Value of Instream Recreation in the Sonoran Desert

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Abstract: This study investigates recreation use value for access to a Sonoran Desert canyon, and associated instream flow, through a case study of Aravaipa Canyon Wilderness. The Wilderness is one of the last perennial streams in Southern Arizona, tributary to the famed and imperiled San Pedro River. Available permit information is combined with zip-code level census data to estimate a zonal travel cost model of recreation trip demand. Estimated consumer surplus per visitor day values are $25.06 and $17.31 (in 2003 dollars), for two separate access sites. Results indicate a significant recreation value of surface water sites in the Sonoran Desert region, while the value discrepancy may imply a premium for remote recreation.

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Introduction

Natural resources management faces the complex challenge of maintaining environmental quality against numerous resource pressures. In the Southwestern United States, and the more specific context of the Sonoran Desert, riparian areas are ribbons of green swirling through a sparse landscape, hosting a concentration of plant and animal life in extreme contrast to adjacent chaparral. These fragile rivers and streams are also impacted by a suite of human activities such as surface water diversions, groundwater pumping, agriculture, cattle grazing, waste disposal, and urban encroachment. In order to reflect an understanding of both natural and anthropogenic concerns, planning and management decisions for riparian areas will be more informed through data collection and analysis regarding diverse resource benefits.

While limited in number, attempts by environmental economists and others to assess the monetary value of protecting instream flow and associated riparian areas now extend back at least several decades (see: Loomis 1987 and 1998). Various case studies identified significant value of water left in its natural channel, previously thought of as "wasted" water. More and more researchers, particularly in water-poor Western states, are investigating the worth of instream flows and stream or river-based recreational access, motivating a conservationist counterpoint to market and cultural forces more traditionally based on resource extraction. Some of the stream-based recreational values documented across the West include whitewater rafting (Ward 1987; Leones et al. 1997), angling (Duffield et al. 1992; Loomis and Creel 1992), and birdwatching (Eubanks et al. 1993). Berrens et al. (1996 and 2000) provide examples of values for protecting instream flows and associated endangered fish habitat.

This case study of Aravaipa Canyon Wilderness (Wilderness) provides a unique look at recreation use value for access to Sonoran Desert riparian areas with protected instream flows. Instream flow advocates argue that increasing scarcity of protected sites with perennial instream flow elevates the importance of riparian management in the Sonoran Desert bioregion. Thus, valuation results for recreational access to the Wilderness may have important applications (e.g., benefit transfer exercises) to other riparian sites in Southern Arizona. A particular example would be the San Pedro River, to which the Wilderness is tributary. Upstream reaches of the San Pedro watershed include the San Pedro National Conservation Area, a celebrated riparian area threatened by regional groundwater pumping (Glennon and Maddock 1994). The San Pedro River provides critical habitat for up to 4 million migrating birds yearly, and supports nearly two-thirds of North American avian biodiversity. The San Pedro River is listed by The Nature Conservancy as one of America's "Last Great Places" (The Nature Conservancy 2000).

For this case study, available permit information is combined with zip-code level census data to estimate a zonal travel cost model (ZTCM) of recreation trip demand. While the ZTCM is open to traditional criticisms of potential aggregation bias, it is not dependent on user surveys, which can bring their own set of selection and responses biases (for a complete review, see Parsons 2003). Further, the simple, robust analysis presented here is easily repeated for other recreation sites, yielding useful information from widely available permit data. Results for Aravaipa Wilderness extend the growing literature assessing nonmarket values for the protection of instream flow in other areas of the Western United States to the specific context of the Sonoran Desert. In addition, value comparison between two sites within the Wilderness allows estimation of a premium on isolated recreation. Evidence for such a premium would at least partially validate current management strategy of permit limits in the Wilderness "to achieve the Wilderness Act mandate of preserving an enduring resource of wilderness composed of natural conditions and outstanding opportunities for solitude" (Bureau of Land Management 1988).

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Description of Resource

The Aravaipa Wilderness is a lush and geologically dramatic riparian canyon in the Sonoran Desert of Southern Arizona. There are two access points with separate visitation. The East site is near Klondyke, Ariz., approximately 275 km (170 driving mi) northeast from Tucson, Ariz. the last 110 km (70 mi) of which are on a graded dirt road. There are seven perennial stream crossings in the last few miles before arrival at the east end of the canyon, limiting access to high clearance and four-wheel-drive vehicles. The West site is near Mammoth, Ariz., and is within 120 paved driving km (75 mi) of Tucson. The West site is accessible by passenger car, and receives more use, yet is also in a predominantly rural setting. Although the East site is physically situated only 8 km (5 mi) from the West site, 18 km (11 mi) of hiking lie between them, with no direct auto route connecting the sites.

The Wilderness lies in a rift valley between two remote "sky-island" mountain ranges: the Santa Teresa Mountains to the north and the Galiuro Mountains to the south. Currently 2,236 ha (5,524 acres) have wilderness designation, surrounded by an additional 20,648 ha (51,023 acres) of Bureau of Land Management (BLM) land. Cactus-spiked talus and sheer cliffs separate the main and side canyon floors from the rim country and tablelands above. Stream elevation falls from 910 m (3,000 ft) at the East site to 790 m (2,600 ft) at the West site, tablelands reach 1160 m (3,800 ft) and higher. At times the narrow shore is entirely composed of matted roots from the cottonwood/willow forest overhead, in other places sandy banks allow comfortable camping. Species of interest include desert bighorn sheep, black hawks, and seven species of indigenous fish, the densest native population in the state. Geologic features range from stream-polished Precambrian schist to extensive Tertiary volcanic and granite units composing upper canyon walls (BLM 2004).

The watershed is approximately 1,414 sqkm (546 mi^2), the majority of which is up-gradient of the eastern Wilderness boundary (BLM 1988). All 18 km (11 mi) of flow within the wilderness are perennial, with ankle to knee-deep crossings common, and occasional swimming holes where the stream tumbles against bedrock. Tight canyon walls and perennial flow require frequent fording. Nine major side canyons enter the Wilderness contributing intermittent and ephemeral flows. Based on 46 years of United States Geological Survey (USGS) data, the mean of mean daily flows in Aravaipa Creek is 968 l/s (34.2 cfs). Low flows of about 300 l/s (10 cfs) tend to occur in June, while higher flows above 1,400 l/s (50 cfs) are common in February and March (USGS 2002). Flood peaks between 1 and several thousand cfs are typical in either the winter rainy or monsoonal summer seasons, with an historic peak of 2,005,000 l/s (70,800 cfs) recorded October 1, 1983 (USGS 2003). Stormflows are intense, but the character of instream flow is normally an intimate trickle compared with higher flows of 14,000 l/s or more (500 cfs) associated with whitewater boating recreation.

The Wilderness is managed by the BLM. Users request a permit in advance for either end of the canyon, with visitation limited to 20 persons/day for the East site, 30 persons/day for the West site, a 3 day stay limit and ten person party limit apply to both. As a Wilderness, human travel is exclusively on foot or equestrian. No vehicles, bicycles, or dogs are permitted (BLM 2004). Visitation records include data for each trip leader purchasing a permit. Date of arrival, choice of East site or West site access, length of stay, number in party, and mailing address (with zip code) are required information.

Aravaipa Creek is the last tributary to the San Pedro River before the San Pedro's confluence with the Gila River. Small rural communities lie along the riparian corridor near the East and West sites; consumptive uses of Aravaipa Creek instream flow are irrigation, stock watering, and domestic. Perennial flow is central to the canyon's Sonoran Desert ecology, archeological significance, and contemporary recreation opportunities. Previous research in the Wilderness found visitors rated water "the most important attribute of the wilderness area" (Moore et al. 1990). The accepted Apache meaning of Aravaipa is in fact "laughing waters." This research attempts to quantify the recreational use value for access to this unique area with protected instream flow and associated riparian features. It is hoped that results will help to provide insight for riparian management in the Wilderness and similar sites in the Southwest.

Non-market use value is measured in economic terms as consumer surplus per Recreation Visitor Day (RVD). Consumer surplus is a dollar measure of net benefit, or satisfaction derived from a Wilderness trip, beyond the enjoyment offset by trip costs. The RVD unit is used to count Wilderness visitors over discrete calendar days. Aggregating consumer surplus across all visitor days allows estimation of recreation value enjoyed over a given period of time (e.g., total visitation for 1 year or management season).

Valuation Methodology

The Wilderness embodies many public goods, and provides diverse benefits. In addition to recreation opportunities, the riparian ecosystem serves water and air quality enhancement functions for the region. Ranching and small-scale agriculture occur at either end of the canyon, reliant on the temperate canyon climate and access to water. Residential property values nearby are enhanced by riparian area proximity, a boost of several percent was documented for a riparian site near Tucson (Colby and Wishart 2002). There are also nonuse values for the Wilderness, applying to those who value its existence from afar or wish to leave it unmarred for the future. Yet for all Wilderness benefits, the only explicit public charge is a recreation access fee of $5.00/person/day. The value of each visitor's recreational experience exceeds this minimal cost, or the Wilderness would have near-zero usage. Using visitation permit information for access to riparian areas with protected instream flow, this study estimates recreation use value, a single component of total Wilderness resource value.

Making use of the extensive permit database collected by the BLM, we employ a variant of the travel cost method (TCM). The TCM is a standard technique used in resource planning, required, for example, by the United States Army Corps of Engineers for estimating recreation effects of federal projects (see Loomis 1999). It is a "revealed preference" approach, using a surrogate market to value a nonmarket good. Access value to a set of one or more sites is built from explicit and implicit expenditures people make in traveling to the chosen location (Parsons 2003). At a minimum these include opportunity cost of driving time and vehicular driving costs, but may also include opportunity cost of time on site, lodging costs, entry fees, or any other expense judged specific to a visit. Under the basic hypothesis that distance is costly, the core of a TCM is achieving a relationship between trip costs (the price proxy) and the quantity of trips demanded. This results in a traditional Marshallian demand curve. Other characteristics of the resource or visiting population may be included (Parsons 2003), as expressed in a general demand model:

$$\text{visitation rate}_{ij} = f(\text{travel cost to site}_{ij}, \text{travel cost to substitute site}_{ik}, \text{socio-demographics}_i, \text{site characteristics}_j) \quad (1)$$

where i=visiting individual (or representative individual from a zone of origination), j=site in question (the destination); and k=substitute site (with $j \neq k$).

Once the TCM demand curve is estimated econometrically, value calculation is often limited to Marshallian consumer surplus (MCS) for seasonal access to the site in its current form, though extensions to quality changes exist (Parsons 2003). A total access value can be obtained by entering the average travel cost value in the fitted demand model, and integrating up to a "choke price" (where predicted trip demand is driven to zero). Then, by dividing through by the predicted number of trips, the resulting MCS estimate can be calculated as a value per RVD.

The classic TCM approach separates visitation into zones, often counties, or cities, but most commonly zip codes. A unique travel cost for each geographic zone is then estimated. Data costs for a ZTCM are usually low, since public land management agencies often collect visitation information and record an address for entrants. However the ZTCM may suffer from aggregation bias in building a model based on homogenized (representative) persons from each zone. There may be significant differences in driving costs to a site from within a zip code, or there may be high intrazonal income diversity, varying the opportunity cost of travel time.

In reality, every visitor represents unique characteristics. An individual travel cost model (ITCM), based on survey data, recognizes this and remedies aggregation bias, but incurs primary data collection costs. Further, statistical problems of truncation (no data on nonvisitors) and endogenous stratification (more likely to sample repeat visitors) occur with ITCMs, and many require strong assumptions regarding the probability distribution of count-data based trip demand (Hellerstein 1995). By running simulations on an artificial dataset with known parameters, Hellerstein (1995) found aggregate models often perform as well or better than individual models, particularly when average per capita demand is small and the visitation base large. Hellerstein concludes "it is an empirical question as to which modeling strategy is best." The Wilderness seems to fit a situation where aggregate model use is supported, although our choice for the analysis was largely driven by budget and data availability. The thorough database maintained by the BLM in conjunction with a ZTCM forms a reasonable basis for examining recreational values without the need for original survey data.

A ZTCM is more robust through inclusion of socio-demographic data (Moeltner 2003). Recent United States census 2000 (Census) data releases are available by zip code, and are ideally suited for this purpose. Commonly, average zonal income is a significant predictor of recreation, though other regressors can be used if hypothesized as important factors for the recreation model at hand. Aggregation bias potentially can be minimized if the variability of the dependent variables is included in the predictive model (Hellerstein 1995). However, a recent econometric test based on a similar ZTCM to that presented here found only a 5% value discrepancy between "corrected" and "uncorrected" models (Moeltner 2003). For our purposes, this small gain is outweighed by the conceptual, operative, and interpretive ease of the classic ZTCM in this case study. To bracket final valuation figures we instead perform a sensitivity analysis on driving cost per mile and carpooling, which are both key choices made by the researcher in construction of the travel cost variable.

Empirical Application

Visitation data for Aravaipa Creek Wilderness was obtained from the BLM Safford field office. The BLM deleted street addresses prior to making the data available for research, though zip codes were retained, allowing ZTCM development. We focus on visitation records for the 5 year period from 1998 through 2002 since these were the most recent contiguous and consistently collected data, and also surround 2000 Census data. Conversation with BLM staff indicated there were no important changes in management during this period of time (T. Schnell, personal communication). Use of multiple data years increases model statistical power, though the span is not so long as to require significant inflation adjustment. Travel costs are calculated in 2000 dollars, the center of the data span. Final valuation figures are adjusted to 2003 dollars.

This study assumes permit data capture all visitation. A full-time BLM ranger is stationed near the West site, and The Nature Conservancy employs a full-time steward near the East site. Permits are checked against parked vehicles at both canyon entrances, and there is some patrolling of the Wilderness interior. Known no-show and cancelled permits were deleted from this study. An uncertain number of additional no-show permits and illegal visitation does exist (P. O'Neill, personal communication), the former somewhat reducing actual visitation and the latter somewhat increasing actual visitation.

Since the Wilderness is unique for Southern Arizona as a whole, the East and West sites are hypothesized to be substitutes for one another. The landscape is comparable between the two though access is distinctly separate. Further, only single-day trips to either site were included in the estimation to maintain as much uniformity of the recreation "good" as possible, and to avoid handling multisite trips and allocation of travel costs (Parsons 2003). Single-day trips constitute 30% of visitation to the East site and 40% of visitation to the West site. For final aggregation we assume multiday trips represent net benefits (consumer surplus) directly proportional to single-day trips. While there are some important investigations of these issues in the literature (see Parsons 2003), we leave further exploration of the multiday data, and likely multipurpose trips, to future research.

An available online program (*Mapquest*™) was used to calculate driving mileage and time for each unique zip code in the database, to both the chosen access site as well as the substitute access site. The program finds the quickest route accounting for slower travel on backroads, which is particularly important as East site access includes extensive unpaved travel.

To ensure that we are isolating the value for our target sites, multipurpose and multisite trips were also controlled by excluding starting locations with estimated driving times beyond 5 h, one way. This time cap choice had the effect of eliminating distant zip codes within Arizona and virtually all out of state visitors. The remaining pool of zip codes within 5 h of both sites limits single-purpose trips to 82% of single-day RVDs for the East site and 90% of single-day RVDs for the West site. These percentages were also applied towards separating the number of single-purpose multiday trips to either site from total visitation. Table 1 summarizes basic visitation statistics for the two sites. Note that visitation to the West site is approximately twice that of the East site.

Table 1. Wilderness Visitation Summary Data for 5 Year Span 1998–2002

	East site	West site
Total permits	1,797	4,272
1 day RVDs	2,700	7,549
2 or 3 day RVDs	10,767	17,886
Total RVDs	13,467	25,435
Single-purpose 1 day RVDs	2,204[a]	6,814[a]
Single-purpose 2 or 3 day RVDs	8,789[b]	16,142[b]
Total single-purpose RVDs	10,993	22,956
Average number visitors/day	7.37	13.93
Average number single-purpose visitors/day	6.02	12.57

[a]82 and 90%, respectively, of 1 day trips were within 5 h drive for the East and West sites.

[b]Calculations by writers based on single-purpose trip percentages for 1 day trips.

Less than 10% of the permits had city and state information but no usable zip code. These permit records with a city origin within the 5 h criteria were assumed to correspond with the distribution of zip codes meeting the 5 h criteria, in both distance to site and RVDs per permit. Visitation from city permit data was added to zip code permit data, weighted by counts observed in zip code permits. A few permitted zip codes were created after 2000 and thus not found in Census results, these were spread proportionately across other zip codes to maintain total visitation.

The Aravaipa Wilderness ZTCM was built to estimate consumer surplus per individual rather than by household, thus the travel cost variable is on an individual basis. The trip leader's zip code is assumed representative of the party as a whole. To achieve a unique travel cost by zip code, the average party number by zip code was calculated. A recent survey-based forest recreation study in the Southwest found a per car occupancy of 4.2, and employed a driving cost of $0.33/mi in 2002 dollars (Starbuck et al. 2005). For this case study, individual driving cost was calculated with the aid of a carpooling step function. The value of this step function matches the permitted party size up to a maximum of four persons per car, a full car corresponding to the lowest individual driving costs. Driving cost per mile was adjusted down to $0.31 for the year 2000 using the Consumer Price Index, and apportioned equally among all party members. Individual opportunity cost was calculated using a third of Census per capita income, multiplied by the round-trip travel time, divided by 2,000 h worked per year. Since Census income figures are for 1999, these were adjusted up to 2000, again using the Consumer Price Index. The total individual travel cost (TC) is then individual round-trip driving cost plus individual time cost plus the $5.00 access fee. Travel cost to the substitute site was calculated the same way. While our approach to constructing the calculated TC is fairly standard (see Starbuck et al. 2005, and discussion therein), there are important issues in how to best incorporate the opportunity cost of travel time (see Shaw and Feather 1999).

The Wilderness demand curve for each site was estimated with a multiple regression model. The visitation rate (V) to the site across zip codes is a continuous dependent variable. Explanatory variables were chosen based on demand theory and common practice in ZTCM studies. These independent variables include TC to the site, travel cost to the opposite canyon entrance substitute site (TC-SUB), and selected or constructed socio-economic variables from Census information. A semilogarithmic model form was hypothesized following previous ZTCM work (Henderson et al. 1999; Moeltner 2003). The model followed from a series of tested relationships, balancing fit, as indicated by the R^2 value, and predictive power, indicated by ratio of estimated RVDs to actual RVDs. To facilitate side-by-side comparison, the same regressors (explanatory variables) were employed for both the East and West sites (discussed further below). The final model was

$$\ln(V_{ij}) = \beta_0 + \beta_1(\mathrm{TC}_{ij}) + \beta_2(\mathrm{TC\text{-}SUB}_{ik}) + \beta_3(\mathrm{APARTY\#}_i) + \beta_4(\%\mathrm{URBAN}_i) + \beta_5(\%\mathrm{YOUTH}_i) + \beta_6(\%\mathrm{MIDAGE}_i) + \beta_7(\mathrm{APC\text{-}INC}_i) + \beta_8(\%\mathrm{HH\text{-}OWN}_i) \quad (2)$$

where i=visiting zip code; j=destination site (East or West); and k=substitute site (East or West, with $j \neq k$). Full definitions and descriptive statistics for the explanatory variables in Eq. (2) are provided in Table 2. Note in particular the difference in average TCs between sites. A Chow Test rejects the null hypothesis that estimated coefficients (the β vectors) for East and West site data are similar at the 95% confidence level. Thus we present separate regression results for each site.

A sensitivity analysis of driving cost per mile was conducted, with parallel regressions using driving costs of $0.34/mi and $0.28/mi to bracket a range 10% above and below the primary $0.31/mi figure. A carpooling step function with a maximum of three instead of four persons per car was also tested. This results in a total of six regressions for each site. Ordinary least squares (OLS) regression was used to estimate these log-linear models. One outlier was noted for the three regressions involving the West site with the four-person carpooling function, this part of the analysis was rerun omitting this observation.

Using the β vector estimated for a given regression, average values of the independent variables across zones were inserted into the prediction equation. The logarithmic prediction equation was then exponentiated and multiplied by zonal population, resulting in a traditional demand curve relationship. Estimates of MCS were calculated by direct integration of the demand curve, evaluated between the average travel cost (TC^*) up to the choke price (TCch), the latter being the maximum travel cost observed in the sample. The formula used for single-day MCS for a given site j (East or West) was

$$\mathrm{MCS}_j = (\text{zonal population}) \int_{\mathrm{TC}^*}^{\mathrm{TCch}} [\exp(\beta_{0j}^* + \beta_1 \mathrm{TC}_j)] d\mathrm{TC} = (\text{zonal population}/\beta_1)[\exp(\beta_{0j}^* + \beta_1 \mathrm{TCch}_j) - \exp(\beta_{0j}^* + \beta_1 \mathrm{TC}_j^*)] \quad (3)$$

where β_0^*="grand intercept," shorthand for the evaluation of sample means for all explanatory variables except travel cost. Conceptually, this calculates site MCS for all visitors by first integrating the Wilderness demand curve for an average visitor, and then expanding this value by multiplying the zonal visitation rate by the zonal population. Since our MCS is calculated on the 5 year period (which negates variation due to single-year weather effects, etc.), the MCS per season was taken as one-fifth of this value, adjusted to 2003 dollars. Single-day MCS per season is divided by the number of trips predicted in Eq. (2) to yield MCS per RVD. Yearly MCS values reported in Tables 3 and 4 are expanded to include single-purpose multiday trips as well as single-purpose single-day trips.

Table 2. Descriptive Statistics, by East and West Site

Variable name	Description	East site destination (with 83 zones of trip origination) Mean	East site destination Standard deviation	West site destination (with 143 zones of trip origination) Mean	West site destination Standard deviation
V_{ij}	Individual visitation rate zone i to site j[a]	0.00233	0.00513	0.00317	0.0792
TC_{ij}	Travel cost ($) zone i to site j	75.621	22.675	53.055	22.737
$TC\text{-}SUB_{ik}$	Travel Cost ($) zone i to substitute site k ($k \neq j$)	42.856	14.439	90.494	30.481
$APARTY\#_i$	Average number in party traveling from zone i	4.482	2.069	3.538	1.673
$\%URBAN_i$	Percentage of urban population in zone i	82.160	32.212	80.598	32.574
$\%YOUTH_i$	Percentage of population less than 18 years in zone i	24.593	6.595	25.321	7.114
$\%MIDAGE_i$	Percentage of population between 34 and 64 years old, zone i	37.990	6.138	38.335	6.702
$APC\text{-}INC_i$	Average per capita income in zone i (thousands of dollars)	22.812	10.052	23.527	10.707
$\%HH\text{-}OWN_i$	Percentage of owner-occupied dwellings, zone i	69.257	19.015	71.916	16.868

[a]Recreation visitor days per zone divided by zonal population.

Results and Discussion

Tables 3 and 4 summarize the results for the models and sensitivity analysis for the East and West sites, respectively. From basic demand theory, in all cases the expected negative relationship between travel cost and trip rate is found (and significant in all cases) along with a positive relationship with income as expected of a normal good (again significant in all cases). For all six West site models presented in Table 4, the estimated coefficients are significant for all eight explanatory variables. For the six East site models presented in Table 3, the estimated coefficients on several variables are never significant (TC-SUB, APARTY#, %MIDAGE) and for another (%YOUTH) are significant in only half of the cases.

An interesting result is the negative effect of urban population percentage on visitation. Any higher visitation due only to population density is accounted for through conversion of absolute trip number to trip rate by zone. Other factors being equal, the Wilderness is slightly more popular with rural visitors, perhaps because of the crowding limits administered by the BLM. The final regressor significant in almost all cases is household ownership. Visitation rates are higher from zip codes with a lower percent of home ownership. Renters seem more likely to visit, perhaps because of fewer opportunities for solitude, lack of their own backyards, or fewer property maintenance responsibilities and commitments normally associated with home ownership. Other variables, including travel cost to the substitute site, fluctuate in significance across the two sites. Though only significant for the West site, the sign of the travel cost to the substitute site is positive for the West site and negative for the East site. There is a possibility that the East site serves as a spillover substitute when West site permits are booked, but that a complementary relationship holds in the reverse case. Brief examination of visitation data suggests permit limits are more binding for the West site.

The sensitivity analysis shows that with a 10% increase or decrease in driving cost per mile consumer surplus correspondingly increases or decreases, though the percentage change is somewhat damped. As the maximum number of persons per car drops from four to three, estimated consumer surplus increases 18–30%. Model fit and estimation performance is similar within the six regressions tested for each site, with a slight edge for driving cost set at $0.28/mi and the carpooling function set at four. The range of consumer surplus estimates, $23.00–35.05 per RVD for the East site, and $16.25–22.07 per RVD for the West site, compare reasonably well with other work, though on the conservative side. A recent meta-analysis of outdoor recreation value (Rosenberger and Loomis 2001) finds a mean value of $37.31 and a median value of $34.75 for five intermountain-region hiking studies (adjusted to 2003 dollars). These values are not site specific, or specific to stream-based recreation, but they do offer a general guide. No completed Sonoran Desert recreation valuation studies, concerning areas with protected instream flow

Table 3. East Site Demand Model Coefficients, with Sensitivity Analysis, and Marshallian Consumer Surplus (MCS) Results

	Sensitivity parameter: Persons per car (max)/Driving cost per mile					
Variable	4/$0.31	4/$0.34	4/$0.28	3/$0.31	3/$0.34	3/$0.28
Constant	−3.764[b]	−3.785[b]	−3.741[b]	−4.341[b]	−4.362[b]	−4.317[b]
TC	−0.042[b]	−0.038[b]	−0.046[b]	−0.031[b]	−0.028[b]	−0.035[b]
TC-SUB	−0.004	−0.004	−0.005	−0.002	−0.002	−0.003
APARTY#	0.047	0.047	0.046	0.083	0.084	0.082
%URBAN	−0.018[b]	−0.018[b]	−0.018[b]	−0.016[b]	−0.016[b]	−0.016[b]
%YOUTH	−0.025	−0.025	−0.025	−0.037[c]	−0.037[c]	−0.037[c]
%MIDAGE	0.032	0.032	0.032	0.040	0.040	0.039
APC-INC	0.090[b]	0.083[b]	0.098[b]	0.062[b]	0.056[c]	0.068[b]
%HH-OWN	−0.018[c]	−0.018[c]	−0.018[c]	−0.014	−0.014	−0.014[c]
R_2	0.497	0.494	0.501	0.461	0.459	0.464
Estimated/Actual RVDs (%)	85	85	86	81	81	82
$ MCS/day	25.06	27.50	23.00	32.35	35.05	29.25
$ MCS/year[a] (thousand)	55.1	60.5	50.6	71.1	71.1	64.3
$ MCS NPV[a] (million) with $r=0.04$	1.38	1.51	1.26	1.78	1.93	1.61

[a]Includes estimated single-purpose multiday trips.

[b]=0.01 significance level, 2-tailed.

[c]=0.05 significance level, 2-tailed.

or otherwise, are known. Neither are studies known which address on-foot recreation with instream flow being the primary draw. This study shows instream flow recreation in the Sonoran Desert clearly represents significant worth to society, consistent with other recreation values found using a variety of estimation techniques for the Western United States and elsewhere. However we caution the reader that these recreation values represent only one dimension of instream flow benefits, and do not substantiate a full argument for protecting the instream resource. As argued early in the "Methodology" section, numerous use and nonuse values exist that are directly related to the perennial nature of Wilderness instream flows.

One suggestive result from this analysis is the premium on MCS per RVD displayed by the East site over the West site. For all driving cost and carpooling combinations, the consumer surplus per RVD of the East site is 40–60% larger than that of the West site. To be clear, multiple (unobserved) factors are potentially represented by this premium. However, a few striking dif-

Table 4. West Site Demand Model Coefficients, with Sensitivity Analysis, and Marshallian Consumer Surplus (MCS) Results

	Sensitivity parameter: Persons per car (max)/Driving cost per mile					
Variable	4/$0.31	4/$0.34	4/$0.28	3/$0.31	3/$0.34	3/$0.28
Constant	−5.368[b]	−5.373[b]	−5.363[b]	−4.659[b]	−4.667[b]	−4.650[b]
TC	−0.061[b]	−0.057[b]	−0.065[b]	−0.051[b]	−0.047[b]	−0.054[b]
TC-SUB	0.025[b]	0.023[b]	0.026[b]	0.019[b]	0.018[b]	0.020[b]
APARTY#	0.277[b]	0.277[b]	0.276[b]	0.304[b]	0.304[b]	0.303[b]
%URBAN	−0.018[b]	−0.018[b]	−0.018[b]	−0.021[b]	−0.021[b]	−0.021[b]
%YOUTH	−0.034[b]	−0.034[b]	−0.034[b]	−0.041[b]	−0.041[b]	−0.041[b]
%MID-AGE	0.039[b]	0.038[b]	0.039[b]	0.034[c]	0.034[c]	0.034[c]
APC-INC	0.028[c]	0.027[c]	0.029[c]	0.031[c]	0.030[c]	0.033[c]
%HH-OWN	−0.018[b]	−0.018[b]	−0.018[b]	−0.021[b]	−0.021[b]	−0.021[b]
R_2	0.656	0.654	0.657	0.625	0.624	0.626
Estimated/Actual RVDs (%)	71	71	72	71	71	71
$ MCS/day	17.31	18.51	16.25	20.40	22.07	19.28
$ MCS/year[a] (thousand)	88.0	94.1	82.7	103.8	112.3	98.1
$ MCS NPV[a] (million) with $r=0.04$	2.20	2.35	2.07	2.59	2.81	2.45

[a]Includes estimated single-purpose multiday trips.

[b]=0.01 significance level, 2-tailed.

[c]=0.05 significance level, 2-tailed.

ferences between the sites allow some speculation. The East site is accessed through far more rustic means, is permitted for and receivers lower visitation, and offers a higher probability of encountering wildlife. It is noteworthy that previous survey research in the Wilderness found “peace, quiet, and wildlife” to rank second only to perennial flow as the most important attributes for the Wilderness (Moore et al. 1990). Permit limits not only reduce visual encounters between hikers, they also reduce overall stress on the resource, increasing sustainability. Though visitation is twice as high at the West site, consumer surplus per season is only between 46 and 63% higher (as estimated in Tables 3 and 4). One possible inference is that solitude is not only a philosophic goal of the Wilderness Act; it is also of implied economic value on an RVD basis.

As shown in the last lines of Tables 3 and 4 for the separate sites, we aggregated recreational values across visitors. We further aggregated through time assuming a similar pattern of visitation and valuation for the site. For example, despite its fairly strict restrictions on access and limited size, total recreational net present value (NPV) for the Wilderness, using the base case and a discount rate of 4%, is estimated at $3.6 million, and as high as $4.7 million under different combinations of parameters from the sensitivity analysis.

As a caveat, and in response to a reviewer’s concerns over possible misspecification for the East site models (Table 3), we reestimated various sets of the six models dropping combinations of insignificant variables. Model results were highly robust to these alternative specifications. For example, when dropping the four variables (TC-SUB, APARTY#, %MIDAGE, %YOUTH) whose estimated coefficients are not significant in a majority of Table 3 models, estimated coefficients on the remaining variables are unchanged in sign and nearly identical in magnitude (and underlying probability values). One change is that the estimated coefficient on %HH-OWN is now significant in all six cases (rather than four). For all six models, the percentage of estimated to actual RVDs for the trimmed specification is within 1% of the same value predicted in the extended specification (Table 3). Further, in terms of goodness of fit and estimated R^2 values the trimmed specifications produce slightly lower values (ranging from 0.407 to 0.472, with the identical ordering across models); in terms of estimated $MCS per day values the trimmed specifications produce slightly lower values (ranging from $23.01 to 32.33, with the identical ordering across models). Given this overall stability in results, we focus on the results presented in Tables 3 and 4, which facilitates parallel comparison of the East and West sites under the same theoretical specification for all models.

Finally, our analysis presents initial ZTCM results using a publicly available data set on BLM permits. As with any empirical study, there are qualifications. Such qualifications also suggest avenues for pursuing additional research on recreational access and stream-based recreation in the Aravaipa Wilderness. For example, our future research plans include investigating the time series aspect of the visitation data; ideally such an extension will allow us to incorporate physical regressor variables such as streamflow and weather conditions using streamgage and climate records. Huszar et al. (1999) provide an example where a function for a physical indicator variable (fish catch, which is affected by lake level) is linked to a travel cost model. Possible ZTCM issues include investigating multiday and likely multipurpose trip behavior, including effects of censoring distant zip codes, and issues associated with binding permit limits at the site (Parsons 2003). As with other studies (e.g., see Parsons 2003, p. 294) that examine groups of related single-site models separately, we find limited evidence of significant substitute price effects (effect apparent in the West but not the East site models). Shonkwiler (1999) argues more detailed specifications may be needed to estimate separate recreation demand models as a system. Additional research is not limited to the permit data. New analysis of or an update to previous survey work in the Wilderness (Moore et al. 1990) could disaggregate and quantify recreational values associated specifically with instream flow and remoteness, among other Wilderness features.

Conclusions

Desert life revolves around water. Those enjoying the “laughing waters” of Aravaipa Canyon Wilderness, one of the last perennial streams in Southern Arizona, testify to the value of instream flow and the associated riparian areas it supports. The BLM’s 1981 priority instream flow permit of 140 l/s (5 cfs) indicates a proactive step towards protecting the flow and thus the resource. Valuation of stream-based recreational access in this study is a starting point for demonstrating how important that instream flow permit is to maintain, if not expand.

There is also suggestive evidence that remoteness and permit limits may also have a significant role in consumer surplus benefit, exemplified by an apparent premium paid on East site visits. This is an issue that merits further investigation. Of course, a solitude value is also embedded in West site consumer surplus, since both sites are managed with permit limits. Because of solitude value, it is uncertain whether relaxing permit limits would increase recreational use MCS. Values aside from recreational use value may also be impacted by freer access. Finally, restricted visitation assists resource sustainability (i.e., meeting assessed carrying capacity constraints), extends further benefits, and is aligned with the original vision of the 1964 Wilderness Act.

From a broader perspective, the attempt to assign recreational use values to Aravaipa Creek may be seen as a first step in understanding the benefits of other riparian areas in the Sonoran Desert. Exploring the multiyear Wilderness visitation data presented here adds to regional riparian understanding. Relevance to the greater San Pedro River watershed is most direct, with a pending struggle to maintain instream flow and riparian habitat in the face of increasing human water extractions. Cogent applications are also found in nearby Pima County, which is working to enact the Sonoran Desert Conservation Plan, perhaps the most ambitious regional planning effort in the West today. The Plan hinges on protection of core environmentally and culturally significant sites in the greater Tucson area, many of which are riparian areas (Pima County 2004).

Complex ecosystems are built around natural water features. In the Western United States acute water resource issues are often centered on the few remaining free-flowing streams. Here all the extractive use values of agriculture, industry, and municipality are juxtaposed against instream use and nonuse values. Because traditional extractive economies have been so important in the past, inertia has blocked support of reallocating water back to streams. Nonmarket valuation of riparian areas offers a way to view this recurrent conflict in terms of raw dollars, assisting choices in regards to efficient use of precious water resources. Further, it must be stressed that this recreational value study encompasses only a fraction of total resource value. Other use values, such as property values of nearby ranches and residences, are surely substantial. Ecosystem service values of wilderness areas, such as air and water quality enhancement, or contributions to the larger habitat of critical fish and wildlife species, are barely understood and largely unquantified. In addition, nonuse values of river systems have been reported in some cases to be much larger than use values (Brown 1992); there is also evidence that this holds for wilderness areas more generally (Loomis 1996). In closing, while the complexity of riparian systems and associated instream flows has slowed the full understanding of their benefits, investigation of the recreational use values of the remaining protected areas—in the Sonoran Desert and elsewhere—can be an important input to environmental planning and decision making.

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