THE VALUE OF WATER LEVELS IN WATER-BASED RECREATION:

A POOLED REVEALED PREFERENCE/CONTINGENT BEHAVIOR MODEL

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Abstract. In this paper we present estimated recreation values for preventing a decline in water levels at, and even the total loss of, a large western lake that is drying up. We use a Poisson version of the count data travel cost model; however, in addition to and in combination with revealed preference (RP) data, we employ contingent behavior (CB) responses to hypothetical questions on alternative water levels and number of trips. The pooled model used allows for tests of differences between results using RP and CB data. This particular pooled RP/CB approach has not to our knowledge previously been applied to examine the values of alternative water quantities in water-based recreation.

1. INTRODUCTION

In this paper we use stated preference (SP) data on recreation trips that are responses to hypothetical water level scenarios constructed for survey respondents. These SP or contingent behavior (CB) data supplement revealed preference (RP) data on actual trips taken during a season. CB responses are those one obtains in response to a question such as: "how many trips would you take to this lake if the water level was 20 percent higher than it was when you visited in June?". We combine these two sources of data in order to ascertain whether and to what extent water levels matter in the demand for trips to a lake recreation site. Though a great deal of recreational economic analysis has focused on water quality issues, far fewer valuation studies have focused on the importance of the quantity of water at a recreation site. Our application is to a lake in Nevada, a state where the quantity of virtually all surface water is of interest because it is so scarce.

Nevada's Walker Lake is one of the rare perennial, terminal lake "sinks" found in the Great Basin area of the United States (Thomas, 1995). Walker Lake is an important sport fishing location and is also a key site for other water-based recreation as the home of Walker Lake State Park. It is one of only three terminal lakes in Nevada that contain fish. However, Walker Lake is at serious risk of becoming useless in this regard. The lake's level has declined approximately 140 feet since 1882, though very recent wet years in the region have ended a drought period and slowed the decline. Upstream agricultural uses on the Walker River, which feeds the lake and has its headwaters in California, are usually blamed for the decline. Walker River water is about 140 percent allocated, with this overallocation possible because of return flows.

Because Walker Lake is a terminal lake, dissolved solids that flow into it build up in concentration as water in the lake evaporates. Total dissolved solids (TDS) in Walker Lake have increased steadily over the years, from approximately 2,500 milligrams per liter (mg/L) in 1882 to 13,300 mg/L in 1994 (Thomas, 1995). Agriculture is often deemed directly responsible for this increase in TDS, though this point is debatable, as a newly developed water quality model shows that even if all TDS loading from agriculture were eliminated, TDS would still be a problem at the lake (Humberstone, 1999). A more certain link exists between lake volume and TDS, with TDS increasing as the volume of water in the lake declines.

Increasing TDS levels have increased the likelihood that certain species of fish cannot survive in Walker Lake (see Thomas, 1995; Humberstone, 1999). Laboratory experiments suggest that the lake's key fishery species, the Lahontan Cutthroat Trout, cannot survive at TDS levels equal to or greater than 16,000 mg/L (Vinyard and Dickerson, 1998). Thus, the recent measurements of Walker Lake TDS of 13,300 mg/L cause concern. Furthermore, it has been suggested that volumes of water at Walker Lake greater than a critical level of 2.3 million acre-feet must be maintained to stay below the 16,000 mg/L critical TDS threshold and maintain the fishery (Humberstone, 1999). For reference, the end-of-year lake level in 1997 was approximately equal to this critical level, and was below it during the years from 1992 to 1996. Even at the current TDS levels the Lahontan Cutthroat Trout must be stocked in order to grow to sizes of interest to sport anglers. Finally, it is estimated that if average annual deficit conditions continue, the critical TDS level of 16,000 mg/L will be exceeded in approximately twenty years (Humberstone, 1999).

As a possible way to halt the decline of Walker Lake as well as address other important allocation issues, several parties in Nevada and California have begun discussion of the potential for a regional or state water bank. At the practical level, however, a great deal of water would have to be somehow moved to Walker Lake to bring about a substantial change. Humberstone's forecasting model shows that a 16% reduction in all upstream current diversions is not sufficient to maintain the fishery in all future years, though the exact necessary level of upstream diversions remains unknown.

Several previous studies have estimated recreational use values for water quantity changes (e.g., Creel and Loomis, 1992; Cameron, Shaw and Ragland, 1999; Cameron et al., 1996; Ward et al., 1997; Cordell and Bergstrom, 1993; Fadali and Shaw, 1997). However, the pooled data approach that we use to combine RP and CB data, which is somewhat similar to that used by Englin and Cameron (1996), has not previously been used to examine the value of water quantities in recreation. To our knowledge, the use of CB data to examine the impacts of water level changes has only been performed previously by Cameron et al. (1996) and Cameron, Shaw and Ragland (1999). Cordell and Bergstrom (1993) undertook an analysis of use values for North Carolina reservoirs, but their study was essentially a contingent valuation (stated willingness to pay or WTP) approach which may be different because the study focuses on WTP rather than trip behavior.

2. THE MODEL

Travel cost models most often only use data on actual reported trips (RP approach). However, with increasing frequency modelers are supplementing these data with information from either contingent valuation method (CVM) or CB experiments. Different modelers have taken different approaches to do this, and we briefly describe three of these approaches here. First, some have pooled RP and CVM data to estimate welfare measures, for example through a pooled Tobit estimation approach (e.g., Cameron, 1992; Kling, 1997). Second, an approach of combining CB methods and discrete choice models, which employs the random utility framework of trip choice modeling, has been used by Adamowicz, Louviere and Williams (1994) and Adamowicz et al. (1997). A hybrid of these first two approaches can be found in Niklitschek and Leon (1996). These authors use no actual RP data, but combine stated intended trip demand and CVM or WTP data to examine water pollution issues at a South American beach area.

In a third approach that is quite different than any of the above, Englin and Cameron (1996) have combined CB and RP data into a panel framework and estimated welfare measures using Poisson specifications, following an approach initially developed by Hausman et al. (1984). Our approach, which we refer to as a pooled Poisson RP/CB count data model, is most similar to the third approach above (Englin and Cameron), differing chiefly from theirs in that we estimate pooled Poisson models rather than using a fixed effects Poisson specification. The three main features of our approach are (1) it pools CB and RP data, (2) it employs a count data framework, and (3) it uses the Poisson log likelihood function. These three features are discussed below.

There are two main gains from pooling CB and RP data. CB survey questions can be constructed in order to elicit information about scenarios that lie outside (in some cases, well outside) observed historical values for variables such as water levels, site amenities, and travel costs. In contrast, RP approaches are confined to use of data corresponding to actual historical values of the data for such variables. As in most econometric modeling, we are sanguine that examination of marginal changes within the range of the actual data can be carried out, but extrapolation of the results of RP studies to conditions outside those that are observed are potentially problematic. The use of CB data in combination with RP data addresses this issue and is particularly important for applications in which a large nonmarginal environmental change is in fact the expected outcome in the absence of mitigation efforts. Examples include the potential total loss of reservoirs in the Columbia River Basin addressed by Cameron et al. (1996) and here, the potential "drying up" of Walker Lake.

Another advantage of pooling RP and CB data in one model is that the researcher can test for similarities (or differences) in empirical results derived from these two different types of data. In this manuscript, we test for this by examining whether the source of the data has a statistically significant influence in the model, with the null hypothesis being that it does not.

The second main feature of our approach is that it uses a count data formulation, which is well-developed in the literature. Applications to individual behavior are solidly grounded in consumer theory (Hellerstein and Mendelsohn, 1993). The count data model has been applied to recreation demand in several instances (beginning with Shaw, 1988 and later including Hellerstein, 1991; Creel and Loomis, 1992; Englin and Shonkwiler, 1995; Shonkwiler and Shaw, 1996; Englin et al., 1998). Recently, Huszar et al. (1999) apply the count model to examine the issue of water level changes at a reservoir. The count data model provides a useful framework for dealing with total seasonal trips and seasonal welfare measures. It has rarely been developed for multiple recreation site analysis (with exceptions in Englin et al. 1998 and Shonkwiler 1999), which may put it at a disadvantage to multiple site approaches such as the random utility model, at least for dealing with analyses where potential site substitution is important. Use of a single site count model is likely the most defensible as an approach when the site is somewhat unique, and when one is interested in total seasonal trip changes. As a terminus lake, Walker Lake qualifies in the first regard, and we wish to examine how the total loss of the lake may affect total seasonal welfare.

The third main feature of our approach involves use of the Poisson log likelihood function. We use this specification to model the underlying trip distribution because it is an appropriate way to accommodate the presence of zero values (thereby allowing the inclusion of nonparticipants) and nonnegative integer values that reported trips take. The Poisson handles zero trip observations, which can be a problem in other recreation demand econometric modeling approaches (e.g., under the assumption of normally distributed error terms).

The starting point for the model is the demand for trips to a single recreation site, Walker Lake:

$$TRIPS = F(C, X, Z, D) \tag{1}$$

where *TRIPS* is the quantity of recreation trips demanded, C is the cost of travel to the site, X is a vector of respondent-specific attributes, Z is a vector of site-specific attributes, and D is a (1,0) indicator variable indicating whether the data for the observation is CB (D=1) or RP (D=0) data.

As mentioned above, the Poisson regression model provides an appropriate specification given the nature of recreation site trip data. The log likelihood function for the Poisson is:

$$\text{Log}\, L(\beta) \;=\; \sum_{i=1}^{N}\left[-\lambda_i + TRIPS\beta'\mathbf{x}_i - \ln TRIPS_i!\right] \qquad 2$$

where $\lambda_i = \exp(F(C_i,X_i,Z,D_i))$.

While the model above yields a welfare measure that is an approximation of the exact Hicksian measure, it has a simple and attractive feature allowing calculation of the consumer's surplus per trip. Assuming β_{COST} is the coefficient on the travel cost, for a change in the travel cost to a very large (infinite) travel cost, CS per trip is simply $-1/\beta_{COST}$. Total seasonal consumer's surplus is simply the total predicted trips divided by β_{COST}. When using a single-site cross-sectional model, the site characteristics cannot typically be used to explain the model (as they obviously do not vary for individuals in the data), and there can be no direct link to be made between site quality changes (such as the water quantity change of interest here) and estimated welfare impacts. However, in our case we have data from the contingent scenarios linking a variety of water levels to recreation trips, and this allows use of this framework to examine the site quality change of interest.

For the purpose of hypothesis tests we refer to White’s standard errors, from which inferences can be drawn even in the presence of misspecification (White, 1982). In addition, the Poisson distribution yields unbiased parameter estimates even when the distribution is misspecified (Gourerroux, Montfort and Trognon, 1984).

3. DATA AND VARIABLES

Between November 1995 and March 1996, a mail survey questionnaire was sent to a group of recreators who visit several lakes in the region of northwest Nevada. The mail survey was implemented using most of the guidelines suggested by Dillman (1978), but the total budget for this project precluded extensive efforts to obtain a return from those who failed to respond. We acknowledge that potential bias in remaining sample responses is an issue (Cameron, Ragland and Shaw). Approximately 44 percent of the questionnaires were returned, after subtracting those surveys that were returned because of bad addresses. A large proportion of the sample consisted of anglers, many of whom had participated in the annual Walker Lake fishing derby, typically held in the winter.

3.1 Contingent Behavior Scenarios

Economic analysis on this project took place simultaneously with beginning research in the hydrologic and other physical sciences, so the survey design could only incorporate a scant amount of existing scientific information. The main source of scientific information in 1996 was found in Thomas (1995), and records from the U.S. Geological Survey. This information was used to construct the CB scenarios.

There were three different versions of the mail survey questionnaire that presented baseline conditions and hypothetical scenarios for a rise in the water level of Walker Lake, and each respondent received only one version of the survey. Each version first asks individuals to report their actual trips to Walker Lake by month for the previous year. (These RP data by themselves are used by Fadali and Shaw (1998) in conjunction with monthly actual water levels at Walker Lake, to estimate recreator values to avoid total loss of the lake.) Then, each questionnaire version depicts slightly different hypothetical scenarios, with each being a variation on possible water levels. Scenarios are presented using information in text form. Additionally, two of the three versions present to the respondent a pair of computer-enhanced photographs, one with "baseline" actual 1996 conditions and the other with enhanced "new" conditions.

As stated above, asking CB questions is relatively new in recreation modeling and there is not much literature to provide guidance on survey design. Focus groups conducted prior to final survey questionnaire design allowed experimentation with text and photographs and the amount of possible information to give the respondent before fatigue set in. Ideally, one would want to match the hypothetical scenario as closely as possible to the actual trip data collected, in this case presenting and asking about water levels that take place in certain months, possibly at several different recreation destinations. It was decided that the focus would be on one water (Walker Lake) and that adding the time dimension (the month the water level would occur) was simply too much to expect the respondent to understand and absorb, especially as the instrument was to be a mail survey. Thus, the monthly timing of the water level occurrence in the scenario is not specified and the analysis is confined to modeling annual, rather than monthly, behavior.

After being presented with a scenario that described a water level increase or decrease, respondents were asked whether they would change behavior from their actual number of reported trips for 1996 because of this different water level. If respondents answered "No (my trips would stay the same)", then the number of trips under the hypothetical scenario was tallied as being the same as the actual number of self-reported trips in 1996. The breakdown into distinct steps, or obtaining a yes/no response prior to the response on number of trips, was done simply to clarify the questions, allow the respondent to see a more simple-looking mail survey questionnaire, and to provide the “non-player” with the option to skip over several subsequent questions.

If the respondents stated yes, they were next asked whether they would take more or fewer trips, and then asked to report how many more or fewer trips they would take during each month of the year. The three scenarios were:

- a text-only high-water scenario that described conditions (lake surface area, level of TDS, condition of sport fish, and number of usable boat ramps) at water levels approximately 20 feet higher than end-of-1996 levels of 3,946.5 feet,
- an identical high-water scenario that included computer generated photos of the higher water level at Walker Lake, and
- a low-water scenario including photos, which described conditions associated with water levels approximately 20 feet lower than 1996 conditions.

It is clear that the 20-foot increases depicted in the surveys would translate to large increases in volume at the lake (approximately 700,000 acre feet), but this number was chosen based on available physical science information that suggested increases which might prevent fishery loss (Thomas, 1995). These scenarios are perhaps both politically and practically improbable in view of current institutions, but the key point in doing such analysis relates to whether the respondents believed in the scenarios. If the respondent thought the scenarios were plausible, as may be the case for a person asked in a marketing study to rate a currently unavailable automobile design, the responses can be tested for consistency. If the respondent thought the scenarios were implausible, he or she was given the option of providing no response to the question.

During the process of data cleaning to produce the final data set, surveys were eliminated if they either contained contradictory information or did not provide enough information. We eliminated 23 respondents who skipped the contingent scenario entirely because we do not know what they were thinking. We also eliminated 11 respondents who said their trips would not change in response to the scenario but who then continued on to report a changed number of trips, as these respondents appear to be confused. We also eliminated over 100 respondents who answered "I am not sure" (as to whether they would change their trips under the different scenario.)

After eliminating surveys with inconsistent/missing contingent behavior or demographic data, a sample of 236 respondents remained. Each respondent contributed two observations to the model (reported actual 1996 trips and contingent trips under the new water level scenario), for a total of 472 trip observations. Of the 236 respondents, 82 received surveys involving lower water level scenarios and 154 received higher water scenarios. Of the 154 higher water scenario completes, 91 were the version with photos accompanying the text. Of the 236 respondents, 136 said they would not change the number of trips they would take under different hypothetical conditions. One hundred and seventeen of the respondents did not take any trips to Walker Lake originally, while 99 respondents indicated they would take no trips under the contingent scenarios (6 of these 99 respondents did visit Walker Lake at the baseline but indicated they would not under the new scenario, since all 6 received the low-water scenario).

3.2 Explanatory Variables

The dependent variable is number of trips to Walker Lake. For the 236 observations that correspond to RP trip data, the dependent variable represents the actual number of trips taken in 1996. For the other half of the 472 observations (contingent trips data), the increase (or decrease) in number of trips indicated by the respondent as a response to the hypothetical scenario was added to (subtracted from) the baseline number of trips taken in 1996. This yields the number of trips that the respondent says he/she would take under the new scenario. For respondents who answered that they would not change the number of trips they take in response to the new scenario, the number of contingent trips was set equal to the actual trips taken in 1996.

The independent variables included in the model consist of travel cost, one site-specific attribute (the actual and hypothetical water levels), six respondent-specific characteristics, an indicator variable CB denoting the source of the data point (RP *versus* CB), and an interaction term between CB and travel cost. The independent variables are shown in Table 1. Mean values of selected variables are shown in Table 2.

4. RESULTS

We first discuss the results of the pooled Poisson model (Section 4.1). Then, using those results we develop and present estimates of the value of recreation at Walker Lake, the impact of changes in water level on trips taken, and the influence of water level changes on recreation values (Section 4.2).

4.1 Model Results

Table 3 presents the results of two specified pooled Poisson models:

1. The first specification includes the variables CB and CB*COST (unrestricted model). Inclusion of these variables allows one to test the null hypothesis that the source of data (CB versus RP) is not a statistically significant influence in the model. The results of this model specification are shown in the second column of Table 3.

2. The second specification omits the variables CB and CB*COST (restricted model). Estimation of the model without these variables allows one to determine the influence of their omission on other parameters of interest. The results of this model are shown in the third column of Table 3.

Inspection of Table 3 shows that most results are similar across the two specifications. The estimated coefficient on Walker Lake water level is positive and significant at the .01 level. This means that, *ceteris paribus*, higher water levels are associated with higher numbers of trips to the lake. While the sign of this coefficient may not be surprising to some readers, other studies have shown that different types of users may have different reactions to higher and lower water levels. For example, beach users may find a very high water level interferes with their enjoyment of the shore. Because most of our respondents are anglers and the negative impacts of the Lake's decline were made clear, we were expecting a positive influence.

The estimated coefficient on travel cost is negative, as expected, and statistically significant at the .01 level as well. The gender and age of the respondent both have the expected signs (positive) and are statistically significant. The indicator variable denoting that the respondent is retired from the work force has a negative coefficient. This may run counter to some expectations because retirement allows more time to take trips (age is controlled for here), but it may pick up the influence of lost wage effects on engaging in outdoor recreation. In any case the variable is significant at only the .10 level. The size of household, level of respondent's education, and household income are not statistically significant in the model.

While the estimated coefficient of CB is not statistically significant, the White's standard error for the coefficient on CB*COST would appear to indicate slight statistical significance (at the .10 level for a two-tailed test). At first glance this suggests that the source of data (contingent behavior scenario *versus* actual revealed preference data) may have a marginal influence in the model, indicating differences in the hypothetical and RP data. Comparison across columns 2 and 3, however, shows that inclusion of the two CB indicator variables has very little (in some cases no) influence on estimated coefficients for the remaining variables. The parameter most affected by dropping the CB indicators is that for water level, which falls from .028 to .024 (14% decrease) due to inclusion of the data source indicators. This is a relatively modest alteration.

To explore the issue of differences in the data further, we conducted a Wald test. This test, as opposed to a likelihood ratio test, provides the appropriate hypothesis test for the influence of the source of data (CB *versus* RP) because of the consistency of the covariance matrix (Gourerroux, Montfort and Trognon, 1984). Specifically, this test is preferred over the likelihood ratio test because the results do not depend on the validity of the assumed underlying (Poisson) distribution. The null hypothesis is the set of restrictions:

$$H_0: \beta_{CB} = \beta_{CB*Cost} = 0 \qquad 3$$

Under H_0 , the Wald test statistic W has a chi-squared distribution with two degrees of freedom (the number of restrictions). The critical value for the chi-squared distribution (n = 2, P = 0.95) is c = 5.99. For the (unrestricted) regression shown in column 2 of Table 2, W = 4.492 < 5.99 = c. Therefore, one cannot reject the null hypothesis that the set of restrictions holds. The indicator variables denoting the source of data (CB *versus* RP) are not significant factors in the model.

The results of the Wald test are relevant to the issue of "convergent validity," which involves comparing the results of stated preference analyses with those of revealed preference studies (Pearce et al., 1998). We conclude that because one cannot reject the null hypothesis for the Wald test, convergent validity does hold for our data set. That is, the contingent behavior and revealed preference data both lead to the same welfare estimates (presented below). While this is not the primary focus of this study, the results provide interesting insights to an issue currently of some discussion in the literature. We provide two caveats below.

First, our results indicate that convergent validity holds for this particular data set, not necessarily in any wider or more general sense. Second, as suggested by Pearce et al., caution is necessary in testing for convergent validity, since revealed and stated preference methods often may measure different categories of value (use values only and use plus nonuse values, respectively).

4.2 Estimated Values

Table 4 shows estimated values derived from the results of the models. First, we report the estimated average consumer surplus per trip to Walker Lake, calculated as $-1/\beta_{COST}$. For the unrestricted model, the estimate of per-trip consumer surplus equals \$88/trip. The estimate of consumer surplus from the restricted model equals \$120/trip.

At first glance, these per-trip values may appear somewhat high. For example, the median value for cold water recreational fishing as reported in Walsh et al. (1990) is approximately \$40 per day (1997 dollars). However, it is important to remember that the values estimated by our model are in units of dollars per "trip" rather than per "day". According to the results of on-site surveys conducted at Walker Lake, the mean trip length is about 3 days (Fadali, Shaw, and Espey, 1998). Multiplying the Walsh et al. per-day value by 3 days yields \$120/trip. This is quite close to the values we estimate in this manuscript, and is in fact equal to the estimate of consumer surplus from the restricted pooled Poisson model. This provides some comfort that the per-trip value is not outside the range of the literature, but several recreation modellers caution against the use of such per trip values at all.

The second type of result included in Table 4 is our estimate of average annual consumer surplus (per person) from recreational visits to Walker Lake. The estimates range from \$485/person/year to about \$665/person/year. This estimate can be interpreted as the seasonal amount a recreational user would be willing to pay to prevent loss of access to Walker Lake.

The third row of Table 4 presents estimates of the effect of changes in the Walker Lake water level on the number of trips. The results indicate that for a one-foot decline in water level, each recreational user would take (on average) between 0.1 and 0.2 fewer trips per season. In the fourth row, we show the consumer surplus losses associated with this decline in trips. Each one-foot drop in water level is estimated to result in a loss on the order of \$12 to \$18 per person per season or year. Again, the typical single site count model does not allow examination of this effect, unless the data are time series (as in Huszar et al.) or RP and CB data are combined to yield variation in the site quality variable. Also, while the calculation here relates to a partial derivative which is marginal, the use of the CB data allows for the nonmarginal changes introduced in the hypothetical scenarios to influence the eventual magnitude of the coefficient, and thus the magnitude of this consumer's surplus estimate.

5. TOTAL VALUES TO RECREATIONAL USERS AND AGRICULTURE, POLICY IMPLICATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

We can use the results above to examine the recreation values of changes in total volume (acre-feet) of water at Walker Lake. These estimates in turn can be linked with recent work in the physical sciences that relates water volume to critical TDS levels for sport fish at Walker Lake. First, scientists have estimated that to maintain the TDS concentration at the 1994 level of 13,300 mg/L, it would be necessary to add 33,000 more acre-feet annually to Walker Lake than the long-run average annual inflow (Thomas, 1995). Furthermore, to reduce TDS from 13,300 mg/L to 10,000 mg/L (a level considered to be more in line with conditions necessary to support the fishery), the lake volume initially would need to be increased by about 700,000 acre-feet and the lake level increased by about 20 feet. In addition, to maintain this higher lake level, an extra 47,000 acre-feet/year (above the long-term average) would subsequently need to be added to the lake.

Our hypothetical scenario of a 20-foot rise in lake level was in fact based directly on the initial increase in water volume (700,000 acre-feet) that is estimated to be necessary to lower TDS to 10,000 mg/L. Our scenario thus yields the value that recreators attach to an increase in water level associated with this reduction in TDS. Since the range of values estimated by the model is from about $12/person/year/ to about $18/person/year for a one-foot rise in lake level, the estimated range of values for a 20-foot rise is approximately $240/person/year to $360/person/year.

The next step is to develop a range of estimates of the aggregate value to recreators of the 20-foot rise in lake level. This involves estimating the number of recreators who either visit Walker Lake currently or would do so given a rise in the level of the lake. There is significant uncertainty regarding the true number of visitors, but estimates are available. Fadali and Shaw (1998) estimated that 20,000 persons visited Walker Lake during 1996, based on a regional stratified sample of the population responding in a telephone survey. However, this estimate may be considered a “lower” estimate because it includes only residents in Nevada counties relatively close to Walker Lake, and specifically does not account for potential visitors from other Nevada counties and California. To address this downward bias, we also calculate aggregate values using a “higher” estimate of number of visitors equal to 30,000. We recognize that the true number of visitors may indeed be greater than our “higher” estimate, but we use this value to be conservative.

It is also important to ascribe some value to area recreators who do not currently take trips to Walker Lake but who may begin to take trips given a rise in lake level. Based on the survey results of Fadali and Shaw, there are about 185,000 persons from the Nevada counties close to Walker Lake that took at least one water-based recreation trip to a waterbody in the region in 1996. Note again that this is a lower-bound estimate, since it omits any and all visitors from other counties (including California). Nevertheless, using this figure, one can estimate that between 155,000 and 165,000 persons (depending on whether 20,000 or 30,000 persons visited Walker Lake in 1996) were engaged in water recreation in the surrounding region without visiting Walker Lake. Fadali and Shaw compute the per-person values to prevent the drying-up of Walker Lake and find that the values for current Walker Lake non-visitors are about five percent of the values for Walker Lake visitors. In our analysis we apply this ratio to our current visitor values and thus use a “lower” value of $0.60/person/year/foot (.05*$12) and “higher” value of $0.90/person/year/foot (.05*$18) for current non-visitors to Walker Lake.

The calculations of aggregate values for a 20-foot rise in the level of Walker Lake use the per-person values and visitation estimates above and are shown in Table 5. The "lower" estimate of aggregate value is \$6.78 million, and the "higher" estimate is \$13.59 million. Once again, these estimates likely understate true aggregate recreational user values because they are based on a number of total recreational users that does not include individuals outside of nearby Nevada counties.

It is interesting to compare the estimated aggregate recreational user values to the foregone value to agricultural water users associated with a 20-foot rise in Walker Lake. Fadali and Shaw calculate that the likely value of water per acre-foot in agriculture in this area is between \$12 and \$45. Recall from above that the 20-foot rise in lake level would require a one-time inflow of 700,000 acre-feet, followed by annual inflows that are 47,000 acre-feet above the historical average annual inflow average. Thus, we can break the comparison of agricultural and recreator values into two steps: the first for the initial 700,000 acre-feet allotment, and the second for the continuing annual increased flow.

For the initial allotment, we calculate a "lower" agricultural value to be \$8.4 million ((700,000 A-F)*(\$12/A-F)) and a "higher" value as \$31.5 million ((700,000 A-F)*(\$45/A-F)). Note that our range of estimated recreational user values of approximately \$7 million - \$14 million lies partially within the range of estimated agricultural values. This indicates that even annual recreational user values may be high enough to purchase the initial 700,000 A-F allotment from upstream users, in the event that a water market in this region were formed. In actuality the purchase by recreational users of the initial allotment seems even more feasible given that the 700,000 A-F only has to be purchased up-front, whereas the recreational user values we estimate are annual values associated with the longer lived increase in lake level. After the first year of a potential trade, the necessary continuing annual increased inflow of 47,000 A-F is calculated to be worth from $0.6 million to $2.1 million per year (foregone) to agricultural users. This is significantly lower than the annual value of $7 million -$14 million that recreational users associate with higher water levels at Walker Lake.

Some hydrologists have suggested that if the 1987 to 1994 drought at Walker Lake had existed for just another two years, the lake would have been unable to recover for future use. At best it is currently a fragile ecosystem. As stated in the introduction, it is possible that a water bank will be created for this region, though national, state and local politics will undoubtedly play the deciding role. On the positive side, water banks may in fact be most beneficial during drought periods (Loomis, 1992). Part of the success for a potential bank depends on whether a market exists for the water, with one possibility being the demand that recreators have for increases in water supplies at one or more recreational sites. The results of this manuscript indicate that recreator demands are likely sufficiently high to bid away agricultural water on a rental basis for the case of Walker Lake. These results support those of Fadali and Shaw, who employed only RP and not CB data in a multiple site recreation model. A major advantage of our results over theirs is that we are able to focus more carefully on values for water level changes at Walker Lake, while they simply examine the welfare impacts from a total loss of the Lake.

As in this study, economic analysis must often be performed ahead of physical science analysis because of the funding and timing of research projects, even though having the best physical science results often improves the quality of economic analysis. This suggests that it is wise to build an economic model flexible enough to incorporate better scientific data and measurements as they become available. Using storage-elevation relationships from the physical sciences, we can flexibly translate water level changes to volume changes, identifying the critical water level change needed. Our model then allows one to recover the value for additional water for a variety of water levels considered. A key science finding yet to come is a more precise identification of the critical volume of water for sustaining the Walker Lake fishery. If more water is needed to avoid the TDS level critical for sport fish species, our model can be used to examine that situation.

As noted above, obtaining large increases in volume at Walker Lake may not be possible given the current political climate, existing institutions, and withdrawals from the system. Future study of the Walker River Basin needs to better address the exact volume needed to avoid the 16,000 mg/L TDS level over the years to come, and the role of uncertain factors such as global climate change and the incidence of extreme precipitation events. Finally, there needs to be much more research on the willingness to sell on the part of agricultural users in the Basin, and other factors that could lead to actual development of a water bank.

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Table 1:

Variables

Variable Name	**Variable Definition**
WATER	Water level at Walker Lake, in feet
GENDER	Indicator variable denoting respondent gender (= 1 if male; otherwise 0)
AGE	Age of the respondent in years
HOUSEHOLD	Number of persons in respondent's household
EDUCATION	Respondent education (1 = did not finish high school (HS); 2 = completed HS; 3 = 1-3 yrs. college; 4 = 4 yrs. College; 5 = 1 or more yrs. Graduate school)
INCOME	Annual household income (including interest, dividend, and retirement income)
COST	Travel cost, including opportunity cost of time
RETIRED	Indicator variable denoting respondent is retired (= 1 if retired; otherwise 0)
CB	Indicator variable denoting whether the observation is from CB or RP data (= 1 if from CB data; otherwise 0)

CB * COST	Interaction term composed of CB * COST

Table 2:

Mean Values of Selected Variables

WATER	3,949
GENDER	0.80
AGE	45.39
HOUSEHOLD	2.83
EDUCATION	3.10
INCOME	$58,602
TRAVEL COST	$180
RETIRED	0.15

Table 3:

Results of Pooled Poisson Models[1]

Variable	**With CB Indicator Variable and CB*Cost Interaction Term**	**Without CB Indicator Variable and CB*Cost Interaction Term**
Constant	-92.55*** (23.43)	-108.92*** (26.48)
WATER	0.024*** (0.006)	0.028*** (0.007)
GENDER	0.529** (0.269)	0.526** (0.267)
AGE	0.036*** (0.007)	0.036*** (0.007)
HOUSEHOLD	0.102 (0.104)	-0.101 (0.103)
EDUCATION	-0.151 (0.095)	-0.150 (0.095)
INCOME	$-6*10^{-6}$ ($4*10^{-6}$)	$-6*10^{-6}$ ($4*10^{-6}$)
COST	-0.011***	-0.008***

	(0.003)	(0.002)
RETIRED	-0.498* (0.279)	-0.501* (0.281)
CB	-0.239 (0.400)	Not included
CB* COST	0.005* (0.003)	Not included
Log Likelihood	-2725	-2755

[1] White's standard errors are shown in parentheses.

* Denotes statistical significance at the .10 level for a two-tailed test.

** Denotes statistical significance at the .05 level.

*** Denotes statistical significance at the .01 level.

Table 4:

Consumer Surplus and Changes in Trips

Estimate	**With CB Indicator Variable and CB*Cost Interaction Term**	**Without CB Indicator Variable and CB*Cost Interaction Term**
Average Per-Trip Consumer Surplus	$88	$120
Average Annual Consumer Surplus	$485	$664
d(TRIPS)/d(WATER) at Mean Predicted Value of TRIPS	0.132 trips annually per person per change in water level (feet)	0.154 trips annually per person per change in water level (feet)
Changes in Annual Recreator Values due to Water Level Change	$11.60 annually per person per change in water level (feet)	$18.54 annually per person per change in water level (feet)

Table 5:

Estimated Annual Aggregate Values to Recreators

of a 20-foot Rise in Water Level at Walker Lake[1]

"Lower" Estimate:	
Walker Lake Visitors: (20,000 recreators) * (20 feet * $12/foot) =	$4.8 million
Non-Walker Lake Visitors: (165,000 recreators) * (20 feet * $0.60/foot) =	$1.98 million
Total	**$6.78 million**
"Higher" Estimate:	
Walker Lake Visitors: (30,000 recreators) * (20 feet * $18/foot) =	$10.8 million
Non-Walker Lake Visitors: (155,000 recreators) * (20 feet * $0.90/foot) =	$2.79 million
Total	**$13.59 million**

[1] Both the "lower" and "higher"estimates presented in this table tend to understate the true aggregate values of all recreators, because they are based on recreator populations that only include individuals from Nevada counties relatively close to Walker Lake. The values of current and potential recreators from other Nevada counties, California, and other states are omitted.