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Estimating the effects of fish quality and size on the economic value of fishing in Oklahoma streams and rivers: A revealed preference and contingent behavior approach

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ABSTRACT

Fishing in Oklahoma's rivers and streams provides a unique experience for anglers in the state. Despite its popularity, information on total demand and economic benefits associated with stream fishing is limited in the state. Research on the role of site quality indicators, such as fish size and quantity, on recreational fishing has shown mixed results. Whether fish size or quantity plays an important role in determining fishing demand and economic value may have important management implications. We estimated the demand and economic value of fishing under varying scenarios by using anglers' responses to hypothetical behavioral questions related to fishing in Ozark Highland streams and rivers in Oklahoma. We asked how intended number of trips might change in the future given hypothetical increases in catch rates of fish, catch rates of trophy-sized fish, and catch rates of preferred fish species, in combination with anglers' trip-related data. Under current conditions, we estimated consumer surplus per person per trip to be \$55 and aggregate value across all stream anglers in Oklahoma to be \$68.51 million. Changes in marginal benefits varied among hypothetical scenarios of fish size and abundance but was maximized with a 25% increase in catch rates of trophy-sized fish. The study findings contribute to the understanding of the economic benefit of fishing in streams and suggest that fish size, rather than fish quantity, is more important to stream anglers in the area.

1. Introduction

1.1. Background

Fishing is a recreational activity with important socio-economic and cultural significance in the United States, contributing to more than 800,000 jobs with an overall economic value exceeding \$115 billion (American Sportfishing Association [ASA], 2013). The major source of economic impact generated from recreational fishing is expenditures on angling products and services such as food, lodging, transportation, and fishing equipment (ASA, 2013). Moreover, fishing was the second-most pursued wildlife-related recreational activity in the United States, followed only by wildlife watching (U.S. Fish and Wildlife Service, 2016) In 2016, 30.1 million anglers took 322 million fishing trips in freshwater habitats and spent about \$29.9 billion (U.S. Fish and Wildlife Service, 2016) and the average angler in Oklahoma spent approximately 31 days per year pursuing their sport (Jager, 2015). Fishing also provides an opportunity for outdoor retreats as a recreation activity of cultural significance (Hunt and Grado, 2010).

However, the prominence of fishing as a recreational activity is declining in the United States (Hutt and Neal, 2010). The decline could be driven, in part, from a demographic shift of the country toward a greater composition of racial minorities because Whites have disproportionately participated in angling activities as compared to racial minorities (Hunt et al., 2007; U.S. Fish and Wildlife Service, 2016). Racial identity may be an important factor to consider when evaluating fisheries under changing demographics. For example, in Oklahoma, the views of Native Americans have rarely been integrated into fisheries

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management. In the Ozark Highlands, Native Americans potentially represent a larger number of stream anglers because of its location within the boundaries of the Cherokee Nation. Past studies have indicated that angling motivations and preferences among racial minorities are often different compared to White anglers (Hunt and Grado, 2010; Hunt et al., 2007). Demographic characteristics such as education are negatively associated with angling participation for racial minorities while it generally positive for White anglers (Lee et al., 2016). In terms of preferences for facilities, minority groups tend to prefer well-established sites with visible docks and walkways as a place to fish (Valdez et al., 2019).

Fishing site attributes also play an important role in determining an angler's decision to fish at a particular site (Hutt and Neal, 2010; Melstrom et al., 2015). For example, Melstrom et al. (2015) indicated that fish abundance played a positive role in angler decisions to visit certain rivers and streams. Similarly, proximity to a fishing location, safe environment, and site facilities (restrooms, shelter, etc.) play an important role in an angler's decision to select a site (Hutt and Neal, 2010). Past studies have also acknowledged the role of both consumptive and non-consumptive attributes of fishing sites in anglers' motivation to go fishing and satisfaction from the fishing experience (e.g. Arlinghaus, 2006; Connelly and Brown, 2000; Hutt and Neal, 2010; McCormick and Porter, 2014). Place attachment or emotional bond between individual and place influences recreationists satisfaction with a place or recreation site (Ramkissoon et al., 2013). Place dependence or satisfaction associated with functional attachments of a site in meeting recreational needs, in which anglers display fidelity to particular fishing sites regardless of availability of similar sites, has also been documented with respect to recreation demand (Hailu et al., 2005; Stylidis, 2018). Place dependence positively influences recreationists' place satisfaction (Ramkissoon et al., 2013), but place dependency may not necessarily affect recreation demand significantly (Hailu et al., 2005).

In Oklahoma, most anglers fish standing waters (lakes, reservoirs, ponds) while only 45% of anglers fish in rivers, streams, and creeks (Jager, 2015). However, fishing in rivers and streams is concentrated in the eastern part of the state, particularly for bass (Centrarchidae: *Micropterus*) (Fisher et al., 2002). How stream anglers prioritize fishing location attributes is unknown in eastern Oklahoma, but, in general, the number of access points and status of facilities at fishing sites has been shown to affect angling experience in other systems (Connelly et al., 2013). In addition, river-specific attributes such as turbidity, length of river available for fishing, and ease of floating may play important roles when choosing a fishing site (Ji et al., 2016). Surveys on such important information can help fisheries management agencies design programs to meet the interests and needs of anglers (Hutt and Neal, 2010; York, 2019).

Among site attributes, fish size and quality are considered important determinants of fishing demand (Alberini et al., 2007; Deely et al., 2019; Melstrom et al., 2015). Furthermore, different approaches such as travel cost (Deely et al., 2019), choice models (Hunt, 2005), and contingent behavior models (Alberini et al., 2007; Prayaga et al., 2010), have been used to quantify the effect of these factors on demand and economic value. However, these studies have found mixed results from significantly positive (Deely et al., 2019) to no relationship between fish size and quality with economic value (Alberini et al., 2007; Prayaga et al., 2010). In a pooled revealed preference and contingent behavior model, the actual trip frequencies are combined with stated trip frequencies for future scenarios to form a panel data set (Deely et al., 2019). This approach has been particularly useful in fisheries studies examining the impact of changes in price, water levels, and water clarity on fishing demand (Egan and Herriges, 2003; Eiswerth et al., 2000; Englin and Cameron, 1996). However, only a few studies, in Australia and Europe, have applied this approach to understanding the impact of change in catch rate on fishing participation (Alberini et al., 2007; Deely et al., 2019; Prayaga et al., 2010). To our knowledge, the effect of fish size and quantity on economic value in freshwater streams has not been conducted in the United States.

The purpose of this study was to estimate the effect that fish quantity and fish size may have on the frequency of trips to rivers and streams for Oklahoma anglers, in turn, allowing estimation of the potential effect of economic benefits to anglers from fishing. We combined data related to anglers' current and intended fishing trips in Oklahoma rivers and streams to explore the effect of (a) an increase in catch rate, (b) an increase in catch rate of preferred species, and (c) an increase in catch rate of trophy-sized fish, on fishing trips in Oklahoma. Likewise, given the importance of socio- psychological factors in fishing participation (Hunt and Grado, 2010; Hutt and Neal, 2010), we also identified the role of place dependence and demographics on fishing demand.

Our research contributes to the state of current knowledge in three unique ways. First, we used the travel cost method to estimate welfare associated with angler's current and future trips in Oklahoma streams and rivers. Second, we studied the interconnections between fishing demand and satisfaction coming from place dependence to reflect functional attachment to a site in achieving the specific recreational goal. To this end, our study extended the recreational demand model by investigating influence of place dependence on fishing demand. Finally, despite active programs to increase participation of minorities in recreational fishing in the United States, only a few studies have examined race dynamics in catch-related preferences (Hunt et al., 2007). The present study estimated the demand of anglers in Oklahoma streams and rivers in an area predominated by Native Americans.

2. Materials and methods

2.1. Data collection

We employed a mixed-mode survey methodology for data collection including onsite handover and mail back questionnaires, mail survey packets (a personalized cover letter, questionnaire, and a business reply envelope), and a web-based questionnaire (Dillman et al., 2014; Vaske, 2019). Field biologists, social scientists, and experts on non-market valuation methods reviewed and provided feedback on the draft survey and the survey protocol was approved by Oklahoma State University's Institutional Review Board (IRB Approval # AG-19–12). The survey instrument included four sections. In the first section, we asked questions related to angling experiences, travel distance to fishing site, preferred species, party size, and number of trips to Oklahoma rivers, streams, and creeks. The series of trip frequency questions provided revealed preference and contingent behavior data for hypothetical scenarios of different catch rates (Table 1). The second section included specific information about black bass, including Smallmouth Bass (*Micropterus dolomieu*), which is the most pursued species of the genus in eastern Oklahoma (Chapagain et al., 2020a). This section also included discrete choice questions related to black bass fishing sites, in which

Table 1
Revealed preference and contingent behavior questions asked to the respondents.

Revealed preference
How many times did you go fishing in Oklahoma in the past 12 months including your most recent trip
Contingent behavior
How many trips do you intend on taking only in rivers, streams, and creeks in the next 12 months in Oklahoma?
If there were a 10% increase in catch rate, how many trips would you take?
If there were a 25% increase in catch rate, how many trips would you take?
If there were a 10% increase in catch rate of fish species you prefer the most, how many trips would you take?
If there were a 25% increase in catch rate fish species you prefer the most, how many trips would you take?
If there were a 10% increase in catch rate of trophy-sized fish, how many trips would you take?
If there were a 25% increase in catch rate of trophy-sized fish, how many trips would you take?

respondents were asked to indicate their most and least important characteristics when deciding where to fish. The third section included questions about anglers' perceptions and motivations to fish streams and rivers in Oklahoma. Finally, the fourth section was designed to gain socio-economic characteristics of the respondent. A complete copy of the survey questionnaire is available upon request.

For onsite distribution, a survey instrument with business reply envelope was handed to anglers at various access points along three streams in the Ozark Highlands of eastern Oklahoma: the Illinois River (above Lake Tenkiller), Baron Fork, and Caney Creek. These three river systems are in close proximity to each other and are popular for bass fishing. However, they differ in terms of size (i.e., length, area, discharge), and number of public access points, providing different levels of fishing opportunities (Chapagain et al., 2020a). However, due to excessive rain and flooding during the summer of 2019, only 37 surveys were returned with this method. To increase sample size, the survey was then mailed to an additional 1015 anglers with Oklahoma fishing licenses. This sample was stratified to target the zip codes from which anglers had visited our study rivers or had returned fish tags implanted in bass in these rivers as part of another study (Chapagain et al., 2020a). The mail survey followed protocols suggested by the Dillman Tailored Design Method (Dillman et al., 2014), which included a survey packet with a personalized cover letter, survey, and a postage-paid, business reply envelope. After accounting for 187 undeliverable addresses, we received 64 completed surveys for an adjusted response rate of 8.04%. Finally, an online version of the survey was emailed to 1671 anglers using the Qualtrics survey platform (Qualtrics, 2020). The desired email addresses for this electronic database were solicited from creel surveys, tag returns, social media, online fishing forums, and the Oklahoma fishing license database. In total, we received 101 responses from the web-based questionnaire, with an adjusted response rate of about 7.8% after accounting for 373 incorrect email addresses.

To calculate the cost of travel, only the cost of vehicle depreciation, gas, and upkeep (such as oil, repairs, maintenance, and tires) were considered for the mileage rate (Parsons, 2017). Following a commonly used practice in travel cost literature, we used variable operating cost for large sedan i.e., \$0.14 per km, to apply evenly across all anglers surveyed rate (American Automobile Association [AAA], 2019). The cost of travel was thus the product of round-trip driving distance and mileage rate. Similarly, we used the most common practice for valuing travel time as one-third of hourly wage rate as an opportunity cost of time (Lankia et al., 2019; Parsons, 2017). The wage rate was calculated by dividing household income by total number of working hours in a year (i.e., 2080 h). Travel cost was the sum of cost of travel plus opportunity cost of time in travel. To address non-response and mixed-mode biases (Dillman et al., 2014), we conducted a standard check by conducting chi-square tests and *t*-tests on key demographics (age, gender, race, education, income) between early respondents (i.e., those who responded before sending a reminder) and those who responded after sending reminders in the mail and web-based survey (Joshi et al., 2019; Thompson and Hansen, 2012). Likewise, we compared socioeconomic information from the latest Oklahoma Department of Wildlife Conservation's (ODWC) angler report to our results for bias (Joshi et al., 2019; Thompson and Hansen, 2012). Finally, because data were collected three different ways, we compared angler opinions about site attachment among the online, onsite mail-back, and mail survey respondents. Because data were collected through a mixed-mode approach, we also tested whether the mixed method influenced our sample respondents in terms of their angling behavior and consequently the need for any transformation in our analysis. We tested respondents' age and household income for normality with Shapiro-Francia test, which showed our data to be non-normal (Mbah and Paothong, 2015). As a result, we used non-parametric Kruskal-Wallis tests ($P < 0.05$) for all demographic characteristics (i.e., education, race, gender, age, and household income) to determine significant differences in respondent characteristics by different modes, followed by a Dunn's test ($P < 0.05$) with Bonferroni correction to compare between two different modes.

$$P(Ki = Ki|K > 0) = \frac{\Gamma\left(\frac{1}{\beta} + K_i\right)}{\Gamma\left(\frac{1}{\beta}\right)\Gamma(K_i + 1)} \cdot \frac{(\alpha\lambda_i)^{K_i}\quad(1 + \beta\lambda_i)^{-\left(\frac{1}{\alpha\beta} + k\right)}}{1 - (1 + \beta\lambda_i)^{-\left(\frac{1}{\beta}\right)}}, \text{where } ki = 1, 2 \ldots n, \beta > 0. \tag{2}$$

2.2. Conceptual model

The foundation for our demand analysis is built on the premise of the travel cost method (Haab and McConnell, 2002). The method is a demand-based model for recreational use where the number of trips taken by an individual to a site or multiple sites is modeled as a function of cost to reach the site and other demographic factors (Parsons, 2017). The empirical process of the method involves estimating the parameters of the demand function and calculation of welfare measures based on estimated parameters. Because anglers chose a given river, stream, or creek from among many available alternatives when they were surveyed, the cost of their travel to reach that site reflects demand (Haab and McConnell, 2002). As such, this situation can be depicted with a generic demand model:

$$\sum_{j=1}^{n} K_{ij}B_{ij} + M_i \leq N_i, \tag{1}$$

where K_{ij} represents angling trips by an angler i to site j, B_{ij} cost of commute, M_i expenses incurred during the visit, and N_i total income. Because the response variable in the travel demand function depicting the number of angling trips is an integer, we used a negative binomial regression model, expressed as (Yen and Adamowicz, 1993):

In Eq. (2), K_i represents the number of angling trips and K_i is its realized value (Yen and Adamowicz, 1993). Similarly, two key attributes of the above relationship, the gamma function and over-dispersion parameters, are presented by Γ and β, respectively. Finally, the following relationship describes its distribution function of this regression framework (λ_i):

$$\lambda_i = \exp(x_i\alpha) \tag{3}$$

In Eq. (3), x_i and α are the vectors of explanatory variables and their parameter coefficients, respectively.

2.3. Empirical model

In basic demand function literature, the empirical research suggests that socio-economic attributes, as well as the availability of substitute sites, play important roles in trip demand (Haab and McConnell, 2002; Joshi et al., 2017).

$$Trip = f(travelcost, sociodemopgrahics, substitute, relatedvariables) \tag{4}$$

Following the demand curve represented by Eq. (4) above, consumer surplus (CS) of an individual fishing trip is computed as the area under the demand curve and above the average cost line; mathematically, the area is equal to the negative inverse of the travel cost coefficient. Therefore, the resulting CS can be divided by party size to yield per-person per-trip value as shown in Eq. (5):

$$CS = \frac{-1}{\alpha_{Tcost}} \tag{5}$$

In Eq. (5), α_{Tcost} represents the estimated parameter of the travel cost variable. We calculated the upper and lower bounds of the confidence interval of the travel cost coefficient through bootstrapping the standard errors to calculate the confidence interval of CS (Kling and Sexton, 1990). We used negative binomial regression instead of Poisson because a test of over-dispersion using the likelihood ratio test rejected the null hypothesis that mean and variance were equal. We used negative binomial regression models by following past recreation demand studies (Deely et al., 2019; Lankia et al., 2019; Prayaga et al., 2010) to combine contingent behavior responses with revealed trip responses by using panel negative binomial regression. Separate models were estimated for each contingent behavior scenario, and panel data of three different data sets was formed for each scenario. Each model included responses of trips taken in the past 12 months before completing the survey, number of trips respondents intended to take in the next 12 months under a status quo condition, and annual trips the respondent would take under different scenarios of increased catch rate. Each panel data set included a dummy variable indicating if the data is related to number of trips in the last 12 months, and a dummy representing contingent behavior data. The base category for each panel set was a dummy for number of trips in the future under status quo condition. A random-effects panel negative binomial model was estimated for each contingent behavior model. All the contingent behavior scenarios were compared to the estimated future trips and economic values under the status quo condition. Change in demand was estimated by calculating the difference in predicted change in status quo condition and increased catch rates. The marginal economic effect, which provides additional value associated with changes in contingent behavior, was calculated using the following formula (Prayaga et al., 2010; Deely et al., 2019):

$$Marginal\ \ effect = \beta_{cb} * \left(\frac{-1}{\beta_{Tcost}}\right) \tag{6}$$

where β_{cb} is the coefficient for contingent behavior dummies for each contingent behavior scenario.

To calculate the total annual economic benefits of fishing in Oklahoma streams and rivers, we used data collected by ODWC (Jager, 2015; York, 2019) and estimated the number of stream anglers in the state. York (2019) estimated there were 757,469 anglers in Oklahoma, including resident and non-resident anglers, as well as annual and lifetime license holders. Among lifetime license holders, approximately 80% go fishing every year in Oklahoma (Jager, 2015). Also, approximately 13% of licensed anglers fished most often in rivers, streams, and creeks (Jager, 2015). Therefore, on average, we estimated that 81,731 anglers fish in Oklahoma rivers and streams, annually.

The total number of trips in the last 12 months to Oklahoma streams and rivers served as a dependent variable in the travel cost model (Table 1). Similarly, total visits in the past 12 months, visits intended for the next 12 months, and intended future visits under hypothetical scenarios of increased catch rates were dependent variables for the contingent behavior models.

Consistent with previous research on recreation demand (Deely et al., 2019; Joshi et al., 2017), we chose age, income, and race as socio-demographic variables in the model. In particular, the variable “income” captures the ‘income effect’ in the demand model. Likewise, expenses to visit another similar fishing site (substitute cost) were chosen as an independent variable to capture the substitution effect (Chapagain et al., 2020b). Respondents were asked where they would have fished if, for some reason, they were not able to visit their most recently visited fishing site. Finally, other variables such as group size, experience, identity as a bass angler, and membership of a fishing group were also considered for the regression analysis (Chapagain et al., 2020b; Deely et al., 2019). Stata version 16.1 was used for data cleaning and analysis, and we used *nbreg* and *xtnbreg* commands for revealed preference and contingent behavior models, respectively. We did not

Table 2
Definition and descriptive statistics of variables used in the models.

Variable	Definition	Mean	Std. Dev.
Dependent			
Current Trips	Fishing trips in Oklahoma rivers and streams in last 12 months	13.37	20.64
Intend trips	Intended trips in next 12 months under status quo	17.24	27.49
Rate10	Intended trips if catch rate increase by 10%	18.44	27.69
Rate25	Intended trips if catch rate increase by 25%	20.65	28.99
Prefer10	Intended trips if catch rate of the most preferred species increase by 10%	20.49	28.52
Prefer25	Intended trips if catch rate of the most preferred species increase by 25%	23.11	29.61
Size10	Intended trips if catch rate of trophy-sized fish increase by 10%	20.70	28.81
Size25	Intended trips if catch rate of trophy-sized fish increase by 25%	23.64	30.90
Price			
Travel cost	Travel cost with opportunity cost based on 33% of wage	\$35.91	\$34.54
Socio-economic			
Income	Mean annual household income (in thousands)	\$85.65	\$36.66
Age	Age of the respondents	50.26	15.51
Native American	A dummy variable, 1 if the race of the respondent is Native American, and 0 otherwise	0.26	0.44
Other			
Substitute cost	Travel cost to reach a substitute fishing site	\$47.41	\$49.70
Current	A dummy variable, 1 if dependent variable in panel describes trips in past 12 months, and 0 otherwise	–	–
Future	A dummy variable, 1 if dependent variable in panel describes trips in next 12 months under status quo, and 0 otherwise (served as base variable)	–	–
Scenario	A dummy variable, 1 if dependent variable in panel describes contingent scenario, and 0 otherwise	–	–
Group size	Number of individuals in the group	2.15	0.87
Experience	Number of years fishing in Oklahoma	35.85	17.05
Bass angler	Dummy variable, 1 if the respondent has taken bass fishing trips in last 12 months	0.76	0.43
Member	Dummy variable, 1 if the respondent is a member of fishing group or online forum	0.30	0.46
Satisfaction	A variable representing place dependence i.e., whether respondent gets more satisfaction visiting the most visited fishing site than any other sites (measured on a Likert Scale from 1 to 5; 1 = strongly disagree, 5 = strongly agree)	3.23	1.07

apply corrections for endogenous stratification (i.e., frequent visitors are more likely to be sampled than less-frequent visitors) and zero-truncation (i.e., respondents must have taken at least one trip). These artifacts often exist in data collected onsite, but onside data represented only a small portion of total responses in our study. Moreover, past studies have shown that endogenous stratification had insignificant effects on coefficient estimates and economic values (e.g., Dobbs, 1993; Shrestha et al., 2002).

3. Results

Out of 202 returned surveys, 188 complete surveys were available for final analysis in the revealed preference model after dropping observations with incomplete information for variables used in the analysis. Respondent demographics from our survey were similar to results from a state-wide study (Jager, 2015), suggesting minimal non-response bias (Table 2). In our survey, average age of respondents was 50 years (SD ± 15.51) and a majority of respondents were White (72%), with an average household income of about $86,000 (SD ± $36,660). The average cost of travel from respondent's home to fishing site was $36 (SD ± $34.54). Jager (2015) reported that anglers in Oklahoma were on average 48 years old and mostly White (84%). In our survey, 26% of respondents identified as Native American and almost two-fifths of the respondents held a bachelor's or graduate degree. Average group size was around 2.6 people (SD ± 1.11). Almost one-third of respondents to our survey were members of a fishing group or online forum. On average, respondents to our survey had 36 years (SD ± 17.05) of fishing experience, and they traveled approximately 68 km (SD ± 82.6) to their fishing sites (compared to 63 km for statewide anglers; Jager, 2015). Likewise, we did not find any statistical difference between early and late respondents.

While comparing responses from the three different modes of our survey, we did not find any statistical variations ($P < 0.05$) between eight out of nine statements about how emotionally attached respondents were to the site they fished most recently. Among five demographic characteristics (education, race, gender, age, and household income), only age and income were significantly different for the three different survey modes. The age of mail respondents (59.02 ± 15.5) was significantly greater than the age of the respondents for the other two groups (50.95 ± 16.5) while household income for mail respondents (77,844.87 ± 37,736.1) was significantly lower than respondent's answers obtained through the internet (90,981.75 ± 35,162.9). Although mode effects are important statistical considerations in survey-based research, Dillman et al. (2009) found that data collected through mail and web respondents behaved similarly, so we aggregated angler responses by survey mode for further analysis.

Table 3
Regression estimates and incident rate ratios (IRR) of fishing in Oklahoma streams and rivers with assumption of wage rate included (N = 188).

Variables	Coefficient	Std. error	IRR
Travel cost	-0.008[a]	0.00	0.99
Income	-0.003	0.00	0.99
Age	-0.026[a]	0.01	0.97
Substitute cost	0.002	0.00	1.00
Group size	0.029	0.10	1.04
Experience	0.008	0.01	1.01
Bass angler	0.413[c]	0.22	1.51
Member	0.498[b]	0.20	1.64
Native American	0.131	0.23	1.04
Satisfaction	0.174[b]	0.09	1.19
Constant	2.792[a]	0.55	16.94
Log likelihood	-645.074		
Pseudo R^2	0.036		

[a] Indicates significant at 1%,
[b] Indicates significant at 5%,
[c] Indicates significant at 10%.

3.1. Revealed preference model

Among the independent variables, coefficients for travel cost, age, bass angler, member, and satisfaction were significantly different ($P < 0.1$) (Table 3). Categorically, travel cost and age were negative, but bass angler, member of fishing group or online forum, and level of satisfaction were positive. Incident rate ratio (IRR) estimates indicate how changes in the variable under consideration, with all other variables are held constant, would result in proportional changes in angling participation rate. For example, increasing the age of respondents by 1 year would result in a proportional change of 0.97 in angling participation rate. Our model showed that the predicted number of fishing trips in Oklahoma Ozark Highlands rivers and streams was 13.3 per year (Table 3). In terms of species, the predicted number of trips per year for bass anglers (those who have taken at least 1 trip) was 14.2 compared to only 9.38 trips for non-bass anglers. The predicted number of trips for a member of a fishing group and online forums was 18.18, whereas trips for non-members were 11.10. Using the coefficient of our travel cost variable (Table 3) and equation (Eq. (5)), the estimated CS per person per trip was $55, with confidence intervals through bootstrapping the standard errors ranging from $44 to $72. Our results indicated that anglers took, on average, 15.24 trips to rivers and streams. Using CS per-person per-trip ($55), predicted fishing trips in streams and rivers (15.24), and the estimated total number of Oklahoma stream and river anglers (81,731), we estimated the statewide net benefit of fishing in streams and rivers to be $68.51 million, with a confidence interval of $54.81 million and $90.93 million.

3.2. Contingent behavior models

The random-effects panel negative binomial models were estimated for each contingent behavior model (Table 4). The total number of observations for each panel set for contingent models was 564 (i.e., 3 times 188). The dependent variable for each model included responses from current trips, future trips under status quo condition, and intended trips under improved fishing conditions. The levels of significance differed but signs of the coefficients associated with all variables are consistent across all six models (Table 4). The dummy for current trips was negative and significant across the board at the 1% level, suggesting that anglers took fewer trips in the last 12 months than the number of trips they intended to take in the future (which is the base category in the regression). Similarly, all dummy variables representing contingent behavior in the future were positive and significant suggesting that they are likely to take more trips under "improved" fishing conditions with a higher catch rate. Compared to the revealed preference model, the coefficient for bass angler satisfaction was not significant but the coefficient representing Native Americans was significant across the models.

Predicted change in demand and marginal effect in economic value varied for each of the contingent models (Table 5). Regarding the predicted number of fishing trips, models predicted that respondents would take the most trips for trophy-sized fish, and an increase in trip numbers was as high as 54% (i.e., an increase of 9 trips within 12 months when the catch rate of trophy-sized fish increased by 25%; Table 5). The marginal effect on economic value due to improvement in catch rate was highest ($32.23) when the catch rate of trophy-sized fish increased by 25%, however, this marginal effect was close to scenarios for preferred species ($27.25). Increased catch rate of trophy-sized fish resulted in a higher percentage increase in demand and economic value than the percentage increase due to an increase in catch rate only, suggesting that size of fish is more important to anglers than fish quantity. Using predicted change in annual visits and marginal change in economic value (Table 5), in conjunction with the estimated number of Oklahoma stream and river anglers (81,731), we estimated an increase of $1.48 million for a 10% increase in catch rate. Alternatively, we estimated an increase as high as $24.58 million for a 25% increase in catch rate of trophy-sized fish.

Table 4
Random effect negative binomial regression estimates for contingent behavior models (N = 564) of anglers fishing Oklahoma streams and rivers.

Variable	Quantity		Preferred species		Trophy-sized fish	
	10% increase Coef. (SE)	25% increase Coef. (SE)	10% increase Coef. (SE)	25% increase Coef. (SE)	10% increase Coef. (SE)	25% increase Coef. (SE)
Travel cost	-0.007[b] (0.00)	-0.006[b] (0.00)	-0.006[b] (0.00)	-0.006[b] (0.00)	-0.006[b] (0.00)	-0.005[b] (0.00)
Current	-0.275[a] (0.09)	-0.274[a] (0.04)	-0.276[a] (0.05)	-0.276[a] (0.05)	-0.277[a] (0.04)	-0.276[a] (0.05)
10% increase in quantity	0.078[b] (0.08)	–	–	–	–	–
25% increase in quantity	–	0.221[a] (0.04)	–	–	–	–
10% increase in preferred species	–	–	0.203[a] (0.04)	–	–	–
25% increase in preferred species	–	–	–	0.335[b] (0.04)	–	–
10% increase in size	–	–	–	–	0.210[b] (0.04)	–
25% increase in size	–	–	–	–	–	0.363[a] (0.04)
Income	-0.004 (0.00)	-0.003 (0.00)	-0.003 (0.00)	-0.002 (0.00)	-0.004[c] (0.00)	-0.002 (0.00)
Age	-0.023[a] (0.00)	-0.020[a] (0.01)	-0.020[a] (0.01)	-0.018[a] (0.01)	-0.021[a] (0.01)	-0.019[a] (0.01)
Substitute cost	0.001 (0.00)	0.0003 (0.00)	0.0003 (0.00)	0.0004 (0.00)	0.0002 (0.00)	0.0003(0.00)
Group size	0.183[b] (0.04)	0.154[b] (0.08)	0.152[c] (0.08)	0.112 (0.08)	0.167[c] (0.08)	0.140[c] (0.08)
Experience	-0.001 (0.00)	0.0002 (0.01)	0.002 (0.01)	0.003 (0.01)	0.002 (0.01)	0.001 (0.01)
Bass angler	0.120 (0.09)	0.111 (0.18)	0.132 (0.18)	0.147 (0.17)	0.138 (0.18)	0.154 (0.17)
Member	0.534[a] (0.08)	0.468[a] (0.17)	0.477[b] (0.17)	0.439[a] (0.16)	0.501[a] (0.17)	0.456[b] (0.16)
Native American	0.337[c] (0.08)	0.340[c] (0.17)	0.299[c] (0.17)	0.251[c] (0.16)	0.368[b] (0.17)	0.326[b] (0.16)
Satisfaction	0.023 (0.03)	0.057 (0.07)	0.031 (0.07)	0.039 (0.07)	0.037 (0.07)	0.052 (0.07)
Constant	3.784[a] (0.25)	3.268[a] (0.55)	3.243[a] (0.56)	2.874[a] (0.53)	3.308[a] (0.56)	2.855[a] (0.53)
Log likelihood	-1781.49	-1820.55	-1832.94	-1878.60	-1827.84	-1871.12
Akaike Information Criterion (AIC)	3592.99	3671.11	3695.88	3787.22	3685.68	3772.24

Coef. stands for coefficient, SE stands for standard error,
[a] Indicates significant at 1%,
[b] Indicates significant at 5%,
[c] Indicates significant at 10%.

Table 5
Predicted trip, changes in number of trips and the marginal effect in economic benefits due to contingent behavior of anglers fishing in Oklahoma streams and rivers.

Contingent behavior	Catch rate	Visits		Consumer surplus		
		Predicted annual rate	Change in rate	Per person per trip	Marginal effect	
					Per person per trip	Aggregate benefit (millions)
Quantity (catch rate)	10% increase	20.4	3.2	$71.21	$5.58	$1.48
	25% increase	22.3	5.1	$76.43	$16.87	$7.05
Preferred species	10% increase	22.7	5.5	$78.18	$15.84	$7.08
	25% increase	26.1	8.9	$81.63	$27.35	$19.87
Trophy-sized fish	10% increase	23.4	6.2	$81.56	$17.10	$8.64
	25% increase	26.5	9.3	$88.75	$32.23	$24.58

Note: All the contingent behavior scenarios were compared to the estimated annual visits to the (future) status quo (17.2) and CS value.

4. Discussion

Overall, our results provide important insights into demand and economic value of stream fishing. In the revealed preference model, the negative sign and statistical significance of the travel cost variable suggest that higher costs reduce fishing trip frequency, which is typical recreational demand behavior (Haab and McConnell, 2002; Joshi et al., 2017). This relationship between travel cost and intended trip frequency was also prevalent in the contingent behavior models, which is consistent with previous literature (Deely et al., 2019; Prayaga et al., 2010). Our results suggested that income and substitution effects over angling trip demand were trivial in both revealed preference and contingent behavior models, which is consistent with past recreational studies (e.g. Alberini et al., 2007; Bowker et al., 2007; Bowker and Leeworthy, 1998; Deely et al., 2019; Joshi et al., 2017; Ovaskainen et al., 2012).

The aggregate benefits estimation showed a substantial benefit of fishing opportunities to Oklahoma anglers in streams and rivers. Therefore, the results of this study illustrate the public value of fishing and provide a strong economic reason for maintaining fishing opportunities in Oklahoma; along with ecological and social benefits. Estimates of current economic benefits from this study (e.g., estimated consumer surplus per person per trip at $55) are within the range of values reported in previous studies. For instance, Melstrom et al. (2017) estimated the per trip economic value of recreational fishing in Oklahoma lakes to be $67 ($60 in 2015 dollars) by studying data from 148 lakes, which is only slightly more than $55 we estimated for rivers and streams in this study. Most notably, difference in two estimates is due to different approaches to calculate cost of travel for a fishing trip. We only considered vehicle operating cost (depreciation, gas, and upkeep such as oil, repairs, maintenance), using the mileage rate, spent for total trip to calculate cost of travel (Parsons, 2017). Although there is not system method to parse out travel cost of individual site or activity, we considered only operating cost following a commonly used practice in travel cost literate (Bowker et al., 2007; Parsons, 2017). Melstrom et al. (2017) considered lodging and food costs, but such expenses can be attributed to more than once recreation activity or site. Considering the major portion of angler's expenditure was used for lodging and food in their study, total cost used to estimate economic value may not represent the value of fishing only. They also considered overnight trips which are likely to be multi-purpose and multi-destination trip, therefore, total cost (such as food, lodging) may have spent for other activities.

Our results indicate that anglers fishing in Oklahoma's streams and rivers would like to take more trips, should the proposed increase in overall catch rate, catch rate of trophy-sized fish, and catch rate of preferred species be realized. This result suggests that factors such as fish size and species help determine the decision to go fishing to a site in addition to catch rates (Prayaga et al., 2010). These findings differ from other similar studies (e.g. Alberini et al., 2007; Prayaga et al., 2010) that revealed no meaningful effect when hypothetically improved catch rates on angling trip frequency were proposed. However, our findings are consistent with Deely et al. (2019), who solicited information from both onsite and online platforms, possibly reducing the avidity and endogenous stratification bias. Since all these studies, including our own, were conducted in different parts of the world, differing preferences may be attributed to socio-economic and cultural variations in anglers. For instance, fishing demand, harvest rate, fishing motivation differ for anglers with different socio-economic background (Chapagain et al., 2020a).

Past research has shown how various fishing site qualities affect an angler's decision to go fishing in rivers and streams (Melstrom et al., 2015), but our study was unique in that it specifically assessed how fish size within a particular group of fishes (i.e., mostly bass) might further contribute as a factor. In addition, we quantified changes in demand and economic value with change in fish quantity, size, and species. In particular, increases in trophy-sized fish added the most angler participation and provided more economic value to anglers compared to increases in smaller fish and preferred species. These results imply that fish size is more important to stream anglers in Oklahoma than fish quantity. Although ODWC had stocked non-native Tennessee lake-strain Smallmouth Bass in the area in the past, which likely have a larger growth potential than the native Neosho Smallmouth Bass subspecies (Taylor et al., 2018), they quit stocking to prevent genetic introgression with the native subspecies. As a result, a dichotomy can be construed between managing a fishery for maximizing fishing demand and providing more benefits to anglers versus conserving biodiversity, especially for locally-adapted black bass forms (Taylor et al., 2019; Seguy and Long, 2020).

Similarly, anglers who were involved in online fishing forums and groups (e.g. Oklahoma Smallmouth Bass Alliance, Ozarks Smallmouth Alliance Oklahoma Kayak Anglers) were more avid than anglers in general, demonstrating social media to be an effective platform for mass and interpersonal communication among anglers (Nguyen et al., 2012; Shiffman, 2018). Social media has become an important source of communication in the past two decades and many anglers use online platforms to share pictures of their catch and share information with their peers. Engaging anglers through social media platforms can become an effective tool for managers (Taylor and Sammons, 2019) especially as fiscal resources decline (Fawcett et al., 2020; Gharis et al., 2014; Joshi et al., 2020). Declining participation among elderly anglers is a concern in Oklahoma, a state where the average angler age has increased in the past two decades (Jager, 2015; York, 2019). As a result, while the use of social media can help attract and engage relatively younger anglers, traditional outreach platforms such as university extension factsheets, newspapers, or other forms of printed media can remain relevant.

Our findings suggest that race and party size did not play an important role in determining number of fishing trips to rivers and streams. However, Native Americans and those traveling together in larger groups were likely to take more angling trips with an increase in overall catch rate. This dynamic in recreational behavior is consistent with previous research that suggests higher importance in consumptive aspects of fishing among minorities than Whites in the United States (Hunt and Ditton, 2002). Likewise, the joyful feeling of fishing success that comes with the sense of potential catch outcomes (Beardmore et al., 2015; Schramm et al., 1998) might have excited anglers traveling in larger groups to plan for future trips. This suggests that managing a fishery for multiple angler segments is important, and that gathering opinions from under-represented groups, such as Native Americans, is vital.

Our results suggest that sense of place and emotional attachment are large motivators for the number of trips anglers take. This result is intuitive because anglers satisfied with their recreation experience are likely to fish more frequently. Place attachment establishes emotional bonds, and those who positively appraise a recreational site feel a strong connection and higher satisfaction through repeated interactions (Farnum, 2005; Oh et al., 2013; Stylidis, 2018). Place dependence has been used to understand the potential of a recreation site to satisfy the needs and desires of individuals (Stylidis, 2018). Interestingly, these anglers were also more interested in making trips in the future with catch-related efficiencies. These findings are consistent with previous research on fisheries (Oh et al., 2013) and suggest the continued importance of activity-specific preferences (e.g. catching fish) for the specialized recreationists who feel connected to a certain fishing site and do not prefer to search for substitute sites. These results contrast with previous findings that activity-specific experiences (e.g. catching fish) become less important than overall feelings, once recreationists frequently visit the same place and become place specialists (Ditton et al., 1992). It is worth noting that we did not ask anglers to compare between catch-related or non-catch related outcomes, in connection to their place attachment. The role of non-catch outcomes on place attachment would require future research, but could help guide management of facilities, such as stream access, as a way to increase angler satisfaction.

A couple of limitations of this study are worth noting. First, despite our best efforts to conduct onsite surveys, flooding, and other inclement weather situations did not allow us to solicit information from a single survey mode. Although the mixed-mode survey has been routinely used in recent years, the effect of mode bias in survey responses cannot be ruled out completely. Second, although the total responses used for regression analysis are comparable to those of similar studies (Alberini et al., 2007; Deely et al., 2019), the sample size was less than ideal. These caveats notwithstanding, our study results provide important findings that can help wildlife management agencies and university extension programs promote sustainable angling in Oklahoma. Although the research was conducted in Oklahoma, our findings may be applicable across the southern United States where similar angling cultures exist.

5. Conclusion

Our results have important implications for fisheries management and policy. Foremost, our study demonstrated that fishing opportunities in streams provide substantial economic benefits to Oklahoma anglers with an overall value as high as $68.51 million. The economic valuation from this study provides justification for management by federal and state agencies responsible for wildlife and outdoor recreation on rivers and streams. This value is also a lower-bound estimate of welfare loss to Oklahoma anglers if fishing opportunities are unavailable for some reasons, further demonstrating the value of the unique recreational fishing opportunities in Ozark Highlands rivers and streams.

Moreover, contingent model results imply that the economic benefits associated with stream and river fishing in Oklahoma could increase with higher catch rates, but would be maximized through increases in catch of larger-sized fish. Stated differently, our results found that anglers in Oklahoma streams and rivers value catching more larger fish compared to catching more fish overall. The marginal benefits under the different contingent behaviors we examined provide useful information about potential effects of different fishery management alternatives.

Our contingent behavior analysis revealed that Native American anglers in Oklahoma placed a higher value on catch-related aspects of fisheries rather than size-related aspects of the fishery, in contrast with the general angling population. Because bass fishing trends are moving toward voluntary catch-and-release (Long et al., 2015), it is imperative to consider minority preferences in future fishery management actions. With the state of Oklahoma collaborating with several Native American tribes for issuance of fishing licenses, a statewide survey of tribal license holders could provide additional insights among this minority group in particular when managing shared fisheries resources. Results showing higher demand for younger anglers and forum members imply that social media along with traditional extension sources could be an important outreach platform to reach specific angler subgroups with fishing related information.

CRediT authorship contribution statement

Omkar Joshi: Conceptualization, Methodology, Software, Writing – original draft preparation, Funding acquisition, Supervision. **Binod Chapagain**: Conceptualization, Methodology, Formal analysis, Writing – original draft. **James M. Long**: Conceptualization, Writing – review & editing, Funding acquisition, Supervision. **Betsey York:** Writing – review & editing. **Andrew T. Taylor:** Conceptualization, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

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.

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References

Alberini, A., Zanatta, V., Rosato, P., 2007. Combining actual and contingent behavior to estimate the value of sports fishing in the Lagoon of Venice. Ecol. Econ. 61, 530–541. https://doi.org/10.1016/j.ecolecon.2006.05.003.

American Automobile Association, 2019, Your driving costs. How much are you reallying paying to drive. ⟨https://exchange.aaa.com/wp-content/uploads/2019/09/AAA-Your-Driving-Costs-2019.pdf⟩ (accessed 1 March 2021).

American Sportfishing Association, 2013, Sportfishing in America. ⟨https://asafishing.org/uploads/2011_ASASportfishing_in_America_Report_January_2013.pdf⟩ (accessed 1 March 2021).

Arlinghaus, R., 2006. On the apparently striking disconnect between motivation and satisfaction in recreational fishing: the case of catch orientation of German anglers. North Am. J. Fish. Manag. 26, 592–605. https://doi.org/10.1577/M04-220.1.

Beardmore, B., Hunt, L.M., Haider, W., Dorow, M., Arlinghaus, R., 2015. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers. Can. J. Fish. Aquat. Sci. 72, 500–513. https://doi.org/10.1139/cjfas-2014-0177.

Bowker, J.M., Bergstrom, J.C., Gill, J., 2007. Estimating the economic value and impacts of recreational trails: a case study of the Virginia Creeper Rail Trail. Tour. Econ. 13, 241–260 https://doi.org/10.5367%2F000000007780823203.

Bowker, J.M., Leeworthy, V., 1998. Accounting for ethnicity in recreation demand: a flexible count data approach. J. Leis. Res. 30, 64–78. https://doi.org/10.1080/00222216.1998.11949819.

Chapagain, B.P., Long, J.M., Taylor, A.T., Joshi, O., 2020a. Variation in black bass angler characteristics by stream size and accessibility in Oklahoma's Ozark Highland streams. North Am. J. Fish. Manag. https://doi.org/10.1002/nafm.10565.

Chapagain, B.P., Poudyal, N.C., Joshi, O., Watkins, C., Applegate, R.D., 2020b. Seasonal and regional differences in economic benefits of Turkey Hunting. Wildl. Soc. Bull. 44, 271–280. https://doi.org/10.1002/wsb.1093.

Connelly, N.A., Brown, T.L., 2000. Options for maintaining high fishing satisfaction in situations of declining catch rates. Hum. Dimens. Wildl. 5, 18–31. https://doi.org/10.1080/10871200009359170.

Connelly, N.A., Keeler, S., Knuth, B.A., 2013. Understanding angler preferences for species and water bodies: importance for New York's future fisheries management. Hum. Dimens. Wildl. 18, 386–402. https://doi.org/10.1080/10871209.2013.822133.

Dobbs, I.M., 1993. Adjusting for sample selection bias in the individual travel cost method. J. Agric. Econ. 44 (2), 335–342. https://doi.org/10.1111/j.1477-9552.1993.tb00276.x.

Deely, J., Hynes, S., Curtis, J., 2019. Combining actual and contingent behaviour data to estimate the value of coarse fishing in Ireland. Fish. Res. 215, 53–61. https://doi.org/10.1016/j.fishres.2019.03.008.

Dillman, D.A., Phelps, G., Tortora, R., Swift, K., Kohrell, J., Berck, J., Messer, B.L., 2009. Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet. In: Social Sci. Res., 38, pp. 1–18. ⟨https://psycnet.apa.org/doi/10.1016/j.ssresearch.2008.03.007⟩.

Dillman, D.A., Smyth, J.D., Christian, L.M., 2014. Internet, Phone, Mail, and Mixed-mode Surveys: The Tailored Design Method. John Wiley & Sons, New york.

Ditton, R.B., Loomis, D.K., Choi, S., 1992. Recreation specialization: re-conceptualization from a social worlds perspective. J. Leis. Res. 24, 33–51. https://doi.org/10.1080/00222216.1992.11969870.

Egan, K., Herriges, J.A., 2003, Mixed Poisson regression models with individual panel data from an on-site sample. Unpublished manuscript. Department of Economics, Iowa State University.

Eiswerth, M.E., Englin, J., Fadali, E., Shaw, W.D., 2000. The value of water levels in water-based recreation: a pooled revealed preference/contingent behavior model. Water Resour. Res. 36, 1079–1086. https://doi.org/10.1029/1999WR900332.

Englin, J., Cameron, T.A., 1996. Augmenting travel cost models with contingent behavior data. Environ. Resour. Econ. 7, 133–147.

Farnum, J., 2005, Sense of place in natural resource recreation and tourism: an evaluation and assessment of research findings. General Technical Report, PNW-GTR-660. ⟨https://doi.org/10.2737/PNW-GTR-660⟩.

Fawcett, J., Parajuli, R., Boby, L., Kays, L., Strnad, R., 2020. Tools for quickly adapting during pandemincs, disasters, and other unique events. J. Ext. 58, V58–52tt51.

Fisher, W.L., Schreiner, D., Martin, C., Negash, Y., Kessler, E., 2002. Recreational fishing and socioeconomic characteristics of eastern Oklahoma stream anglers. Proc. Okla. Acad. Sci. 79–87.

Gharis, L.W., Bardon, R.E., Evans, J.L., Hubbard, W.G., Taylor, E., 2014. Expanding the reach of extension through social media. J. Ext. 52, V52–53a53. ⟨https://eric.ed.gov/?id=EJ1035347⟩.

Haab, T.C., McConnell, K.E., 2002. Valuing Environmental and Natural Resources: The Econometrics of Non-market Valuation. Edward Elgar Publishing, United Kingdom.

Hailu, G., Boxall, P.C., McFarlane, B.L., 2005. The influence of place attachment on recreation demand. J. Econ. Psychol. 26 (4), 581–598. https://doi.org/10.1016/j.joep.2004.11.003.

Hunt, L.M., 2005. Recreational fishing site choice models: insights and future opportunities. Hum. Dimens. Wildl. 10, 153–172. https://doi.org/10.1080/10871200591003409.

Hunt, Ditton, R.B., 2002. Freshwater fishing participation patterns of racial and ethnic groups in Texas. North Am. J. Fish. Manag. 22, 52–65. https://doi.org/10.1577/1548-8675(2002)022%3C0052:FFPPOR%3E2.0.CO;2.

Hunt, Grado, S.C., 2010. Use of social and economic information in fisheries assessments. In: Hubert, W.A., Quist, M.C. (Eds.), Inland fisheries management in North America, 3rd edition.,. American Fisheries Society, Bethesda, Maryland, pp. 425–447.

Hunt, K.M., Floyd, M.F., Ditton, R.B., 2007. African-American and Anglo anglers' attitudes toward the catch-related aspects of fishing. Hum. Dimens. Wildl. 12, 227–239. ⟨https://psycnet.apa.org/doi/10.1080/10871200701442825⟩.

Hutt, C.P., Neal, J.W., 2010. Arkansas urban resident fishing site preferences, catch related attitudes, and satisfaction. Hum. Dimens. Wildl. 15, 90–105. https://doi.org/10.1080/10871200903443316.

Jager, C., 2015. 2014 Oklahoma Angler Survey. Oklahoma Department of Wilddlife Conservation.

Ji, Y., Herriges, J.A., Kling, C.L., 2016. Modeling recreation demand when the access point is unknown. Am. J. Agric. Econ. 98, 860–880. https://doi.org/10.1093/ajae/aav096.

Joshi, O., Chapagain, B., Kharel, G., Poudyal, N.C., Murray, B.D., Mehmood, S.R., 2020. Benefits and challenges of online instruction in agriculture and natural resource education. Interact. Learn. Environ. 1–12. https://doi.org/10.1080/10494820.2020.1725896.

Joshi, O., Poudyal, N.C., Hodges, D.G., 2017. Economic valuation of alternative land uses in a state park. Land Use Policy 61, 80–85. https://doi.org/10.1016/j.landusepol.2016.10.034.

Joshi, O., Poudyal, N.C., Weir, J.R., Fuhlendorf, S.D., Ochuodho, T.O., 2019. Determinants of perceived risk and liability concerns associated with prescribed burning in the United States. J. Environ. Manag. 230, 379–385. https://doi.org/10.1016/j.jenvman.2018.09.089.

Kling, C.L., Sexton, R.J., 1990. Bootstrapping in applied welfare analysis. Am. J. Agric. Econ. 72, 406–418. ⟨https://www.jstor.org/stable/pdf/1242343.pdf⟩.

Lankia, T., Neuvonen, M., Pouta, E., 2019. Effects of water quality changes on the recreation benefits of swimming in Finland: combined travel cost and contingent behavior model. Water Resour. Econ. 25, 2–12. https://doi.org/10.1016/j.wre.2017.10.002.

Lee, K.J., Scott, D., Floyd, M.F., Edwards, M.B., 2016. Social stratification in fishing participation in the United States: a multiple hierarchy stratification perspective. J. Leis. Res. 48, 245–263.

Long, J.M., Allen, M.S., Porak, W.F., Suski, C.D., 2015. A historical perspective of black bass management in the United States. In: Trigali, M.D., Birdsong T.W., J.M.L., Allen, M.S. (Eds.), Black Bass Dirversity: Multidisciplinary Science for Conservation. American Fisheries Society, Besthesda, Maryland, pp. 99–122.

Mbah, A.K., Paothong, A., 2015. Shapiro-Francia test compared to other normality test using expected p.value. J. Stat. Comput. Simul. 85, 3002–3016. https://doi.org/10.1080/00949655.2014.947986.

McCormick, J.L., Porter, T.K., 2014. Effect of fishing success on angler satisfaction on a central Oregon rainbow trout fishery: implications for establishing management objectives. North Am. J. Fish. Manag. 34, 938–944. https://doi.org/10.1080/02755947.2014.932869.

Melstrom, R.T., Jayasekera, D., Jager, C., Boyer, T.A., 2017, The economic value of sportfishing trips to Oklahoma lakes. Oklahoma Cooperative Extension Service, Fact

Sheet: AGEC-1054, Stillwater. ⟨https://extension.okstate.edu/fact-sheets/the-economic-value-of-sportfishing-trips-to-oklahoma-lakes.html⟩ (last accessed 20 August 2021).
Melstrom, R.T., Lupi, F., Esselman, P.C., Stevenson, R.J., 2015. Valuing recreational fishing quality at rivers and streams. Water Resour. Res. 51, 140–150. https://doi.org/10.1002/2014WR016152.
Nguyen, V.M., Rudd, M.A., Hinch, S.G., Cooke, S.J., 2012. Differences in information use and preferences among recreational salmon anglers: implications for management initiatives to promote responsible fishing. Hum. Dimens. Wildl. 17, 248–256. https://doi.org/10.1080/10871209.2012.675412.
Oh, C.-O., Sutton, S.G., Sorice, M.G., 2013. Assessing the role of recreation specialization in fishing site substitution. Leis. Sci. 35, 256–272. https://doi.org/10.1080/01490400.2013.780534.
Ovaskainen, V., Neuvonen, M., Pouta, E., 2012. Modelling recreation demand with respondent-reported driving cost and stated cost of travel time: A Finnish case. J. For. Econ. 18, 303–317. https://doi.org/10.1016/j.jfe.2012.06.001.
Parsons, G.R., 2017. Travel cost models. In: Champ, P.A., Brown, T.C., Boyle, K.J. (Eds.), A Primer on Nonmarket Valuation. Springer, Dordrecht, Netherlands, pp. 269–328.
Prayaga, P., Rolfe, J., Stoeckl, N., 2010. The value of recreational fishing in the Great Barrier Reef, Australia: a pooled revealed preference and contingent behaviour model. Mar. Policy 34, 244–251. https://doi.org/10.1016/j.marpol.2009.07.002.
Qualtrics, 2020, The leading research & experience software | Qualtrics. ⟨https://www.qualtrics.com/⟩ (last accessed 10 February 2020).
Ramkissoon, H., Weiler, B., Smith, L.D.G., 2013. Place attachment, place satisfaction and pro-environmental behaviour: a comparative assessment of multiple regression and structural equation modelling. J. Policy Res. Tour., Leis. Events 5 (3), 215–232. https://doi.org/10.1080/19407963.2013.776371.
Seguy, L., Long, J.M., 2020. Perceived ecological threats and economic benefits of non-native black bass in the United States. Fisheries. https://doi.org/10.1002/fsh.10520.
Schramm, H.L., Arey, S.D., Miko, D.A., Gerard, P.D., 1998. Angler perceptions of fishing success and the effect of on-site catch rate information. Hum. Dimens. Wildl. 3, 1–10. https://doi.org/10.1080/10871209809359128.
Shiffman, D.S., 2018. Social media for fisheries science and management professionals: how to use it and why you should. Fisheries 43, 123–129. https://doi.org/10.1002/fsh.10031.
Shrestha, R.K., Seidl, A.F., Moraes, A.S., 2002. Value of recreational fishing in the Brazilian Pantanal: a travel cost analysis using count data models. Ecol. Econ. 42 (1), 289–299. https://doi.org/10.1016/S0921-8009(02)00106-4.
Stylidis, D., 2018. Place attachment, perception of place and residents' support for tourism development. Tour. Plan. Dev. 15, 188–210. https://doi.org/10.1080/21568316.2017.1318775.
Taylor, A.T., Long, J.M., Schwemm, M.R., Brewer, S.K., 2018. Hybridization and genetic structure of Neosho Smallmouth Bass in the Ozark Highlands. North Am. J. Fish. Manag. 38, 1226–1240. https://doi.org/10.1002/nafm.10225.
Taylor, A.T., Long, J.M., Tringali, M.D., Barthel, B.L., 2019. Conservation of black bass diversity: an emerging management paradigm. Fisheries 44, 20–36. https://doi.org/10.1002/fsh.10187.
Taylor, A.T., Sammons, S.M., 2019. Bridging the gap between scientists and anglers: the Black Bass Conservation Committee's social media outreach efforts. Fisheries 44, 37–41.
Thompson, D.W., Hansen, E.N., 2012. Factors affecting the attitudes of nonindustrial private forest landowners regarding carbon sequestration and trading. J. For. 110, 129–137. https://doi.org/10.5849/jof.11-010.
U.S. Fish and Wildlife Service, 2016. 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. US Department of the Interior, Washington DC.
Valdez, R.X., Drake, M.D., Burke, C.R., Peterson, M.N., Serenari, C., Howell, A., 2019. Predicting development preferences for fishing sites among diverse anglers. Urban Ecosyst. 22, 127–135.
Vaske, J.J., 2019. Survey Research and Analysis: Applications in Parks, Recreation and Human Dimensions. Venture Pub., California, United States.
Yen, S.T., Adamowicz, W.L., 1993. Statistical properties of welfare measures from count-data models of recreation demand. Rev. Agric. Econ. 15, 203–215.
York, B., 2019. Oklahoma Department of Wildlife Conservation 2019 Oklahoma Angler Survey. Oklahoma Depatment of WIldlife Conservation.