Estimating the Economic Value of Ice Climbing in Hyalite Canyon: An Application of Travel Cost Count Data Models that Account for Excess Zeros*

D. Mark Anderson

Department of Economics, University of Washington, Box 353330, Savery 305, Seattle, WA 98195-3330, USA

Tel.: 1 406 366 0921
E-mail address: dma7@u.washington.edu

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Abstract

Recently, the sport of ice climbing has seen a drastic increase in popularity. This paper uses the travel cost method to estimate the demand for ice climbing in Hyalite Canyon, Montana, one of the premier ice climbing venues in North America. Access to Hyalite and other ice climbing destinations have been put at risk due to liability issues, public land management agendas, and winter road conditions. To this point, there has been no analysis on the economic benefits of ice climbing. In addition to the novel outdoor recreation application, this study applies econometric methods designed to deal with "excess zeros" in the data. Depending upon model specification, per person per trip values are estimated to be in the range of $76 to $135.

Key words: Ice climbing; Recreation demand; Count data models; Travel cost model

JEL Classification: Q26

I. INTRODUCTION

The sport of ice climbing is increasing in popularity among outdoor recreationists. In 2005, an estimated one million Americans participated in ice climbing--a 42% increase from 2003 (Outdoor Industry Foundation 2006). As little as 30 years ago, only hardy outdoorsmen climbed ice. Today, due to the vast improvements in climbing gear, routes once considered epic are routine. Ice climbing is no longer limited to a small group of enthusiasts and it is not uncommon to witness family outings at the local ice crag. The growing popularity has even led to the development of artificial ice walls in areas that do not feature natural frozen waterfalls. The town of Ouray, Colorado is famous for its ice park, a two mile long stretch of manmade ice that attracts climbers from around the world. In addition, ice climbing festivals are becoming widespread throughout Europe, Canada, and the United States (Wurdinger and Rapparlie 2006).

As with many outdoor activities, as the demand for the sport grows, so does the potential for conflict. The growing popularity of mountain biking has led to trail degradation and conflicts with hikers and horseback riders (Fix and Loomis 1997; Morey et al. 2002). Hunting access to public lands has spurred intense debates between gun right activists and anti-gun groups.[1] Dirt bikes and all-terrain vehicles have been banned in most national parks and designated wilderness areas. The U.S. Forest Service has proposed restrictions on the placement of fixed protective gear used by rock climbers for safely ascending and descending rock routes (Grijalva et al. 2002). Access to specific ice

[1] Hunting access on public lands was an important part of Montana's attorney general race (*Missoulian* 2008).

climbing sites has become problematic. In some cases, the concern is of legal matters.[2] In other cases, the issue is public land management. Alternatively, ice access difficulties may result from road closures due to natural elements such as snowfall or avalanche hazard.[3]

It is essential to estimate the economic benefits of ice climbing to assist resource management decisions aimed at impacting user access. However, existing climbing demand research has focused solely on rock climbing.[4] For at least three reasons, it is reasonable to believe that value estimates for rock climbing sites do not serve as close approximations for ice sites. First, ice climbing is limited to regions that experience periods of below freezing temperatures; yet, in many of these areas, the season can be quite short. Second, because higher elevations favor ice, ice climbing routes often involve long and arduous approaches. Roadside rock climbing is much more common than roadside ice climbing. Lastly, if access to a popular rock climbing site is closed, there often are many other sites of similar quality available within a close proximity. This is not necessarily the case with ice climbing.[5]

Estimates for the economic value of ice climbing remain absent from the literature. This paper attempts to fill that void by estimating count data travel cost

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[2] For example, in the 1990s, legal battles surrounded Bridalveil Falls, a classic Colorado ice climb. Off-limits since its first ascent in 1974, the route was opened to climbers after negotiations exempted private land owners of liability (NY Times 1997).

[3] Strobach Mountain, WA; Red Lodge, MT; Hyalite Canyon, MT; and the Ghost Wilderness, Alberta are four of many examples of popular ice climbing destinations that can become difficult to access due to winter road conditions.

[4] Shaw and Jakus (1996) estimate the demand for rock climbing at the Mohonk Preserve in New York. Hanley et al. (2001) and Hanley et al. (2002) study the demand for rock climbing in Scotland. Scarpa and Thiene (2005) take a latent-class approach based on intensity of preferences to analyze rock climbing in the Northeastern Alps. Grijalva et al. (2002) value the loss of rock climbing access in wilderness areas due to Forest Service regulations. Ekstrand (1994) measures rock climbing demand in Eldorado Canyon, Colorado.

[5] For example, from Hyalite Canyon, the closest area with a comparable number of routes is near Cody, Wyoming over 200 miles away.

models for Hyalite Canyon, Montana. Hyalite Canyon is one of the premier ice climbing venues in North America and is currently plagued by access issues. Because a large number of survey respondents reported taking zero trips to Hyalite, this paper uses econometric methods that account for “excess zeros”. The value of Hyalite Canyon ice climbing is estimated to be in the range of $76 to $135 per person per trip. The remainder of this paper is organized as follows: Section II briefly reviews the sport of ice climbing and the background of Hyalite Canyon access; Section III describes the data and variables; Section IV provides a brief theoretical foundation; Section V describes the estimation strategy; Section VI discusses results; Section VII concludes.

II. BACKGROUND ON ICE CLIMBING AND HYALITE CANYON

Ice climbing is a relatively new form of outdoor recreation. While the roots of European mountaineering can be traced back to the 18th century, it was not until recent years that people started climbing steep waterfall ice.[6] Today ice climbers scale anything from thick pillars to thinly veiled rock faces. Climbers equip themselves with a pair of ice axes and attach crampons (footwear consisting of spikes) to their boots. To ascend, a climber swings her axes above her head and kicks the front points of her crampons into the ice. If the climber is leading, she will place ice screws in the ice on the ascent. The climber clips her rope to the ice screws to protect against a fall. The lead climber is belayed from below by the follower. When the lead climber finishes the pitch, she belays the follower from the top. On the way up, the follower takes the screws out of the ice

[6] In the late 1960s, Chad Chadwick, a Montana native, was reported as the first climber to have used crampons with “front points” in the United States. This innovation allowed much steeper ice to be climbed. Chadwick recorded the first “front point” ascent on Rock Creek Falls near Red Lodge, Montana (Josephson 2004).

that were originally placed by the leader. To descend, the climbers can rappel off of a natural structure, such as a large boulder, or fixed anchors when available. For some routes, walk-off descents are possible.

Hyalite Canyon lies south of Bozeman, Montana, in the Gallatin Mountains and is home to one of the most dense concentrations of waterfall ice in the country. Due to snowfall each winter and spring, the road up the canyon becomes impassable for lengths of time. In addition, the Gallatin National Forest has considered closing the road to passenger vehicles at the Hyalite Reservoir dam during the winter and spring months. The majority of the ice climbs are approached from the Grotto Falls parking lot approximately three miles further down the road from the dam.[7] The Grotto Falls lot is also the access point for the Hyalite Creek trail, a popular outing amongst cross-country skiers, snowshoers, and winter campers. Those wanting to climb ice or use the Hyalite Creek trail would be required to ski, snowshoe, or snowmobile in from the dam. To the extent the aggregate willingness to pay of ice climbers and other user groups is sufficiently large, leaving Hyalite Canyon road open ***and*** plowing after heavy snowfall could lead to economic benefits. Currently, the status of road access for Hyalite remains uncertain.[8]

III. DATA AND VARIABLES

There is no one preferred method for administering nonmarket valuation surveys and significant tradeoffs exist with the various techniques available. For many outdoor activities, obtaining data on participants is a difficult task. This is especially the case

[7] There are other points along the road at which closure has been proposed, all of which would require a longer approach to the Grotto Falls lot than if the road were closed at the dam.
[8] For further details, see the Gallatin National Forest Service's Travel Management Plan (2006).

with ice climbing. As Shaw (1988) points out, estimates of demand functions using on-site samples are subject to possible bias because individuals who go to the site frequently have a higher probability of being sampled. In addition, drawing a sample from the general population would be prohibitively costly because those that climb ice represent a very small minority. As an alternative, Shaw and Jakus (1996) propose finding known groups of climbers that belong to climbing clubs or outdoor groups. Lastly, web surveys are another option available for conducting nonmarket valuation research (Champ 2003).

The data for this paper are from the 2006-2007 Hyalite Canyon Access Survey.[9] The survey was administered on-line and links to the questionnaire were posted on montanaice.com. This site serves as the primary source of information for Montana ice route conditions and road access reports. As a result, many climbers frequent the site before an excursion. In order to survey as broad of an ice climbing audience as possible, links to the survey were also posted on popular climbing web sites with nation-wide audiences such as climbing.com and alpinist.com. Web-based surveys are becoming more popular for conducting non-market valuation research; however, issues regarding the differences between samples from on-line interviews and other methods remain a concern (see, e.g., Canavari et al. 2005; Marta-Pedroso et al. 2007). Critics cite sample frame and non-response bias as two disadvantages of this survey mode. The first issue deals with the non-random omission of individuals from the sample frame, while the second problem is bias due to respondents and non-respondents having different characteristics (Fleming and Bowden 2009). Despite these problems, web-based interviews are acceptable for studies of specialized sport activity (see, e.g., Hynes et al. 2008). Fleming and Bowden (2009) compare results from a conventional mail survey to

[9] The full text of the survey is available from the author upon request.

a web-based survey for visitors of Fraser Island, Australia and find that response rates, socio-demographic characteristics, and consumer surplus estimates are similar across survey modes. Another potential disadvantage of web-based surveys is that it can be difficult to monitor whether a respondent submits more than one survey. To lessen the likelihood of multiple survey submissions by a single respondent, the Hyalite Canyon Access Survey did not allow multiple responses from the same registered email address. Unfortunately, it was not possible to gauge the response rate of those who viewed the survey on-line.

The dataset contains approximately 1,000 observations. Because of the inability to observe whether or not individuals travel by airplane, the sample was limited to those residing within 550 miles of Hyalite Canyon.[10] As a result, there was usable data for approximately 400 individuals. Limiting the sample in this manner not only addresses the travel mode issue (i.e. the discrepancy between driving travel costs and air travel costs), but also helps to mitigate the problem of bias due to multiple destination trips.[11] People travelling from far distances may visit other recreation sites on a trip to Hyalite Canyon. As a result, it would be incorrect to attribute all of their travel cost to Hyalite Canyon ice climbing.

Of the respondents, nearly all reported ice climbing as one of their winter outdoor activities. Contingent valuation questions regarding the climber's willingness to pay for access were not part of the questionnaire, but location of residence and travel expense questions were included. In regard to the dependent variable, respondents were asked

[10] As a sensitivity check, distances between 400 and 1,000 miles where considered. The results remained robust to these specifications.

[11] Unfortunately, the survey did not ask respondents to differentiate between single and multiple destination trips. For further discussions on multiple destination effects, see Parsons and Wilson (1997), Loomis (2006), and Martinez-Espineira and Amoako-Tuffour (2009).

how many days, on average, they climb per season in Hyalite.[12] It is important to address two concerns that arise due to the wording and response format of this question. First, for travel cost models, the number of "trips" taken is required rather than the number of "days" spent recreating at the site. Fortunately, respondents were also asked how many nights they spend away from home when taking an ice climbing trip. For climbers in the sample from the greater Bozeman area, it was assumed that the number of days climbed in Hyalite corresponded to the number of trips per season. From the author's own experience of living and climbing in the area and from testimony of other Bozeman climbers, this seems like a reasonable assumption to make. It is extremely rare that locals camp out at the climbing site. For climbers not residing in the Bozeman area, the average number of trips was calculated by simply dividing the average number of days climbed by the average number of nights spent per trip.[13]

A second potential limitation of the question used to generate the dependent variable was that the response was interval coded. Rather than use an econometric model to account for the series of intervals, the lower limit of the interval was chosen for analysis in order to maintain consistency with the count data travel cost literature. For example, if a respondent indicated climbing at Hyalite for 11 to 15 days, then 11 days was used as the count. To be sure, this is the conservative way to proceed. Choosing the lower limit of the interval ensures that consumer surplus estimates are not overstated. It

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[12] The question was presented as follows:
On average, how many days per year do you ice climb in Hyalite Canyon?
I have not ice climbed in Hyalite……1
1 to 5 days per season……………….2
6 to 10 days per season……………...3
11 to 15 days per season…………….4
16 to 25 days per season…………….5
More than 25 days per season………6

[13] The author is unaware of other examples in the literature that have used an average count of trips as the dependent variable.

is also worth mentioning that an interval coded answer comes with the benefit of a potentially higher response rate when recollection of the number of days climbed is a concern. The finer the intervals, the more difficult it may be for the respondent to recall exactly their true amount of climbing. Recall bias is of particular concern with this study because respondents were asked about their average number of days spent climbing per year rather than an explicit number of days during a specified year. Moreover, the authors of the questionnaire did not specify how far back a respondent should go in time to calculate the average. In light of these issues, a series of intervals may actually be more appropriate than an open-ended response. In sum, when designing a questionnaire of this type, one faces a trade-off between the accuracy of intervals and the risk of non-response.[14]

As for explanatory variables, typical respondent characteristics, such as, age and income were reported. Because climbers with more experience and a higher skill set are expected to participate more frequently, other questions were asked to reveal the ice climber's self-reported ability, willingness to participate during all months of the season, and whether or not they own their own gear.[15] Respondents were also asked if they regularly lead climb on ice. However, a lead climbing indicator is excluded from the analysis because of the high correlation with self-reported ability. Respondents also indicated if they had completed a wilderness first aid course. Those with wilderness first aid knowledge may be expected to participate at a higher rate because they are more adept at handling adverse situations.

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[14] Cameron and Huppert (1989) address this issue by assessing the sensitivity of "payment card" contingent valuation results to the choice of estimation method.
[15] It is not uncommon for beginner ice climbers to rent equipment from local gear shops.

Additionally, it is important to consider substitute and complementary winter sports. Individuals were asked to list their winter activities other than ice climbing. Though these variables are likely to play an important role in the respondent's climbing frequency decision, the expected sign of the relationship is ambiguous. For example, someone who is a backcountry skier may ice climb more often because ice access in some areas is easier on skis. On the other hand, a person may ice climb less because they split their time between the two activities. Including dummies for other activities also indicates which individuals may use Hyalite for multi-activity purposes rather than just ice climbing. In addition, it is not uncommon for ice climbers to access climbs via snowmobile. Individuals indicated whether or not they own or have access to a snowmobile. In the context of Hyalite, backcountry ski, snowshoe, and snowmobile indicators are especially important because these are the methods of transport available if automobile access is not possible.

Another important issue to address in travel cost models is that of substitute sites. Excluding prices of substitute sites will lead to overestimates of consumer surplus (Rosenthal 1987). The intuition is similar here as for other types of substitute goods. If the price of a substitute site were to increase, then we would expect the demand for trips to Hyalite to go up. Here, the price of a substitute site is measured in the same manner as the travel cost variable for Hyalite Canyon discussed below. The substitute site variable represents the travel cost from the climber's home residence to the closest premier ice climbing venue other than Hyalite. Premier ice climbing venues are defined as well-known, world-class destinations characterized by dense concentrations of ice, numerous and high quality routes, and long seasons.[16] Premier venues represent sites of a caliber similar to Hyalite. Regressions were also run with a substitute site variable designed to capture "local ice effects". This variable was constructed by calculating the travel cost from the respondent's home address to a nearby climbing site.[17] The estimated value of the coefficient on the travel cost variable was not sensitive to the choice of substitute site variable.[18] Results that consider only the "premier" site are reported.

Site characteristics are also important when modeling the demand for recreation. The previous literature on rock climbing uses the number of routes available in a particular area as a relevant site characteristic (Shaw and Jakus 1996; Grijalva et al. 2002). Following these studies, this paper uses the number of climbs at Hyalite Canyon that are available to the climber based on his/her self-reported ability. Ice climbs are rated on a scale from WI1 to WI7, where WI stands for waterfall ice. Climbers that reported themselves as beginners were assigned routes rated WI1 to WI3, while intermediate and advanced climbers were assigned routes WI1 to WI4 and WI1 to WI5, respectively. Climbs rated WI6 and harder were not included. Only a very small number of climbers climb ice this difficult and few routes at Hyalite receive these grades.

[16] Premier ice climbing sites considered in this paper are found in Southwest Montana, Northeast Wyoming, Central Utah, Central and Southwest Colorado, along the shores of Lake Superior, the New England area, and the Canadian Rockies. The author has drawn on climbing guide books and articles, regional ice climbing internet sites, climber testimony, and his own experience and knowledge in determining these sites. For a list of the exact location of each site (e.g. name of mountain range, drainage, canyon, nearest town, etc.) please contact the author.

[17] For climbers whose nearest ice access is a premier site, the author attempted to locate the next nearest place to ice climb.

[18] For some, a premier ice site may be far away, however, ice sites of lower quality may exist within a relatively close distance. For example, ice climbers living in the Seattle area must travel to the Canadian Rockies or Southwest Montana to climb at a premier ice venue. Ice climbing routes do exist within a 40 minute drive from the city, however, there is a limited quantity of routes and, due to the relatively warm temperatures, ice climbing in Washington is characterized by extremely short seasons. In some years, certain areas will fail to form ice.

Lastly, the travel cost variable includes individual transit costs per mile and the opportunity cost of travel time. Excluding the value of travel time can lead to underestimating the true value of consumer surplus for a recreation trip (Allen et al. 1981). A common procedure is to value travel time at a fraction of the individual's wage rate (U.S. Water Resources Council 1983). Here, travel time is multiplied by one-third of the individual's wage rate and added to the monetary cost of travel to create the travel cost variable.[19,20] Two travel cost variables are considered in the analysis. TC1 includes total transit costs and the opportunity cost of travel time. TC2 is also comprised of transit costs and the opportunity cost of travel time, but also includes lodging expenses and, thus, likely represents a more accurate measure of variable out-of-pocket expenses. Due to incomplete information regarding lodging expenses, the sample size is decreased by 65 observations when using TC2.

Because demographics have not been collected on the general ice climbing population, it is difficult to know whether or not this is a representative sample. Many other recreation demand studies face this problem.[21] As mentioned above, this is of particular concern with web-based samples. As a result, it may be beneficial to compare subgroups within the sample. In doing so, those that have climbed at Hyalite have incomes, age, and self-reported ability similar to those that have not climbed at Hyalite. These groups are also similar in the rates at which they own their own ice gear. In addition, those that live within 550 miles of Hyalite have similar characteristics to those

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[19] TC = (transit cost per mile/ave. group size)*(round trip distance) + (1/50)*(1/3)*(Income/2080)*(round trip distance). Transit cost is measured at $.37/mile (AAA 2007). It is assumed the individual's average speed while travelling is 50 mph and that the average individual works 40 hours per week, 52 weeks per year.

[20] Admittedly, this is a simplistic way to calculate the opportunity cost of travel time. However, a majority of outdoor recreation studies employ this technique. For discussions that treat this issue more carefully, see, e.g., McConnell and Strand (1981), Larson (1993), and McKean et al. (1995).

[21] Shaw and Jakus (1996) also acknowledge this with their sample of rock climbers.

that live further away. This, to an extent, provides some evidence that the sample is representative of North American ice climbers.

IV. SINGLE-SITE TRAVEL COST MODEL

In the single-site travel cost model, the individual's utility is a function of a basket of market goods (*x*), trips to the recreation site (*m*), and site quality (*q*)

$$u = u(x, m, q). \tag{1}$$

Utility is maximized subject to a budget and time constraint

$$wL = x + p_{op}m \tag{2}$$

$$T = L + tm \tag{3}$$

where *L* is work hours, *w* is the wage rate, p_{op} is out-of-pocket trip expenditures, *T* is the total time available, and *t* is the travel time of a trip. This maximization problem yields a demand function for trips

$$m = m(Y, p_{TC}, q) \tag{4}$$

where $p_{TC} = p_{OP} + wt$ is the full price of a trip and $Y = wT$ is income. Specifying demand as log-linear and abstracting from changing site quality, (4) can be rewritten as

$$m = \exp(\beta + \beta_{TC} p_{TC} + \beta_Y Y). \tag{5}$$

If access to the recreation site were closed, then the individual would lose her entire consumer surplus from taking positive trips. The loss in consumer surplus can be approximated by the area under the demand curve between the individual's current price and a choke price. Formally, the consumer surplus is

$$CS = \int_{p_{TC}^{0}}^{p_{TC}^{choke}} \exp(\beta + \beta_{TC} p_{TC} + \beta_Y Y) dp_{TC} = -\frac{m}{\beta_{TC}}. \tag{6}$$

For a more rigorous theoretical analysis, see Hellerstein and Mendelsohn (1993). These authors develop a theoretical framework for the use of count data models in travel cost analysis.

V. ESTIMATION STRATEGY

Basic Poisson Model

Within the data, an individual's reported trips to Hyalite Canyon take the form of non-negative integers. In addition, the frequency of zeros and small numbers make up a large portion of the dataset. Due to these features, a count data demand model is preferred. In this paper, the form of the count model is Poisson. The probability density function is given by

$$P(m=k)=\frac{e^{-\lambda}\lambda^{k}}{k!},\quad k=0,1,\ldots,\infty \tag{7}$$

where m is the number of trips taken and location parameter λ represents the expected number of trips and is assumed to be a function of the demand model variables.[22] To guarantee non-negative probabilities, λ can be parameterized as

$$\lambda=\exp(\beta+\beta_{TC}p_{TC}+\boldsymbol{\beta}'\boldsymbol{x}) \tag{8}$$

where $\boldsymbol{x}$ is a vector of variables that explain the frequency of trips taken to Hyalite and $\boldsymbol{\beta}$ is the corresponding vector of parameters.

In essence, the Poisson model is simply a non-linear regression. However, it is much easier to estimate the parameters with maximum likelihood methods. In particular, the likelihood function, based on the Poisson distribution is

[22] The parameter λ represents the mean and variance of the distribution.

$$L=\prod_{i=1}^{n}\frac{e^{-\lambda_i}\lambda_i^k}{k!},\quad k=0,1,2,... \tag{9}$$

corresponding to the log likelihood function

$$\ln L=\sum_{i=1}^{n}(-\lambda_i+k(\beta+\beta_{TC}p_{TC}+\boldsymbol{\beta}'\boldsymbol{x}_i)-\ln k!). \tag{10}$$

Differentiating between Participation and the Level of Demand

Excess zeros can be a problem when estimating recreation demand models. Specifically, it is sometimes the case that a large portion of the survey respondents have not recreated at the site in question. For these cases, the visit count is recorded as a zero. Many of the Hyalite Canyon Access Survey respondents reported having never climbed at Hyalite. Cragg (1971) was one of the first to address the problem of excess zeros. Since, significant work has dealt with this issue.[23] When the data illustrate a higher frequency of zeros than is consistent with the underlying distribution of the model, introducing a "hurdle" mechanism may be appropriate.

Hurdle count models have been used to model the demand for outdoor recreation. The previously mentioned work by Shaw and Jakus (1996) uses a double hurdle count model to estimate the demand for rock climbing. Yen and Adamowicz (1994) estimate a multinomial-Poisson hurdle model using data from Bighorn sheep hunters in Alberta, Canada. Gurmu and Trivedi (1996) investigate a Poisson hurdle model with survey data on the number of recreational boating trips to Lake Somerville, Texas. Bilgic and Florkowski (2007) apply a hurdle negative binomial model to estimate the demand for bass fishing in the southeastern United States. Martinez-Espineira (2007) employs zero-inflated models to estimate the willingness-to-pay for a coyote conservation program.

[23] For example, see Mullahy (1986); Lambert (1992); Ozuna and Gomez (1992); Haab and McConnell (1996); Gurmu and Trivedi (1996); Greene (1994).

Hurdle count models have also been used in other areas of research. Zorn (1996) evaluates hurdle Poisson specifications using data on Congressional responses to Supreme Court decisions.

Single Hurdle Model

The intuition behind a single hurdle model is straightforward. The model essentially amounts to two-stages. In the first stage, a binomial probability model directs the binary outcome of whether a count variable has a value of zero or a positive value. In the second stage, a truncated model is estimated based on the assumption that when the individual participates the number of trips will be positive. In the context of Hyalite Canyon, a hurdle mechanism (e.g. probit or logit) can explain the choice of whether or not to ice climb at Hyalite. Some climbers in the sample ice climb elsewhere, but optimally choose not to climb at Hyalite. These climbers do not get over the hurdle. The structural equations are

$$\begin{aligned} &P(m_i > 0) = \mathrm{F}(\boldsymbol{x}_{i1}) \quad \text{(estimated with a binary choice apparatus)} \\ &m_i = f(\boldsymbol{x}_{i2}, \varepsilon_{i2}) \text{ for } \mathrm{m}_i > 0 \quad \text{(estimated with a truncated model)} \end{aligned} \tag{11}$$

where $\boldsymbol{x}_{i1}$ represents a vector of variables pertaining to the participation decision and $\boldsymbol{x}_{i2}$ contains variables that explain trip frequency. For the purposes of this paper, a logit and truncated Poisson are estimated. However, because the two stages are estimated independently, the idea works for any binary choice model and any truncated count model.

Zero-Inflated Poisson (ZIP)

The basic idea of the zero-inflated model is to allow for the zero trip observations to be generated from one of two processes. In one process, the trip outcome is always zero and is not generated by the Poisson process but rather by an unrelated procedure. In the other, the usual Poisson process applies and the zeros essentially represent the "no trip" corner solution of an individual's utility maximizing recreation decision.[24] That is, this model takes into account that some respondents derive zero utility from Hyalite ice climbing while others are in the market for Hyalite ice but optimally choose zero trips.

Even though nearly all of the respondents in the sample reported being ice climbers, it is reasonable that a factor other than travel costs generates some of the zero trip observations. Because of this, the zero-inflated model seems the most attractive choice for analyzing the data. For example, some may be in the market for only certain types of ice climbing. A respondent may simply prefer climbing long multiple-pitch ice routes or only wish to go ice climbing in an area within close proximity to an urban center.[25] These types may not derive utility from Hyalite because it is characterized by shorter, single-pitch routes and is nowhere near a major city.

The zero-inflated Poisson is

$$P(m_i = k) = F(\boldsymbol{\beta}_1'\boldsymbol{x}_{i1}) + (1 - F(\boldsymbol{\beta}_1'\boldsymbol{x}_{i1}))\frac{e^{-\lambda_i^k}\lambda_i^k}{k!}, \quad k = 0,1,2,3,... \qquad (12)$$

where $F(\bullet)$ represents the probability that $x_i = 0$ and $1 - F(\bullet)$ represents the probability that the Poisson process is at work. The model is often termed a double hurdle model because the respondent must first cross a "participation" hurdle and then the Poisson covariates need to allow for positive trips.[26]

It is well known that Poisson models do not account for possible overdispersion of the data and that negative binomial models allow for a more flexible modeling of the

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[24] Perhaps the most theoretically-consistent manner in which to translate zero trip demand into something measurable is by the Kuhn-Tucker method formulated in Phaneuf et al. (2000).
[25] This is certainly the case for other outdoor activities as well. For example, a downhill mountain biker may not be in the market for cross-country mountain biking.
[26] This exposition is based on Haab and McConnell (2003).

variance. Negative binomial and zero-inflated negative binomial models were also considered during the estimation process. Results from these specifications were similar to the results generated by the Poisson and zero-inflated Poisson models. Table A1 in the appendix illustrates a summary of the negative binomial and zero-inflated negative binomial estimates.[27]

Estimating Site Value and the Price Elasticity of Demand

An estimate for consumer surplus is based on equation (6), which yields the well-known result

$$\widehat{CS} = \frac{-\hat{\lambda}}{\beta_{TC}}. \tag{13}$$

To the extent that income effects are minimal, then the Marshallian measure of consumer surplus will serve as a good approximation of the economic value of ice climbing at Hyalite Canyon. However, if income effects play an important role, then measures of compensating variation and equivalent variation will better approximate economic benefits. Based on demand of the form in (5), Bockstael et al. (no date) show the formulas for compensating variation and equivalent variation to be

$$\widehat{CV} = \frac{1}{\beta_Y}\ln\left(1+\frac{\hat{\lambda}\beta_Y}{\beta_{TC}}\right) \tag{14}$$

and

$$\widehat{EV} = -\frac{1}{\beta_Y}\ln\left(1-\frac{\hat{\lambda}\beta_Y}{\beta_{TC}}\right). \tag{15}$$

[27] For an excellent discussion that compares gradually more flexible versions of zero-inflated count models, see Scarpa et al. (2007).

Price elasticities can also be derived from the estimated demand model. Elasticities provide measures of the sensitivity to price and are useful when determining access fees that can be used toward site maintenance. Marginal effects in the Poisson are given by

$$\frac{\partial \lambda_i}{\partial x_{ij}} = \beta_j \exp(\beta' \boldsymbol{x_i}). \qquad (16)$$

Thus, the full elasticity is

$$\left(\frac{\partial \lambda_i}{\partial x_{ij}}\right)\left(\frac{x_{ij}}{\lambda_i}\right) = \beta_j \left(\exp(\beta' \boldsymbol{x_i})\right)\left(\frac{x_{ij}}{\exp(\beta' \boldsymbol{x_i})}\right) = x_{ij}\beta_j. \qquad (17)$$

Loomis and Walsh (1997) report that price elasticities from outdoor recreation studies typically fall in the range of -0.2 to -2.0.

VI. RESULTS

Table 1 describes the variables and Table 2 presents means, standard deviations, medians, and upper and lower quartiles. The average annual number of trips taken, when using the lower limit of the reported interval, was 5.74 for the entire sample. The average travel cost, excluding lodging expenses, was $105.60 per person.

[Table 1 about here.]

[Table 2 about here.]

Table 3 and Table 4 illustrate results for TC1 and TC2, respectively. The “Positives” column for the single hurdle and ZIP models describes the relationship between the count of trips taken and the travel cost. The “Zeros” and “Inflate” columns represent the results for the logit portion of the single hurdle and ZIP models, respectively. For the single hurdle and ZIP models the variables are partitioned into participation decision variables and frequency decision variables. Here, the chosen set of explanatory variables is different for the participation and frequency segments of the hurdle and ZIP models. For the participation decision, the winter camping, ice climbing equipment, and beginner indicators have been omitted because these variables are expected to be important only for the frequency decision.[28] The coefficient on the travel cost parameter is negative and significant at the 1% level for the count portion of all model specifications. Tables 3 and 4 also report a test statistic developed by Vuong (1989) for model selection. The Vuong statistic is distributed standard normal and tests of the ZIP versus the standard Poisson yield values of z = 2.09 (Pr. > z = 0.018) in Table 3 and z = 1.96 (Pr. > z = 0.025) in Table 4. The reported Vuong statistics favor the ZIP over the standard Poisson model.

[Table 3 about here.]

[Table 4 about here.]

Tables 5 and 6 report per person per trip benefit estimates along with 95% confidence intervals. The consumer surplus per person per trip is measured by $-1/\beta_{TC}$. The compensating and equivalent variations per person per trip are calculated by dividing (14) and (15) by the sample means of expected trip demand. Calculating confidence intervals around the point estimates of the welfare measures is slightly complicated by the fact that the maximum likelihood estimators of the welfare measures are functions of random variables. Therefore, following Englin and Shonkwiler (1995), the asymptotic variances of the CS, CV, and EV functions are calculated using a Taylor series expansion. Individual per trip values range from \$76 to \$135. These estimates are on par

[28] It is important to note that specifications that used the same set of explanatory variables for the participation and frequency portions of the single hurdle and ZIP models were also considered. The coefficient on the travel cost variable was robust to these alternative specifications.

with results from other studies that concern outdoor recreation at top destinations.[29] The CS, CV, and EV estimates are nearly identical for each specification. This suggests income effects do not play a large role in the individual's ice climbing decision.

At the sample means, the price elasticities of demand range from -0.62 to -1.28 with a 95% confidence interval of (-0.49, -0.74) for the low estimate and a 95% confidence interval of (-1.14, -1.43) for the high estimate.

[Table 5 about here.]

[Table 6 about here.]

VII. CONCLUSION

This paper contributes to the recreation demand literature by considering a novel application of the travel cost method and by studying a site that is currently surrounded by access controversy. Most importantly, the results above indicate that large economic benefits exist from land being used for ice climbing. In the context of Hyalite Canyon, these benefits are estimated upwards of $76 per person per trip and $480 per year for the average individual. Since Hyalite is a top tier ice destination, these results may not directly apply to lesser known locations, but could serve as relevant estimates for ice sites of equivalent popularity and quality.

[29] For comparison, Shaw and Jakus (1996) obtain benefit estimates in the range of $70 to $90 per trip for rock climbing at the "Gunks", New York. Ekstrand (1994) estimates consumer surplus to be approximately $40 per trip for rock climbing at Eldorado Canyon State Park. Fix and Loomis (1998) calculate the value of mountain biking at Moab, Utah to be approximately $63 per day or $235 per trip. Coupal et al. (2001) find the value of snowmobiling to WY residents to be between $31 and $101 per trip. Betz et al. (2003) estimate the per-trip consumer surplus for a potential rail-trail site in north-east Georgia to range between $18 and $29. Shrestha et al. (2007) find that, on average, visitors would pay $74 per visit-day for nature-based recreation in public natural areas of the Apalachicola River region, Florida. Martinez-Espineira and Amoako-Tuffour (2008) estimate consumer surplus per person-trip upwards of $660 for visits to the Gros Morne National Park in Newfoundland.

This study supplies important information regarding the dollar value of the willingness to pay of ice climbers for ice access. This could, in turn, aid resource managers in planning access agendas or recreation fees that impact areas where ice climbing is prevalent. For Hyalite and other areas where road access can become difficult during the winter, these use values could help managers when appropriating funds through fees or other mechanisms for the purpose of plowing after heavy snowfall.

Lastly, this paper illustrates the benefits of using models that explicitly account for excess zeros in the data. When using the travel cost variable that includes lodging expenses, the ZIP predicts per person per trip value estimates to be approximately $15 greater than those predicted by the standard Poisson model.

Appendix

[Table A1 here.]

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Table 1: Model Variables and Descriptions

Variable	Description
Trips	Number of trips to Hyalite.
TC1	Travel cost.
TC2	TC1 plus lodging expenses.
Age	Age of respondent.
Income ($, thousands)	Income (in thousands of dollars).
SkiTouring	Dummy variable that equals 1 if respondent is a backcountry skier, 0 otherwise.
Downhill	Dummy variable that equals 1 if respondent is a downhill skier, 0 otherwise.
Snowshoe	Dummy variable that equals 1 if respondent is a snowshoer, 0 otherwise.
WinterCamp	Dummy variable that equals 1 if respondent is a winter camper, 0 otherwise.
WildFirstAid	Dummy variable that equals 1 if respondent has taken a wilderness first aid course, 0 otherwise.
OwnIceGear	Dummy variable that equals 1 if respondent owns ice climbing equipment, 0 otherwise.
Snowmobile	Dummy variable that equals 1 if respondent owns or has access to a snowmobile, 0 otherwise.
AvidClimber	Dummy variable that equals 1 if respondent is willing to climb all months of the season, 0 otherwise.
Beginner	Dummy variable that equals 1 if respondent reports being a beginner-level climber, 0 otherwise.
SiteCharacteristic	The number of climbs at Hyalite that are available to the respondent based on self-reported ability.
TC_Sub1	Price of nearest “premier” ice venue other than Hyalite.

Table 2: Descriptive Statistics

Variable	Mean	S. D.	25th Pctl.	Median	75th Pctl.
Trips	5.74	7.80	1	1	11
TC1	105.60	120.44	10.55	17.20	215.29
Ave. Lodging Expense	39.37	39.37	9.54	28.63	57.25
Age	34.41	10.78	27	32	42
Income ($, thousands)	39.09	20.55	27.50	42.50	57.50
SkiTouring	0.79	0.41	1	1	1
Downhill	0.74	0.44	0	1	1
Snowshoe	0.70	0.46	0	1	1
WinterCamp	0.58	0.49	0	1	1
WildFirstAid	0.65	0.48	0	1	1
OwnIceGear	0.86	0.34	1	1	1
Snowmobile	0.17	0.38	0	0	0
AvidClimber	0.31	0.46	0	0	1
Beginner	0.22	0.42	0	0	0
SiteCharacteristic	69.59	17.45	71	71	91
TC_Sub1	58.51	73.21	14.97	22.79	73.24

Table 3: Count Data Models of Trips to Hyalite Canyon (TC1)

	(1)	(2)		(3)	
	Poisson	Poisson Hurdle		ZIP	
Variable		Zeros	Positives	Inflate	Positives
TC1	-0.012***	-0.018***	-0.013***	-0.134**	-0.012***
	(0.001)	(0.002)	(0.001)	(0.062)	(0.001)
Age	-0.020***	-0.052***	-0.019***	0.133***	-0.018***
	(0.003)	(0.017)	(0.003)	(0.048)	(0.003)
Income ($1,000)	0.001	0.029	0.001	-0.042	0.001
	(0.001)	(0.011)	(0.002)	(0.026)	(0.001)
SkiTouring	0.117	-0.072	0.151*	0.093	0.120
	(0.073)	(0.386)	(0.078)	(1.008)	(0.074)
Downhill	-0.161***	-0.096	-0.161***	-0.354	-0.166***
	(0.058)	(0.357)	(0.060)	(0.854)	(0.058)
Snowshoe	-0.307***	-0.970***	-0.255**	3.557	-0.262**
	(0.116)	(0.379)	(0.128)	(2.226)	(0.118)
WinterCamp	0.255**	…	0.237*	…	0.236**
	(0.114)		(0.126)		(0.116)
WildFirstAid	0.200***	0.226	0.204***	0.573	0.209***
	(0.052)	(0.328)	(0.053)	(0.911)	(0.052)
OwnIceGear	0.818***	…	0.862***	…	0.808***
	(0.141)		(0.162)		(0.147)
Snowmobile	0.180***	0.006	0.170***	0.300	0.178***
	(0.050)	(0.426)	(0.051)	(0.985)	(0.051)
AvidClimber	0.326***	0.008	0.308***	-0.423	0.309***
	(0.048)	(0.388)	(0.049)	(0.861)	(0.048)
Beginner	-0.141	…	-0.067	…	-0.018
	(0.135)		(0.142)		(0.138)
SiteCharacteristic	0.026***	0.073***	0.025***	-0.119***	0.025***
	(0.002)	(0.011)	(0.002)	(0.034)	(0.002)
TC_Sub1	0.001	0.008***	-0.001	0.152**	0.002
	(0.001)	(0.002)	(0.002)	(0.065)	(0.001)
Log likelihood	-1031.95		-866.14		-1016.35
Vuong test statistic					2.09
					[0.018]
Observations	391		297		391

Standard errors for coefficient estimates are in parentheses. P-value for Vuong statistic is in squared brackets.
* significant at 10%, ** significant at 5%; *** significant at 1%

Table 4: Count Data Models of Trips to Hyalite Canyon (TC2)

	(1)	(2)		(3)	
	Poisson	Poisson Hurdle		ZIP	
Variable		Zeros	Positives	Inflate	Positives
TC2	-0.008***	-0.015***	-0.008***	0.016***	-0.007***
	(0.001)	(0.002)	(0.001)	(0.006)	(0.001)
Age	-0.018***	-0.048**	-0.017***	0.058	-0.017***
	(0.003)	(0.024)	(0.003)	(0.049)	(0.003)
Income ($1,000)	-0.001	0.020	-0.000	-0.030	-0.001
	(0.001)	(0.014)	(0.002)	(0.031)	(0.001)
SkiTouring	0.102	-0.236	0.146*	0.998	0.122
	(0.074)	(0.467)	(0.078)	(1.192)	(0.076)
Downhill	-0.145**	-0.039	-0.154**	0.172	-0.149**
	(0.058)	(0.429)	(0.060)	(0.785)	(0.059)
Snowshoe	-0.285**	-0.889*	-0.268**	4.131*	-0.253**
	(0.118)	(0.458)	(0.128)	(2.456)	(0.120)
WinterCamp	0.246**	…	0.257**	…	0.247**
	(0.117)		(0.126)		(0.118)
WildFirstAid	0.225***	0.925**	0.205***	-1.425*	0.209***
	(0.052)	(0.410)	(0.053)	(0.794)	(0.053)
OwnIceGear	0.810***	…	0.859***	…	0.791***
	(0.143)		(0.162)		(0.148)
Snowmobile	0.178***	0.440	0.167***	-1.238	0.167***
	(0.050)	(0.549)	(0.051)	(1.083)	(0.051)
AvidClimber	0.309***	0.030	0.294***	-0.561	0.290***
	(0.048)	(0.445)	(0.049)	(1.162)	(0.049)
Beginner	-0.172	…	-0.069	…	-0.059
	(0.136)		(0.142)		(0.141)
SiteCharacteristic	0.026***	0.090***	0.025***	-0.101***	0.025***
	(0.002)	(0.015)	(0.002)	(0.032)	(0.002)
TC_Sub1	0.000	0.010***	-0.003	-0.023**	-0.001
	(0.001)	(0.003)	(0.002)	(0.012)	(0.001)
Log likelihood	-969.01		-852.67		-954.91
Vuong test statistic					1.96
					[0.025]
Observations	326		271		326

Standard errors for coefficient estimates are in parentheses. P-value for Vuong statistic is in squared brackets.
* significant at 10%, ** significant at 5%; *** significant at 1%

Table 5: Estimated CS, CV, and EV Per Person Per Trip (TC1)

	Poisson	Hurdle	ZIP
Consumer Surplus	83.62	76.24	82.23
95% CI	(73.93, 93.31)	(62.32, 90.18)	(72.78, 91.69)
Compensating Variation	83.70	76.29	82.29
95% CI	(74.00, 93.40)	(62.37, 90.21)	(72.82, 91.76)
Equivalent Variation	83.53	76.19	82.18
95% CI	(73.84, 93.22)	(62.29, 90.10)	(72.72, 91.64)
Mean Predicted Trips	5.74	7.32	5.74

Table 6: Estimated CS, CV, and EV Per Person Per Trip (TC2)

	Poisson	Hurdle	ZIP
Consumer Surplus	120.01	120.33	135.07
95% CI	(103.24, 136.77)	(95.76, 144.91)	(110.54, 159.60)
Compensating Variation	119.91	120.28	134.96
95% CI	(103.15, 136.67)	(95.75, 144.81)	(110.44, 159.48)
Equivalent Variation	120.10	120.38	135.18
95% CI	(103.32, 136.89)	(95.82, 144.95)	(110.61, 159.74)
Mean Predicted Trips	6.80	8.01	6.80

Table A1: Summary of Negative Binomial and Zero-Inflated Negative Binomial Results

	TC1		TC2	
	(1)	(2)	(3)	(4)
	NB	ZINB	NB	ZINB
Coefficient for Travel Cost Variable	-0.011***	-0.009***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Welfare Estimates				
Consumer Surplus	91.29	106.71	134.33	134.33
95% CI	(77.49, 105.08)	(85.21, 128.22)	(108.65, 160.00)	(108.65, 160.00)
Compensating Variation	91.73	107.22	134.67	134.67
95% CI	(77.93, 105.54)	(85.72, 128.73)	(108.98, 160.35)	(108.96, 160.37)
Equivalent Variation	90.85	106.21	133.99	133.99
95% CI	(77.08, 104.62)	(84.76, 127.66)	(108.24, 159.73)	(108.22, 159.75)

Each column represents a separate regression. Columns 1 and 2 illustrate results when TC1 is used as the travel cost variable in negative binomial and zero-inflated negative binomial regressions. Columns 3 and 4 illustrate results when TC2 is used as the travel cost variable in negative binomial and zero-inflated negative binomial regressions. Standard errors for the travel cost variable coefficient estimates are in parentheses. The models estimated in this table use the same variables as those described for the Poisson and ZIP models except the skiing dummies, snowshoe dummy, and wilderness first aid dummy were excluded from the logit portion of the zero-inflated models. These exclusions were made in order to achieve convergence.
* significant at 10%, ** significant at 5%; *** significant at 1%