Using Revealed and Stated Preference Data to Estimate the Scope and Access Benefits Associated with Cave Diving

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Abstract

In a single-site travel cost model framework, revealed and stated preference data are jointly estimated to provide the first use value estimate associated with recreational cave diving. Focusing on one of Florida's first magnitude springs, we estimate average per-person per-trip use values of approximately $165, generating annual cave diving use values in excess of $1,150. Further, in an investigation of potential site quality changes, we find that divers are sensitive to scope effects with an additional cave system increasing annual per-person use values by approximately $130, while improved access yields an additional $57 in per-person annual consumer surplus. Finally, three additional model specifications are estimated and indicate that divers use different travel cost preferences when assessing their revealed and stated preference trip counts but a single preference structure to evaluate site quality changes.

Introduction

Natural resource management on public lands generates many interesting and complex policy issues. The competing goals of conservation, recreational opportunity provision, and revenue generation often clash. In recent times, natural resource managers have also been forced to search for revenue generation alternatives to supplement shrinking public sector budgets. This situation is especially true in Florida. The Department of Environmental Protection (DEP) has the responsibility of managing Florida's public lands and the Division of Recreation and Parks manages a system of 160 State Parks that combine to put 700,000 acres throughout the state under public management (Florida DEP, 2009). Approximately 70% of Florida's Parks are related in some way to a natural spring. Springs are a unique natural resource in Florida and they are scattered throughout the central and northwest parts of the state. The Florida Geological Survey spring inventory lists over 700 springs (Scott et al., 2004). Of those, 33 are first magnitude springs, comprising 33% of the total number of first magnitude springs in the U.S.[1] These springs are the result of Florida's karst terrain, a terrain dominated by carbonate-rich limestone and rock that is soluble in water as well as a subsurface that readily dissolves with rainfall and the acidic load it picks up as it passes through soils, resulting in caves, sinkholes, and springs that provide ready access to an underlying aquifer. In Florida, the underlying aquifer is the Floridan. As a natural resource, Florida's first magnitude springs produce about 80% of the total spring average daily discharge of 8 billion gallons of fresh water,

[1] A first magnitude spring has a cubic discharge rate of 100 cubic feet per second (2.83 cubic meters per second) or more (Nordlie, 1990).

and Florida derives over 90% of its drinking water from groundwater (aquifer) sources (Nordlie, 1990; Miller, 1997).

Spring recreational use includes scuba diving, snorkeling, tubing, swimming, fishing, and aesthetic enjoyment. While no research to date has measured the non-market valuation of fresh water cave diving, Bonn and Bell (2003) measured the economic impact from Ichetucknee, Volusia Blue, Homosassa, and Wakulla Springs. Although this set of four springs does not provide a true representative sample of all Florida springs, Bonn and Bell (2003) concluded from their visitor surveys that for a "typical spring" annual visitor spending is marginally in excess of $17 million. They also noted that visitors to the springs average about $46 per day in spending, and while they did not distinguish between visitor recreational purposes, they did note that visitor spending varies significantly by spring.

We develop a single-site travel cost model to provide the first estimate of the economic value associated with recreational cave diving. The travel cost model exploits the tradeoff a recreator makes between site quality and visitation costs when choosing where, and how often, to recreate. In the model, travel cost for accessing the site is interpreted as the price, and the number of trips taken in the season is the quantity demanded at that price.[2] The main strength of the travel cost method is that it is based on actual choices (revealed preference) as a recreator considers the benefits and costs of participation and experience along with the consequences of their actions (Whitehead et al., 2009). However, a primary weakness of the travel cost method is that it relies on historical data so analyzing site quality changes, such as changes in the size of a

[2] Parsons (2003) provides a detailed discussion of the travel cost model.

site or improved site access, might not be feasible because individuals may not be able to form preferences due to lack of an actual experience. To overcome this constraint, stated preference methods can be used to estimate site quality benefits beyond the range of an individual's experience (see McConnell et al., 1995; Loomis, 1993; Whitehead and Finney, 2003). A major strength of a stated preference approach is its flexibility; however, the hypothetical nature of the approach has also been recognized as a weakness. Overall, the strengths of both approaches can be exploited through joint estimation of revealed and stated preference data. Essentially, joint estimation has the advantage of allowing the measurement of preferences outside of an individual's historical experience while anchoring the stated preference responses to actual behavior (Rosenberg and Loomis, 1999; Grijalva et al., 2002; Whitehead, 2005; Egan and Herriges, 2006).

The purpose of this paper is three-fold. First, we provide an estimate of recreational fresh water cave diving demand under current site conditions. Second, the marginal effects of changes in site quality are evaluated by considering jointly divers' actual and anticipated trips under two site quality improvement scenarios. This component of the analysis addresses two specific park management policy issues. First, as a new cave system at the site of interest was recently discovered, we are interested in evaluating the marginal effects of increasing the scope of the cave system. Scope effects are tested by combining data that evaluate divers' stated preference for two cave systems in which one system is a subset of the other. In a contingent valuation framework, some research has found that an individuals' willingness to pay increases with the scope of the public good (Carson, 1997; Powe and Bateman, 2004) while others found scope insensitivity (Schkade and Payne, 1994; Whitehead and Finney, 2003). Here, scope effects are examined in a stated preference contingent behavior framework to assess whether a recently discovered additional cave system impacts anticipated trip behavior. The second policy issue concerns potential access improvements to a cave system at the site. As current access to the system is only possible via boat, we test the marginal effects of an improvement in cave access. Access is hypothesized as being important because divers would like to minimize the time and effort involved in accessing the cave system. We hypothesize that improved access will positively impact our individual welfare measures.

Finally, we examine whether diver travel cost preferences are impacted by stated preference elicitation strategies or changes in site quality attributes. As discussed by Huang et al. (1997), when pooling data to jointly estimate revealed and stated preference behavior, a critical issue is "whether the two types of discrete choices can be pooled together under a single preference structure." They further explain that even in the case where actual data on changes in recreation demand is available, use of a single preference structure to describe revealed and stated preference behavior can cause biased coefficient estimates. Therefore different model specifications are estimated that allow travel cost parameters to vary across different trip counts.

The remainder of the paper is organized as follows. Next, the freshwater spring of interest in the study is discussed. Then, the survey design and sample data are presented. This is followed by a discussion of the econometric model, a presentation of the results from the modeling process, and then concluding observations and remarks are made.

Site of Interest

The study focuses on a first magnitude spring in Northwest Florida that is managed as a park by the county under an agreement with Florida DEP. The official name of the spring is Blue Spring and it is located near Marianna in Jackson County. Since Florida has many springs named "Blue," it is generally referred to as Jackson Blue.[3] The water flow from Jackson Blue averages 5.38 cubic meters per second (and that flow has varied in the range of 1.59-8.13 over time) and it is the head spring for a run that was originally named Spring Creek that flowed approximately 15 miles from where it entered into the Chipola River ,which, in turn, flows into the Apalachicola River. In the late 19th Century, the Jackson Blue Spring run was dammed a short distance from its confluence with the Chipola to create a 202 acre ,7km long, body of water that is now called Merritt's Mill Pond. From Memorial to Labor Day, the park is open for both swimming and SCUBA diving, while at other times it is open to just SCUBA diving and a few special events. There are other aquatic caves and springs on Merritt's Mill Pond, the most notable of which are Twin Caves Spring and Hole in the Rock Spring (aka Hole in the Wall). These other caves are currently only accessible via boat. In the study, we are interested in examining the impacts of improving access to Twin Caves Spring.

The primary diving attraction is an extensive aquatic cave system also named Jackson Blue, whose entrance is at the head spring and whose main, water filled, passage extends approximately a horizontal mile into the Floridan aquifer. With the presence of many side passages, the cave actually contains well over 25,000 feet of water filled passage. There is also an extensive cavern area at the beginning of the cave. Approximately 200 feet from the entrance

[3] There is also Madison Blue, Volusia Blue, etc. all following this naming convention

into the cave is a chimney that allows divers to descend to the cave's main level that is about 95 feet in depth. Jackson Blue is well known for its high flow, making it difficult to swim in and easy to swim out, and for its marine fossils, including sea urchins, sea biscuits, sand dollars, and great white sharks' teeth.[4] The cave's limestone was formed during the Eocene, Oligocene, and Miocene epochs that span from 5 to 56 million years ago and includes a long periods of high sea levels. The cave's passages are generally large (large enough for a train to pass through), but the passages do narrow down in many sections especially in areas off the main passage. Jackson Blue is considered to be one of the best cave dives in Florida and divers come from all over the U.S. and overseas to dive the Jackson Blue Spring cave system.

Recently, along a side passage, about 3,600 feet into the cave, another entrance was discovered that is a sink hole on private property. At that entrance (technically an offset sinkhole) more passage was discovered that has effectively doubled the known size of the Jackson Blue cave system. The new section discovery is not yet well known and the section is currently, for all practical purposes, inaccessible due to the main entrance location on private property and a lack of any agreement with the landowner; however, as a park management policy component to this research, we were interested in evaluating the economic benefit of opening the new section to the diving community.

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[4] The water flow does vary with the hydrological cycle and corresponding water table levels and at times the flow is so strong that many divers use dive propulsion vehicles (dpv) or scooters to propel them through the cave. These dpvs are battery-powered, electric-motor-driven propellers that pull the diver through the water at about 120 feet per minute. Even with a scooter, there are sections of the cave where the flow is so high that a diver will back up when going into the flow with the scooter.

Survey Design

The sample diver population was defined by obtaining registration information on each diver that visited Jackson Blue Spring over the last four years[5]. As all divers are required to register with the Jackson County Sherriff's office and that registration process includes providing address information, the Sheriff's office provided a complete set of all divers (n=525) that had ever registered to dive at Jackson Blue during the prescribed period. Questionnaires were sent to each registered diver. A copy of the survey was mailed to all 525 divers, and while there was some data loss due to unintelligible handwriting and divers that had changed addresses, 186 usable responses were received, for a 35% response rate. To increase the response rate, each respondent was told that each completed survey would be entered into a random drawing for a $100 gift certificate at a local Marianna dive shop that caters to cave and technical divers.
The purpose of the survey was to derive a diver-specific demographic profile and to ask questions regarding respondents' diving behavior at Jackson Blue Spring. The survey instrument was also pretested on attendees at the Cave Diving Section of the National Speleological Society annual meeting in Marianna in 2008, and the survey was refined based on their responses.

In the survey, respondents were asked both revealed and stated preference trip count related questions. In terms of diving behavior, each diver was first asked how many day-trips were taken to dive Jackson Blue over the last 12 months. We labeled this revealed preference trip count RP_TRP. Next, three separate stated preference trip count questions were asked to elicit

[5] The system has only been formally open to cave divers for about 4 years.

divers' expected trips over the next 12 months, under current and changes in site quality conditions. Specifically, each diver was asked how many trips they expected to take over the next 12 months (TRP_SP). Eliciting the status quo stated preference response and including a stated preference elicitation dummy in the empirical model provides a means to control for hypothetical bias.

Next, respondents were presented with two hypothetical scenarios. First, they were told that "there was another newly discovered cave near Jackson Blue that was roughly the same size as Jackson Blue. Based on the number of trips you stated you would take over the next 12 months, would the number of trips you expect to take to dive at Marianna change?" If respondents answered yes, they were then asked to state how many more or less trips they would take. This stated preference trip count was termed, TRP_SP_NEWCAVE. Finally, as access to another system (Twin Caves) is currently only accessible to divers via boat, we wanted to measure the value of improved access to that cave system.[6] Each respondent was asked, if "it was possible to access Twin Caves from the shore, based on the number of trips you stated you would take over the next 12 months, would the number of trips you expect to take to dive at Marianna change?" Again respondents were prompted to state their expected change in trip count based on a yes response. This question provided a third stated preference trip count (TRP_SP_TWIN).

Table 1 provides a description of the trip count and socio-demographic variables used in estimation.

Insert Table 1 Here

[6] There is the potential for the County to purchase additional private land that would enable divers to directly access Twin Caves via the shoreline.

Considering the trip count and variable means provides some interesting dive-specific observations.

Insert Table 2 Here

First, in terms of trip counts, the sampled divers made, on average, almost nine fresh water cave dives per year at the site. When asked about their expected number of dives next year, divers stated a reduction in expected dives, to 6.67 dives in the forthcoming dive season. This was surprising as many studies have suggested a tendency for "habit formation" in a recreator's behavior. That is, because of previous visits or past experience, a recreator often indicates that they expect to make more trips to a given site in the future (Adamowicz, 1994; Provencher and Bishop, 1997; Moeltner and Englin, 2004). An expected decrease in trips might be revealing that the dive experience at the site has reached a saturation point for some divers and diminishing returns associated with increased familiarity with the site has set in. However, the descriptive statistics also indicated that the opening of a recently discovered new cave system near the site increased the expected trip count (TRP_SP_NEWCAVE), as does, although to a lesser extent, improving access to an existing cave system (TRP_SP_TWIN). This suggests that the proposed changes in site quality may have a positive impact on the diver welfare measures.

The socio-demographic details are used to establish a typical cave diver profile. The majority of cave divers are married men aged 45 years with an average annual income of approximately $100,000. On average, divers have an "apprentice" or "full cave" training certification level. Finally, divers incur an average travel cost to the Jackson Blue site of $647. Travel costs are calculated as round trip travel expenses, plus site fees, plus the opportunity cost of time estimates. Round trip distance is estimated using the PC*Miler software. Per-mile travel costs are assumed to be $0.48.[7] The opportunity cost of time for the roundtrip travel is calculated as one-third the hourly wage foregone assuming the average diver works 2,080 hours per year.

Estimation Methodology

A single-site travel cost model is estimated with the number of trips taken in a season as the quantity demanded and the travel cost to access the site as the price variable. The basic model is written as:

$$y_i = TC_{y_i}, TC_{sub_i}, \boldsymbol{z}_i, \boldsymbol{q}, SP \tag{1}$$

where the actual/expected number of trips taken to site y, by diver i, is a function of the travel costs to access the site, TC_{y_i}, travel costs to a substitute site, TC_{sub_i}, a vector of socio-demographic and dive experience-related variables, $\boldsymbol{z}_i$, a vector of site quality attributes, $\boldsymbol{q}$, and a stated preference elicitation dummy variable, SP. The socio-demographic and dive experience vector includes variables based on theoretical expectations and empirical observations from the travel cost literature: specifically, it includes diver age, gender, income, and attained certification level. Also, within the stated preference literature, research has shown that values for non-market goods derived from stated preference survey techniques often exceed revealed values (List and Gallet, 2001; Murphy et al., 2005). Therefore, a stated preference elicitation dummy variable is included to account for and measure any hypothetical bias that might be present in the stated preference trip counts (Egan and Herriges, 2006; Whitehead ,2005).

[7] According to AAA's "Your Driving Costs 2006" brochure (http://www.viainfo.net/FaresAndPasses/YourDrivingCosts2006.pdf), a mid-size sedan driven 20,000 miles per year incurs $0.48 travel costs. We also tested a range of cost per mile estimates, from $0.38 a mile (for a small sedan driven 20,000 miles a year) to $0.57 per mile (for a large sedan driven 20,000 mile per year). Regression results did not differ significantly.

The dependent variable is constructed by stacking the four trip count measures (TRP_RP, TRP_SP, TRP_SP_NEWCAVE, and TR_SP_TWIN). The panel nature of the data enables the joint estimation of both revealed and stated preferences.

As the dependent variable is a nonnegative integer with a high frequency of low trip counts, a linear count panel data specification is estimated. For the single-site model, a basic count model is assumed and is written as

$$\Pr(y_i = n) = f(n, x_i\beta), n = 0,1,2 \ldots \quad (2)$$

where n indexes the number of trips. The Poisson model is typically used to study data of this nature with a Poisson probability density function given by

$$\Pr(y_i = n) = \frac{e^{-\lambda_i}\lambda_i^n}{n!}, n = 0,1,2 \ldots \quad (3)$$

where the parameter, λ, is the conditional mean and variance of the distribution. The number of trips each diver takes can then be observed and Equation 2 can be used to write the probability of observing that number of trips. The sample likelihood function is

$$L(\beta|x, y) = \prod_{i=1}^{T} \frac{\exp(-\exp(x_i\beta))\exp((x_i\beta)y_i)}{y_i!} \quad (4)$$

A critical and limiting assumption of the Poisson model is that the conditional mean equals the conditional variance. This is a restricting assumption as recreational count data often exhibit overdispersion of the population with the variance greater than the mean. As such, overdispersion is a form of heterogeneity. A less restrictive model is the negative binomial model, which is a generalized version of the Poisson model with an additional overdispersion parameter that is estimated. It has been shown that as the dispersion decreases to zero, the negative binomial model approaches the Poisson distribution (Agresti, 1996). Because the

Poisson model is a special case of the negative binomial model, a standard likelihood ratio test can be used to compare the models.

To account for overdispersion, a common version of the negative binomial model was assumed, which is essentially a Poisson model with a gamma distributed error term in the mean. The log of the conditional mean from the Poisson model can be re-written as

$$\log\big(E(y_i)\big) = x_i\beta + \theta_i \tag{5}$$

where θ_i represents unobserved diver differences. The model then provides for systematic and random variation in the mean across divers. Substituting the right hand side of Equation 6 into the probability statement for a Poisson random variable yields the distribution of trips, conditional on θ_i, given by

$$\Pr(y_i|\theta_i) = \frac{\exp(-\exp(x_i\beta+\theta_i))\exp\,(x_i\beta+\theta_i)}{y_i!} \tag{6}$$

Haab and McConnell (2003) have shown that if *exp*(θ_i) = v_i has a normalized gamma distribution with E(v_i) = 1, then the unconditional probability function for the number of trips, y_i, is determined by integrating out the error v. The resulting probability function is the negative binomial

$$\Pr(y_i) = \frac{\Gamma(y_i+\frac{1}{\alpha})}{\Gamma(y_i+1)\Gamma(\frac{1}{\alpha})}\left(\frac{\frac{1}{\alpha}}{\frac{1}{\alpha}+\lambda_i}\right)^{\frac{1}{\alpha}}\left(\frac{\lambda_i}{\frac{1}{\alpha}+\lambda_i}\right)^{y_i} \tag{7}$$

where Γ denotes a gamma distribution, α is the overdispersion parameter, and $\lambda_i = exp(x_i\beta)$. That is, λ_i is the expected number of trips and is assumed to be a function of the variables specified in the model. Typically, λ takes a log-linear form to ensure nonnegative trip counts and can be written

$$\ln(\lambda) = \beta_{CONSTANT}CONSTANT + \beta_{TC_y}TC_y + \beta_{TC_{SUB}}TC_{SUB} + \beta_{AGE}AGE + \beta_{MALE}MALE + \beta_{INC}INC + \beta_{CERT\_LEV}CERT_{LEV} + \beta_{SP}SP + \beta_{NEWCAVE}NEWCAVE + \beta_{TWIN}TWIN \quad (8)$$

where the β's are the model coefficients to be estimated.

To account for the time-invariant diver-specific unobservables, a fixed effects panel model is estimated. An average per-person per-trip consumer surplus (CS), or use value measure was then computed using the estimated coefficients. The per-person per-trip CS measure represents the value a diver places on diving at Jackson Blue and was calculated as the difference between a diver's total willingness to pay for the trips and the total trip cost, or price. Using the log-linear specification, per-person per-trip CS is measured as

$$Per\ Trip\ CS = \int_{TC_y^0}^{TC_y^{choke}} f\left(TC_y, TC_{SUB}, z, q, SP\right) dTC_y = \frac{1}{-\beta_{TC_y}} \quad (9)$$

where TC_y^0 is the individual's trip cost and TC_y^{choke} is the choke price at which the number of trips declines to zero. The change in per-person per-trip CS due to the addition of the two proposed changes in site quality (scope and access) is also calculated. The marginal value of a site quality change is measured as

$$Marginal\ Per\ Trip\ Value\ of\ Site\ Quality\ Change = \frac{1}{-\beta^*_{TC_y}} - \frac{1}{-\beta_{TC_y}} \quad (10)$$

where $\beta^*_{TC_y}$ is the estimated travel cost parameter associated with a site quality change. Finally, annual per-person CS measures are estimated by multiplying the per-trip CS estimates by the average number of predicted trips taken each year, λ. Analogous to the per-trip measures, the change in annual CS due to a site quality change as is computed as

$$Marginal\ Annual\ Value\ of\ Site\ Quality\ Change = \frac{\lambda^*}{-\beta^*_{TC_y}} - \frac{\lambda}{-\beta_{TC_y}} \quad (11)$$

where λ^* is the number of expected trips associated with a change in site quality.

Results

In total, we ran four versions of the negative binomial panel model. Model 1 is the basic model that assumes the data are described by a single set of parameters.

Insert Table 3 Here

In Model 1, all regression coefficients are significant at the 10% level, with most significant at the 1% level. The travel cost parameter (TC_JB) is negative and significant indicating that divers living farther from the site take fewer trips. The travel cost parameter on the substitute site also has the expected positive sign indicating that divers living farther from the substitute site take more visits to Jackson Blue. The high level of significance also indicates that the Ginnie Springs cave system (near Gainesville, FL) is a strong substitute site for Jackson Blue.

All the diver-related coefficients are in-line with *a priori* expectations. The INCOME and MALE variables are both positively correlated with trips, so cave diving is a normal good with men more likely to take more trips. The AGE variable is, however, negatively correlated with trips, so older cave divers take fewer trips. Diver certification level is also important. The positive coefficient on CERT_LEVEL indicates that divers with higher certification levels take more trips, which is indicative of the skill level and training commitment required to dive into a cave system. Interestingly, the stated preference elicitation dummy is negative, indicating that divers expected to take fewer trips to Jackson Blue in the forthcoming year under existing conditions. Perhaps, the divers sampled believed that they had experienced most of the benefits that Jackson Blue has to offer and this reduction in trips indicates diminishing returns as familiarity with the system increases.

An important park management policy-based component of this research is to examine the potential welfare implications of opening a newly discovered cave system at Jackson Blue Spring and improving access to an existing system (Twin Caves). While the results indicate that divers are experiencing diminishing returns under current site conditions, the positive coefficient on TRP_SP_NEWCAVE suggests that opening up the newly discovered cave system near the Jackson Blue cave will significantly increase the number of trips taken. Likewise, it is hypothesized that cave access is important because divers would like to minimize the time and effort involved in accessing the cave system. The positive coefficient on TRP_SP_TWIN supports this notion, as divers expected to take significantly more trips to the site if they could access the Twin Caves system from the shore rather than by boat as currently exists.

As the welfare estimates are dependent upon an appropriate estimate of the travel cost coefficient, a second model (Model 2) is estimated that tests whether diver travel cost preferences vary across revealed and stated preference counts. In Model 2, the stated preference elicitation dummy is interacted and included with the travel cost parameter. Model 2 is written as

$$\ln(\lambda) = \beta_{CONSTANT}CONSTANT + \beta_{TC_y}TC_y + \beta_{TC_y}^{SP}TC * SP + \beta_{TC_{SUB}}TC_{SUB} \quad (12)$$

$$+\beta_{AGE}AGE + \beta_{MALE}MALE + \beta_{INC}INC + \beta_{CERT_{LEV}}CERT_{LEV}$$

$$+\beta_{SP}SP + \beta_{NEWCAVE}NEWCAVE + \beta_{TWIN}TWIN$$

where $\beta_{TC_y}^{SP}$ is the marginal effect of the stated preference elicitation strategy on revealed travel cost parameters. Results from Model 2 are largely similar in terms of the magnitude and significance of the coefficient estimates. The finding of note here is that the interaction term

(TC_SP) is negative and significant, indicating that divers are using different travel cost preferences when assessing their revealed and stated preference trip counts. The negativity of TC_SP indicates that divers perceive an increasing disutility associated with accessing the site in the future. A log likelihood ratio test confirms that Model 2 is preferable to Model 1 with at least a 99% certainty.[8]

Also, previous research (Huang et al., 1997) has indicated that using a single preference structure in a combined revealed and stated preference framework to evaluate site quality changes can lead to biased coefficient estimates. To examine this, two more models (Models 3 and 4) are estimated that allow travel cost parameters to vary across different trip counts. In these models, whether travel cost preferences are influenced by site quality changes is tested. For Model 3, the marginal effect on baseline preferences ($\beta_{TC_y}^{NEWCAVE}$) is included due to the opening of a new cave system at the Jackson Blue site. In Model 4, the marginal effect on baseline preferences ($\beta_{TC_y}^{TWIN}$) due to improving access to an existing cave system is examined. Models 3 and 4 are written as

$$\ln(\lambda) = \beta_{CONSTANT}CONSTANT + \beta_{TC_y}TC_y + \beta_{TC_y}^{NEWCAVE}TC * NEWCAVE + \beta_{TC_{SUB}}TC_{SUB} \qquad (13)$$

$$+\beta_{AGE}AGE + \beta_{MALE}MALE + \beta_{INC}INC + \beta_{CERT_{LEV}}CERT_{LEV} + \beta_{SP}SP$$

$$+\beta_{NEWCAVE}NEWCAVE + \beta_{TWIN}TWIN$$

[8] λ = 2[-2181.38 – (-3901.35)] = 343.94 with 1 d.f.

$$\ln(\lambda) = \beta_{CONSTANT}CONSTANT + \beta_{TC_y}TC_y + \beta_{TC_y}^{TWIN}TC * TWIN + \beta_{TC_{SUB}}TC_{SUB} \quad (14)$$

$$+\beta_{AGE}AGE + \beta_{MALE}MALE + \beta_{INC}INC + \beta_{CERT_{LEV}}CERT_{LEV} + \beta_{SP}SP$$

$$+\beta_{NEWCAVE}NEWCAVE + \beta_{TWIN}TWIN$$

Analysis of results from Models 3 and 4 show that, as both $\beta_{TC_y}^{NEWCAVE}$ and $\beta_{TC_y}^{TWIN}$ are insignificant, changes in site quality do not seem to alter diver travel cost preferences. Log likelihood ratio tests confirm that neither Model 3 nor Model 4 is preferable to Model 2 with at least a 95% certainty level. Overall, Model 2 is the preferred model.

Finally, consumer surplus is measured using the estimated parameters from Models 1 through 4. Per-person per-trip consumer surplus measures are calculated and the estimated average predicted trip totals are used to compute per-person annual consumer surplus measures.[9] Next, marginal per-person per-trip consumer surplus and marginal per-person annual consumer surplus changes associated with adding the new cave system and improved access are calculated. Additionally, 95% confidence intervals around all the consumer surplus measures are estimated using the Krinksy-Robb procedure. Finally, all estimates corrected for hypothetical bias are presented with the stated preference elicitation dummy set to zero.

Insert Table 4 Here

Across all models, the magnitudes of the per-person per-trip and per-person annual consumer surplus values do not vary substantially. In Model 2 (the preferred model), depending on whether a hypothetical bias correction is used, the per-person per-trip consumer surplus values under existing conditions range between $161 (with a 95% confidence interval between $143

[9] In all, average predicted trip totals (λ) are estimated under existing conditions, plus with the addition of a new cave system, and improved access conditions.

and $184) and $172 (with a 95% confidence interval between $151 and $199). This translates into per-person annual consumer surplus values between $1,148 (with a 95% confidence interval between $955 and $1,220) and $1,170 (with a 95% confidence interval between $1,027 and $1,359). Also in Model 2, adding a new cave system of similar scope to the existing system increases per-person annual consumer surplus values by $128 to $131.

As a point of interest, the per-person per-trip consumer surplus values estimated in Model 3 (allowing travel cost preferences to vary across scope impacts) declines by $4 with the addition of a new cave (although this marginal effect is not statistically significant). In terms of annual per-person values, even though per-trip values decline, the increase in the number of expected trips generates a positive annual marginal consumer surplus measure. Finally, a similar effect is found under the assumption of improved access to an existing cave system. While again, not statistically significant, the marginal loss in per-person per-trip consumer surplus associated with improved access is $4.40. However, an increase in expected trips due to improved access generates an increase in per-person annual consumer surplus in the range of $46 to $63 in Model 4. In the preferred model, the marginal gain in annual per-person consumer surplus due to improved access is $57 (with a 95% confidence interval between $47 and $67 across the uncorrected and hypothetical bias-corrected model).

Finally, we use consumer surplus estimates from the preferred model and the annual divers visiting Jackson Blue Spring to provide an aggregate valuation.[10] The aggregate per-trip CS estimates range from $80,475 to $81,135 depending on whether a hypothetical bias correction is used. The aggregate annual CS under current site conditions is then in the region of $575,000.

[10] Based on the number of registered divers with the Jackson County Sheriff's Office, we assume an annual visitor count of 500 divers.

The addition of a second cave system adds a marginal value of approximately $64,500, while an improvement in access increases aggregate annual CS by roughly $28,500.

Conclusion

A single-site travel cost model was developed to provide the first economic valuation of recreational cave diving. Revealed and stated preference data were jointly estimated to value recreational cave diving at one of Florida's first magnitude springs with an associated aquatic cave system under both existing conditions and site quality changes. Under existing conditions, diver consumer surplus values were estimated to be approximately $160 to $172 per-person per-trip. Based on the number of expected trips, this translates into approximately $1,150 in annual per-person consumer surplus. At the aggregate level, this equates to an approximate $575,000 in annual consumer surplus.

The marginal values of site quality changes were also examined as (1) a new cave system was recently discovered, and (2) there has been interest in adding land access to the existing Twin Caves system that is currently only accessible via boat. The results show that divers are sensitive to scope effects with an additional cave system increasing per-person annual consumer surplus values by approximately $130. Improved access was also found to yield an additional $57 in per-person annual consumer surplus.

Whether or not single preference structure assumptions hold when combining revealed and stated preference data was also tested. We found that diver travel cost preferences vary across revealed and stated preference counts, with divers perceiving an increasing disutility associated with accessing the site in the future. As such, a model that includes an interactive stated preference elicitation dummy with the travel cost parameter was preferred. However, we also found that a single preference structure was appropriate when evaluating policy-based site quality changes.

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Table 1 – Variable Definitions

Variable	Definition
TRP_RP	Number of actual dive trips taken to Jackson Blue during the 2008-2009 dive season
TRP_SP	Expected number of dive trips taken to be taken to Jackson Blue during the 2009-2010 dive season
TRP_SP_NEWCAVE	Expected number of dive trips taken to be taken to Jackson Blue during the 2009-2010 dive season if a newly discovered cave was available to dive
TRP_SP_TWIN	Expected number of dive trips taken to be taken to Jackson Blue during the 2009-2010 dive season with improved access to Twin Cave
TC_JB	Per-person travel costs to access the Jackson Blue Site
TC_SUB	Per-person travel costs to access a substitute site (Ginnie Springs)
AGE	Age of respondent
MALE	Dummy variable denoting respondent gender (Male = 1)
MARRIED	Dummy variable denoting respondent marital status (Married = 1)
INC	Respondent income ($1000s)
CERT_LEV	Respondent Certification Level (1 = Cavern, 2 = Intro, 3 = Apprentice, 4 = Full)
SP	Dummy variable denoting the trip count was elicited through a stated preference question
NEWCAVE	Dummy variable denoting trip counts elicited under the assumption that a new cave is available to dive at the Jackson Blue site
TWIN	Dummy variable denoting trip counts elicited under the assumption that access to Twin Cave is improved

Table 2 – Descriptive Statistics (n=186)

Variable	Mean	Std. Dev.	Minimum	Maximum
TRP_RP	8.62	12.85	0.00	72.00
TRP_SP	6.67	9.14	0.00	50.00
TRP_SP_NEWCAVE	9.15	11.68	0.00	75.00
TRP_SP_TWIN	7.81	10.59	0.00	55.00
TC_JB	$646.85	$613.73	$45.30	$3,619.10
TC_SUB	$667.65	$626.16	$52.50	$3,655.30
AGE	45.34	10.81	18.00	66.00
MALE	0.87	0.34	0.00	1.00
MARRIED	0.70	0.46	0.00	1.00
INC	$99.59	$43.26	$25.00	$155.00
CERT_LEV	3.48	0.95	0.00	4.00

Table 3 – Results

Variable	Model 1		Model 2		Model 3		Model 4	
	Coeff.	*p*-value	Coeff.	*p*-value	Coeff.	*p*-value	Coeff.	*p*-value
CONSTANT	1.939	0.000	1.732	0.000	1.911	0.000	1.907	0.000
TC_JB	-0.006	0.000	-0.006	0.000	-0.006	0.000	-0.006	0.000
TC_SP			-0.001	0.001				
TC_SP_NEW					-0.000	0.339		
TC_SP_TWIN							-0.000	0.269
TC_SUB	0.005	0.000	0.005	0.000	0.005	0.000	0.005	0.000
AGE	-0.022	0.000	-0.021	0.000	-0.021	0.000	-0.022	0.000
MALE	0.303	0.006	0.300	0.006	0.302	0.006	0.302	0.006
INC	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
CERT_LEV	0.259	0.000	0.257	0.000	0.258	0.000	0.259	0.000
SP	-0.275	0.006	-0.026	0.831	-0.270	0.006	-0.269	0.007
NEWCAVE	0.368	0.000	0.370	0.000	0.452	0.000	0.368	0.000
TWIN	0.179	0.085	0.180	0.085	0.179	0.082	0.270	0.032
Alpha	0.798	0.000	0.784	0.000	0.796	0.000	0.796	0.000
Obs	744		744		744		744	
LOG LIK	-2185.4		-2181.4		-2184.9		-2184.8	

Table 4 – Consumer Surplus Estimates

	Model 1		Model 2		Model 3		Model 4	
	Uncorrected	SP = 0	Uncorrected	SP = 0	Uncorrected	SP = 0	Uncorrected	SP = 0
Predicted Trips								
Baseline	7.07	8.63	6.66	7.79	6.58	8.00	6.54	7.95
Adding New Cave	7.80	9.59	7.40	7.55	7.46	9.14	7.21	8.83
Improved Access	7.39	9.05	6.99	7.13	6.88	8.40	7.01	8.56
Baseline Consumer Surplus								
Per-trip	$162.48	$162.48	$160.95	$172.27	$159.73	$163.74	$159.36	$163.76
95% CI - LB **95% CI - UB**	$145.03 $184.39	$145.03 $184.39	$143.41 $183.62	$151.01 $199.48	$142.26 $180.99	$145.77 $187.57	$1,41.85 $1,81.11	$145.73 $186.39
Annual	$1,149.12	$1,401.65	$1,147.63	$1,170.22	$1,077.92	$1,310.33	$1,070.72	$1,301.22
95% CI - LB **95% CI - UB**	$1,024.31 $1,305.29	$1,252.49 $1,589.84	$954.97 $1,219.53	$1,026.81 $1,359.22	$937.88 $1,195.26	$1,162.98 $1,491.97	$929.89 $1,183.48	$1,159.42 $1,479.96
Marginal Value of New Cave								
Per-trip	$0	$0	$0	$0	-$4.01	-$4.01		
95% CI - LB **95% CI - UB**					-$12.81 $4.36	-$12.81 $4.36		
Annual	$118.61	$156.11	$127.57	$130.94	$113.13	$150.65		
95% CI - LB **95% CI - UB**	$105.97 $135.60	$138.96 $177.69	$106.15 $135.47	$114.68 $152.22	$55.22 $174.42	$80.78 $226.30		
Marginal Value of Improved Access								
Per-trip	$0	$0	$0	$0			-$4.40	-$4.40
95% CI - LB **95% CI - UB**							-$12.63 $3.50	-$12.63 $3.50
Annual	$52.34	$68.89	$56.18	$57.67			$46.31	$63.33
95% CI - LB **95% CI - UB**	$46.70 $59.56	$61.43 $78.39	$46.79 $59.76	$50.50 $67.25			-$7.23 $101.69	-$3.16 $130.22