to value wildlife viewing. For every step, all components, equations, and variables are defined, and explanations are provided.

Step	Component	Equation	Variables	Explanation
(1) Estimate a travel cost model to obtain value per bear viewing trip.	Travel and time cost for roundtrip travel from individual *i*'s home to the park (tc_i)	Visitors who drove to the park: $tc_i = \frac{(d_i \cdot 0.17)+25}{f_i} + \left(t_i \cdot \frac{1}{3} \cdot w_i\right)$ Visitors who flew to the park: $tc_i = (d_i \cdot 0.28) + \left(\frac{25}{f_i}\right) + \left(t_i \cdot \frac{1}{3} \cdot *w_i\right)$	• d_i = roundtrip distance from individual *i*'s home to the park. • \$0.17 = average vehicle operating cost per mile (AAA, 2009). • \$25 = park entrance fee in 2009. • f_i = number of people sharing expenses. • t_i = roundtrip travel time from individual *i*'s home to the park. • w_i= individual *i*'s wage rate. • \$0.28 = average cost per mile for flights within the U.S (Rome2rio, 2018).	Travel cost is the sum of the cost of reaching the site, entrance fees, and the opportunity cost of the visitor's travel time, valued at 1/3 of their wage rate.
	Trip demand, in terms of number of trips taken to the park to view bears in the past year by individual *i* (x_i)	$x_i = f(tc_i, Z_i)$	• tc_i = travel and time costs for individual *i*. • Z_i = vector of explanatory variables of interest for individual *i*.	Individual *i*'s trip demand is a function of travel and time costs and other variables believed to influence the number of trips taken. Estimated as a count data model.
	Consumer surplus per visitor per bear viewing trip (CS_{trip})	$CS_{trip} = \frac{1}{-\hat{\beta}_{tc}}$	• $\hat{\beta}_{tc}$= the coefficient on the travel cost parameter, as estimated by maximum likelihood.	CS per year can be calculated as the expected number of trips divided by the coefficient on the travel cost parameter. Dividing by the expected number of trips per year gives the CS per trip. Because the expected number of trips cancels out, CS per trip is estimated by dividing 1 by the coefficient on the travel cost parameter.

(*Continued*)

Table 1. (Continued).

Step	Component	Equation	Variables	Explanation
(2) Convert value per bear viewing trip to value per bear sighting.	Consumer surplus per visitor per day (CS_{day})	$CS_{day} = \frac{CS_{trip}}{2}$	• 2 = median length of stay (in days).	Dividing consumer surplus per trip by the median length of stay per trip (in days) leads to an estimate of consumer surplus per day.
	Consumer surplus per visitor per black bear or grizzly bear sighting (CS_b or CS_g, respectively)	$CS_b = CS_{day} \cdot 9.2\%$ $CS_g = CS_{day} \cdot 10.4\%$	• 9.2% = proportion of daily time spent in park viewing black bears. • 10.4% = proportion of daily time spent in park viewing grizzly bears.	Yellowstone day-trip visitors spend an average of 7.23 hours in the park (RSG, 2017). The median duration of a grizzly bear jam and black bear jam on park roads is 45 and 40 minutes, respectively (Haroldson & Gunther, 2013).

(*Continued*)

Table 1. (Continued).

Step	Component	Equation	Variables	Explanation
(3) Aggregate to obtain the value of all bear sightings.	Visitors who see a bear and value a bear sighting, by type of bear (t, which is either b for black bear or g for grizzly bear) and season (s, which is 1 for spring, 2 for summer, and 3 for fall) ($v_{t,s}$)	$v_{t,s} = w_s \cdot p_{t,s} \cdot m_s \cdot r_t$ $t = \{g, b\}$ $s = \{1, 2, 3\}$	• w_s = annual number of park visitors by season ($w_1 = 522,206; w_2 = 2,680,457; w_3 = 979,868$) • $p_{t,s}$ = the proportion of visitors who see a specific type of bear in a specific season ($p_{g,1} = .22; p_{g,2} = .15; p_{g,3} = .08; p_{b,1} = .46; p_{b,2} = .32; p_{b,3} = .16$) • m_s = the proportion of visitors, by season, who reported that seeing bears was one of the reasons they came to the park ($m_1 = .72; m_2 = .80; m_3 = .68$) • r_t = the proportion of people who prefer to see a specific type of bear ($r_g = 0.60 + 0.35 = 0.95; r_b = 0.60 + 0.05 = .65$)	w_s estimates come from National Park Service Visitor Use Statistics for Yellowstone National Park. $p_{t,s}$ and m_s estimates come from Duffield et al. (2006). r_t estimates come from Richardson et al (2014, 2015). They found that 60% of visitors had no preference between seeing grizzly versus black bears, 35% preferred seeing a grizzly bear, and 5% preferred seeing a black bear.
	Aggregate value from bear sightings ($A_{t,s}$)	$A_{t,s} = CS_t \cdot v_{t,s}$	• Variables defined above.	Multiplying the consumer surplus estimate from above by the relevant number of visitors yields aggregate value.

(*Continued*)

Table 1. (Continued).

Step	Component	Equation	Variables	Explanation
(4) Calculate the contribution of each individual animal to aggregate sighting value (i.e., calculate the average per-animal sighting value).	Sighting probability function, $(p_{t,s}(t))$	$p_{t,s}(t) = t \cdot \delta_{t,s}$ $0 \leq p_{t,s} \leq 1$	• $\delta_{t,s}$ is the slope (i.e., the change in probability of seeing a bear given an increase in the bear population by one bear).	Yields the proportion of visitors who see a given type of bear in a given season, as a function of the number of bears. The slopes are calculated as the changes in probabilities (current minus initial) over the changes in the numbers of bears (current minus initial).
	Expected sighting value per bear, by species and season $(\frac{\delta A_{t,s}}{\delta t})$	$\frac{\delta A_{t,s}}{\delta t} = CS_t \cdot w_s \cdot m_s \cdot r_t \cdot \delta_{t,s}$ $t = \{g, b\}$ $s = \{1, 2, 3\}$	• Variables defined above.	This amounts to taking the derivative of the aggregate value function with respect to the number of bears. The linear specification implies that the derivative of the sighting probability function is simply the slope of the line.

attributing a visitor's entire trip cost to the recreation site of interest may not be appropriate if individuals are visiting other sites or engaging in other unrelated activities on the same trip, as this could lead to biased consumer surplus estimates (Loomis, 2006; Loomis et al., 2000; Parsons & Wilson, 1997). We included a dummy variable in the travel cost models to account for visitors on multi-purpose/multi-destination trips and an interaction term (dummy variable multiplied by trip cost) to evaluate whether the slope of the demand function and resulting consumer surplus estimates are statistically different across trip purpose.

Step 2

We converted the value per bear viewing trip (step 1) to a value per bear sighting, using information on (1) the length of time that visitors spend in the park per day, and (2) the length of time that visitors spend engaged in a bear sighting. Most visitors see bears from roadside bear jams, for which there are duration estimates (e.g., see Haroldson & Gunther, 2013). This makes it possible to estimate the proportion of a day that a visitor who experiences a bear jam is expected to spend viewing bears. This step is an important extension of our work and captures a conservative reality that small changes in a wildlife population are not expected to affect an entire recreation day, but rather just the portion of the day spent viewing the species of interest. Many visitors that come primarily to view one species still engage in other activities on their visits, meaning the value of their trip is likely not entirely lost given reductions in sightings.

Step 3

To calculate the aggregate value of bear sightings, we multiplied the value per bear sighting (step 2) by the expected number of visitors who both see a bear and actually value a bear sighting. To obtain this expected number of visitors, we used visitation estimates for spring, summer, and fall from National Park Service (NPS) Visitor Use Statistics for Yellowstone National Park. We excluded winter visitation due to bear hibernation. We used an average of monthly visitation in the past five years, excluding 2020 and 2022 due to the COVID-19 pandemic and extensive flooding, respectively, which caused lower than average visitation. From that total, we used estimates of the proportion of visitors who see a specific type of bear by season, as provided by Duffield et al. (2006), to scale down from total visitors to visitors who are expected to see a bear. Duffield et al. (2006) also provide estimates of the proportion of visitors, by season, who reported that seeing grizzly bears or black bears was one of the reasons they came to the park. We used these estimates to scale down to visitors who came to the park in part to view bears. We then scaled down the number of visitors further to account for the possibility that some visitors who came to the park in part to view bears might only obtain value from seeing a certain type of bear (e.g., a person might value a black bear sighting but be afraid of grizzly bears). To do this, we relied on species-specific bear viewing preferences from Richardson et al (2014, 2015). Finally, we multiplied by the value per bear sighting to obtain aggregate value from bear sightings, by type of bear and season. We assumed that a visitor only obtains value from one bear sighting. This is supported by the results of the Yale visitor survey, which found that Yellowstone National Park visitors see a median of one bear per trip. However, it implies that our results are conservative.

Step 4

As a final step, we estimated the contribution of every individual bear to aggregate sighting value, also known as the per-animal viewing value, over a period of interest. We first expanded the sighting probabilities from step 3 by making them a function of the number of bears. As the known grizzly bear and suspected black bear population sizes have increased over time, there have been increases in observations of both types of bears from park roads (Haroldson & Gunther, 2013). We therefore assumed that the probability of seeing a bear is an increasing function of the underlying bear population size. If there were enough data points mapping out probabilities of seeing a bear under different bear population sizes, it would be possible to fit a nonlinear function to the data. For example, Enriquez and Finnoff (2021) assume that an increase in the number of Greater Yellowstone Ecosystem grizzly bears increases the probability of seeing a bear at a decreasing rate. Our application was narrower in geographical scope, and the number of bears in Yellowstone National Park has remained relatively constant over time. We thus used the simplest possible functional specification, a linear function, which amounts to assuming that every additional bear increases the chance of seeing a bear by the same amount regardless of whether the bear population is high or low. For simplicity, the only variable we included in the sighting probability function is bear population, but we aknowldge that other variables could contribute to visitors' chances of seeing a bear (e.g., visitation numbers, climate, abundance of bear resources such as whitebark pine, etc.).

Parameterizing a linear function requires two data points. The probability of seeing a bear in the park must be zero when there are zero bears, which supplies the first point. We used Duffield et al. (2006)'s estimates of the probabilities of seeing a bear across seasons as our best estimates for current sighting probabilities at current population sizes (the second point). Regarding current population sizes, there are approximately 150 grizzly bears with ranges that lie either entirely or partially within Yellowstone National Park (NPS, 2021). The corresponding black bear population has likely been increasing in size since the 1970s, but to our knowledge there are no recent total population estimates (e.g., see Haroldson & Gunther, 2013). We averaged the estimates reported in Cole (1976) to obtain an estimate of the current number of black bears in the park: 575.

Next, we calculated the change in aggregate sighting value given a change in the population of park bears by one bear. This amounts to taking a derivative of the aggregate value function (Table 1) with respect to the number of bears. Because we used a linear specification, the derivative is simply the slope of the line. After taking the derivative, one has information on the contribution that each individual bear makes toward aggregate sighting value over the period of interest (i.e., sighting value per individual animal). The linear sighting probability specification amounts to the value being an average (i.e., one could divide aggregate value by the number of bears to obtain the value per bear); however, more complicated sighting probability functions could be incorporated. We estimated the flow both by type of bear and by season, to reflect that sighting value is a dynamic concept. For example, differences in bear biology across the two types of bears might drive differences in where the species are found, which would in turn affect the probability of visitor sightings.

An underlying assumption in this step has been that all park bears can be seen by visitors in bear jams. However, park staff noted that it is possible that only 5% to 10% of bears use roadside habitats. Therefore, we conducted sensitivity analysis to show how the value per bear changes over different proportions of bears that are visible. When the proportions of bears that are visible are lower, a smaller number of bears are driving the entire aggregate viewing value, which naturally increases the value contributed by every individual bear.

Results

Summary Statistics

The final dataset for the travel cost model, focusing on those visitors who took at least one primary purpose bear viewing trip to Yellowstone National Park in the past 12 months, contained 307 observations (46% of survey respondents). Visitors took between one and fourteen bear viewing trips, with the majority taking only one trip. These visitors participated in a variety of other recreational activities on their trips, including geyser viewing and sightseeing. Visiting the park was the primary purpose/sole destination for the majority (85%) of respondents; it was one of several equally important destinations for 14% of respondents; and it was just an incidental visit for less than 1% of respondents. We present summary statistics for the explanatory variables used in the travel cost model in Table 2.

Value per Bear Viewing Trip (Travel Cost Model)

The results of an ordinary least squares regression model for on-site time, with the dependent variable specified as the number of days spent in the park on the visitor's most recent trip, is shown in Table 3. Both cost variable coefficients are statistically significant with the expected signs ($p = .027$ and $p < .001$). The number of days visitors choose to spend on-site during their trip to Yellowstone increases as the cost of traveling to the site increases, and decreases as on-site costs per day increase, all else constant. This is consistent with previous travel cost studies (Bell & Leeworthy, 1990; Pokki et al., 2020) and provides evidence of endogeneity of on-site time. As a result, consumer surplus will depend on parameters that determine on-site time, and the on-site cost per day should be included in the travel cost model (McConnell, 1992).

The results of a Poisson and negative binomial travel cost regression model corrected for truncation and endogenous stratification are shown in Table 4.[1] As expected, the coefficient on *Trip Cost* is negative and statistically significant ($p = .01$ and $p = .05$), confirming that the number of trips taken throughout the year decreases as trip costs increase, all else constant. The on-site cost variable is also

Table 2. Summary statistics for variables used in the travel cost models of visitor trips to Yellowstone National Park.

Variable	Description	Mean	Std. Dev.	N
Trip Cost	Visitor's transportation costs, entrance fee, & cost of travel time	\$291	\$370	298
On-site Cost	Visitor's daily cost of on-site time plus on-site daily expenditures	\$241	\$233	307
Multipurpose	= 1 if visitor is on a multi-purpose/multi-destination trip	.15	.36	307
Income	Visitor's annual income (U.S. \$10,000)	5.62	3.57	307
Age	Visitor's age	46.37	13.43	304
Gender	= 1 if male	.50	.50	305
Retired	= 1 if retired	.21	.41	307
Education	= 1 (some high school) – 5 (graduate degree)	3.94	0.95	303
Prefer Grizzly	= 1 if visitor prefers to see grizzly bears	.36	.48	307
Habituation	= 1 if visitor has no preference between seeing a habituated or wary bear	.49	.50	307

Table 3. Ordinary least squares regression model for on-site time per trip to Yellowstone National Park.

	Coefficient	p-value
Trip Cost	0.001**	.027
On-site Cost	−0.002***	<.001
Multipurpose	−0.223	.411
Income	−0.046	.144
Age	−0.007	.380
Gender	−0.094	.625
Retired	0.477	.105
Education	0.239*	.064
Prefer Grizzly	0.036	.859
Habituation	0.394*	.057
Constant	2.240***	<.001
N	288	
F(10, 277)	5.34	
Prob > F	.000	
R-squared	.129	

* $p < .10$; ** $p < .05$; *** $p < .01$.

Table 4. Travel cost model results for the Poisson and negative binomial specifications for trips to Yellowstone National Park.

	Poisson		Negative Binomial	
	Coefficient	p-value	Coefficient	p-value
Trip Cost	−0.004**	.012	−0.004*	.053
On-site Cost	−0.007***	.002	−0.004**	.036
Multipurpose	−0.546	.613	−0.180	.886
Multipurpose x Trip Cost	−0.005	.444	−0.001	.904
Income	−0.003	.981	−0.003	.981
Age	0.005	.774	0.016	.451
Gender	−0.947**	.034	−1.535***	.010
Retired	−1.878***	.006	−1.710*	.053
Education	−1.350***	<.001	−1.231***	<.001
Prefer Grizzly	2.469***	<.001	1.987***	<.001
Habituation	−3.689***	<.001	−3.356***	<.001
Constant	4.392***	<.001	−13.753	.981
ln(α)			17.118	0.977
N	292		292	
Log-likelihood	−82.21		−67.00	

* $p < .10$; ** $p < .05$; *** $p < .01$.

negative and statistically significant, supporting the hypothesis that as daily on-site costs increase, visitors choose to take fewer, yet longer, trips to the park throughout the year. Regarding multi-purpose/multi-destination visitors, the dummy variable *Multipurpose* is not statistically different from zero in either model, which indicates that trip purpose does not shift the demand function. The interaction term is also not statistically different from zero, suggesting that the slope of the demand function (and consumer surplus) does not differ according to trip purpose.

Based on the results of the likelihood ratio test comparing the Poisson and negative binomial models, we fail to reject the null hypothesis that alpha is equal to zero (X^2 $(1, N = 292) = .04$, $p = .422$). This suggests that overdispersion is not present and the negative binomial model is not needed. As a result, we focused on the results of the Poisson model. Using these results, consumer surplus per visitor per bear viewing trip is estimated at $305 (inflated to 2022 dollars using the Bureau of Labor Statistics Consumer Price Index).

Value per Bear Sighting

Given a median length of stay of two days, consumer surplus per visitor-day for a bear viewing trip to Yellowstone National Park is $153 with a 90% confidence interval of $57 to $549 (confidence intervals were estimated though bootstrap estimation using 1,000 replications and the approach outlined in Hole, 2007). This estimate falls well within the range of existing estimates for bear viewing in other locations (Clayton & Mendelsohn, 1993; Miller et al., 1998; Richardson et al., 2017). The value per bear sighting is $14.08 and $15.91 per black bear and grizzly bear sighting, respectively.

Aggregate Value

In Figure 1, we show the parameterized linear sighting probability function for grizzly bears and black bears. We list aggregate value, by type of bear and season, in Table 5. For either type of bear, the bulk of annual value is driven by summer sightings. This is because the majority of visitation to the park occurs in the summer. More value

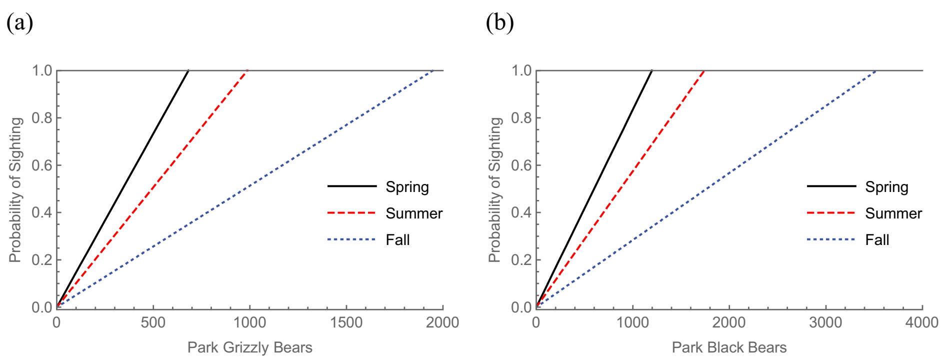

Figure 1. Parameterized functions, by season, for the linear probabilities of seeing a grizzly bear (plot a) and a black bear (plot b) in Yellowstone National Park. The solid, dashed, and dotted lines represent the probabilities in the spring, summer, and fall, respectively.

Table 5. Share of aggregate consumer surplus associated with time spent viewing bears in Yellowstone National Park, by type of bear and season.

	Aggregate Value ($)		
Season	Grizzly Bear	Black Bear	Both
Spring	1,242,717	1,576,882	2,819,599
Summer	4,909,660	6,207,720	11,117,380
Fall	774,269	954,031	1,728,300
Annual	6,926,645	8,738,634	15,665,279

Table 6. Sighting value per bear in Yellowstone National Park, by type of bear and season.

	Value per bear ($)	
Season	Grizzly Bear	Black Bear
Spring	8,285	2,742
Summer	32,731	10,796
Fall	5,162	1,659
Annual	46,178	15,198
Summer & Fall	37,893	12,455

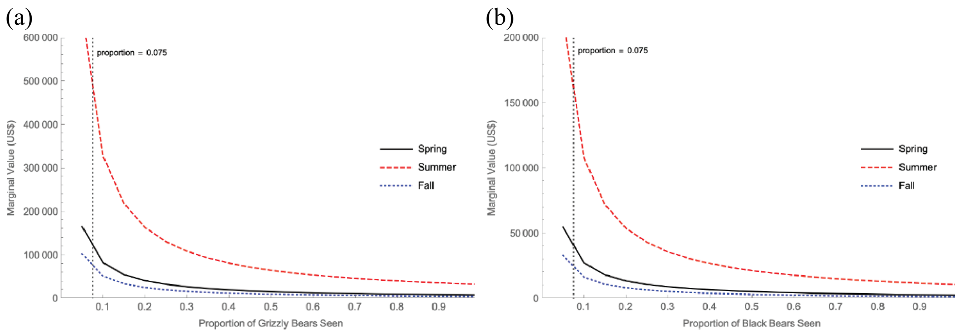

Figure 2. Sighting value per visible bear in Yellowstone National Park, by season, over the proportion of grizzly bears (plot a) and black bears (plot b) that are visible.

accrues from black bear sightings than grizzly bear sightings, which is driven in part by the probabilities of seeing a black bear being higher than the corresponding probabilities of seeing a grizzly bear.

Average Per-Animal Viewing Value

We show average per-bear viewing value estimates in Table 6. The seasonal values can be interpreted as the losses in aggregate sighting value from the loss of one bear prior to or at the beginning of a given season (e.g., due to human-caused mortality). If the lost bear is replaced by a new bear before the next season begins, then aggregate sighting value is only diminished for one season. The values in the bottom two rows of Table 6 represent the losses to visitors when a lost bear is not replaced before the next season begins. The “annual” row shows the losses if the bear is lost prior to or at the beginning of the spring season and then not replaced until the following year. The “summer & fall” row represents the losses if a bear is lost in the spring or at the beginning of the summer and not replaced until the following year.

The linear specification yields expected sighting values of $46,178 per grizzly bear and $15,198 per black bear, based on a five-year average of park visitation. We constructed the estimates in Table 6 under the assumption that visitors who strongly prefer to see a grizzly bear derive no value from black bear sightings (and vice versa), which leads to conservative values.[2]

In Figure 2, we show how the value per visible bear changes over different proportions of bears that are visible. Said differently, we show how the value per bear changes when smaller proportions of the total bear population contribute the bulk of viewing value. The values from Table 6 are the lower bounds of the possible per-bear values (they occur at a proportion of one). As the proportion decreases, the per-bear values increase nonlinearly. For example, since only 5% to 10% of the park's bears use roadside habitats, if we assume that 7.5% of the bear population contributes to sightings, the expected sighting values per bear are substantially larger than those in Table 6. This occurs because a substantially smaller number of bears contributes the entire viewing value. A loss of a roadside bear thus has the potential to significantly reduce economic value beyond what is shown in the table.

Discussion

Despite the global demand for wildlife viewing, there is limited information on the value recreationist derive from viewing specific species, especially in protected areas such as national parks. Numerous types of management actions and human-caused incidents (e.g., poaching) can reduce wildlife sightings despite having minimal effects on the overall size of wildlife populations, yet it is often not understood how such small-scale losses affect the value of the visitor experience. There is a significant need for this type of information for natural resource damage assessments, cost-benefit analyses, and a variety of other policy applications globally.

Using simple data on visitor behavior, wildlife sightings, and wildlife populations, we found societal economic values of roughly $6.9 million and $8.7 million annually for grizzly bear and black bear sightings in Yellowstone National Park, respectively. We found corresponding annual per-animal estimates of at least $46,000 for a grizzly bear and $15,000 for a black bear. In the absence of economically-grounded value estimates, managers may be forced to rely on proxy measures such as per-animal restitution values published by various state fish and wildlife agencies. Although these values are based on several criteria (see Edwards, 2017 for a discussion), to our knowledge, they do not incorporate nonmarket values such as those associated with the visitor experience. In the United States, four states have restitution values for brown/grizzly bears, averaging around $9,000 per bear. Numerous states have restitution values for black bears, averaging around $3,000 per bear. Our per-bear value estimates are five times these averages.[3] Although our estimates are much larger, they are still highly conservative estimates of the average value per bear for several reasons. First, we assumed that visitors derive no utility from a bear sighting if they do not list bears as one of their reasons for coming to the park. Second, our estimates captured only viewing value. They do not capture nonuse values stemming from the public's desire to protect wildlife, regardless of any recreational use. Quantifying nonuse values requires stated preference surveys, such as in Richardson and Lewis (2022).

Our analysis was provided in the absence of other appropriate valuation estimates and thus provided a needed first step to move beyond ad hoc estimates of per-animal values currently utilized. We demonstrated that the economic value of an individual animal depends on various factors, including seasonality and the individual animal's likelihood of being seen. The loss of an animal commonly seen from roadsides and popular visitor locations would result in a much larger loss of viewing value than the loss of an animal that frequents the backcountry and is less often seen by visitors. In national parks and protected areas around the world, there are numerous examples of individual animals that are widely known and recognized by photographers and wildlife viewers, and these animals are often given nicknames or identification numbers. Costello et al. (2023) explore the effect of this individuality and "charisma" of individual animals on wildlife viewing values, which represents an important area for future research.

Depending on the extent of available data, our approach is flexible enough to account for rich species-specific detail. For example, although we used simple sighting probability functions in which a visitor's chance of seeing a bear only depended on the number of bears in the wild, variables such as resource abundance, climate, and the timing of reproductive cycles may also affect sightings and could be incorporated into more complicated functional specifications. More advanced specifications could also be nonlinear (e.g., maybe the chance of seeing a bear increases at a decreasing rate as the number of bears increases). Current data gaps can make it challenging to accurately reflect on-the-ground realities, which highlights the importance of future primary data collection efforts that provide more information about wildlife sightings.

Our approach has broad applicability to other species and geographic locations. Species such as wolves, moose, mountain lion, bison, and bighorn sheep often rank highest in terms of visitor preferences for wildlife they would most like to see (Duffield et al., 2006; Richardson et al., 2014). As a result, these species could be good candidates for further human dimensions research. Sighting probabilities and other aspects of the viewing experience can vary widely, which could lead to interesting differences in flows of nonmarket values by species.

Disclaimers

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Views and conclusions in this article are those of the authors and do not necessarily reflect the opinions or policies of the National Park Service. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the National Park Service.

Notes

1. The negative binomial model was estimated using the *nbstrat* command in Stata 14 (Hilbe & Martínez-Espiñeira, 2005).
2. Ignoring the assumption would result in an annual value of roughly $48,608 for a single grizzly bear and $23,381 for a single black bear. The increase in annual value compared to the baseline is substantially larger for black bears. This occurs because, under the baseline, a substantially larger proportion of respondents prefer to see grizzly bears over black bears (35% versus 5%). When eliminating that difference in preferences, there is an increase in 35% of visitors who gain value from black bear sightings, as opposed to an increase in just 5% of visitors who gain value from grizzly bear sightings.
3. State restitution values vary considerable across states. Relevant to Yellowstone National Park, the state of Wyoming uses a value of $5,000 per black bear and $25,000 per grizzly. Montana uses a value of $1,000 per black bear and $8,000 per grizzly. Idaho uses a value of $400 per black bear.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Leslie Richardson & Aaron J. Enriquez

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