Recreation Benefits of Increased Flows in California's San Joaquin and Stanislaus Rivers

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ABSTRACT: Using a survey of California households, a linked site choice and trip frequency model is estimated and used to calculate the recreation benefits to anglers, wildlife viewers, and waterfowl hunters of additional flows in the San Joaquin and Stanislaus rivers by month of the year. The site selection model utilizes the multinomial logit model and the trip frequency model utilizes a count data formulation. Survey results show that the San Joaquin River is a relatively attractive destination for fishing and wildlife viewing compared to other locations in the San Joaquin Valley. Increasing summer flows in the San Joaquin River yields estimated recreation benefits of $70 or more per acre foot with peak values in August. This value is competitive with agricultural values in the San Joaquin Valley. The model structure allows for estimating monthly values of water at five rivers and may be useful in aiding instream flow decisions involving renewal of federal water delivery contracts and hydroelectric relicensing decisions.

KEY WORDS: Fishing, site choice model, travel cost method, instream flow values.

INTRODUCTION

A common problem facing state and federal water officials in making instream flow decisions is lack of information about the economic value of water for recreational uses. Although the value of water for urban and agricultural uses in the San Joaquin Valley is known (Gibbons 1986), little information is available regarding the value of recreational fishing, hunting, and wildlife viewing associated with the San Joaquin River and its main tributaries. This lack of economic value information has been apparent at the State Board's San Francisco Bay/Delta hearings and in the U.S. Bureau of Reclamation's (1987) Refuge Water Supply Environmental Impact Statement (EIS) and Water Marketing EIS, in which few estimates of the value of river recreation were available. The amount of water the Bureau of Reclamation may ultimately authorize in the new water contracts for projects such as Friant Dam may ultimately hinge on the recreational value of water in the San Joaquin River. More efficient allocation of water would be facilitated if information on the economic value of water for environmental uses was available to decision makers.

This article analyzes participation in fishing, waterfowl hunting, and wildlife viewing at rivers in the San Joaquin Valley (SJV) including the main San Joaquin River and its tributaries such as the Merced, Tuolumne, and Stanislaus rivers as well as the Kings River in the Tulare Basin. Through the economic theory of revealed preference we measure the recreation value that people obtain from these rivers and their flows. By analyzing the effects of increases in water flows on recreation quality and resulting changes in recreation behavior, the econometric models measure the increase in recreation use value of the water to visitors. One should note that the rivers and their flows provide additional values beyond recreation use values, such as existence values. These other sources of value are not measured in this article, which emphasizes valuation based on observed or revealed behavior. In what follows we sketch out the underlying theory, provide the details of the econometric models, and then describe the data sources. The statistical results are followed by estimation of benefits per acre foot of water under different seasonal timing of augmented flow for the San Joaquin and Stanislaus rivers.

Utility and Demand Theory

The basic economic theory used to explain recreational decisions is the theory of constrained utility maximization. We assume that an individual's preferences for goods (x, y) are representable by a utility function, which gives the levels of satisfaction the person obtains from consuming various sets of goods and visiting alternative recreation sites. Decisions must be made about which goods and how much of each to consume because of the budget constraint. The constraint states that one's purchases of goods x and y are limited by one's income level (I) in combination with the prices of x and y (p_x, p_y). Given certain conditions that need not be discussed here (Henderson and Quandt 1980), the consumer maximizes his utility subject to his budget constraint and obtains his demand functions for $x^*(p_x, p_y, I)$ and $y^*(p_x, p_y, I)$. This gives the quantities of x and y to consume that maximize utility for any set of prices and income. If we insert the demand functions back into the utility function we obtain the indirect utility function $V(p_x, p_y, I) = U(x^*, y^*)$. This function gives the highest level of utility that can be achieved at all levels of prices and income.

If we consider a reduction in the price of visits to rivers (e.g., a decrease in a travel cost due to restoration of a closer river), one measure of the willingness to pay for the gain in well being is called compensating variation (CV). Compensating variation is the amount of money a person would be willing (and able) to pay so that person obtains the same amount of utility after the price decrease as was obtained before the price decrease. When the price of good x decreases, CV is defined by the equation $V(p_x', p_y, I - CV) = V(p_x, p_y, I)$, where p_x' is the price of good x after the decrease (Loomis 1987).

To measure differences in well being due to changes in the qualities of goods, we can generalize the utility function to be a function of goods' qualities. Then, the demand functions and the indirect utility function will also be functions of the goods' qualities, and we can measure willingness to pay (CV) in a fashion analogous to the price change case discussed above.

It is important to note that individuals' utility functions are not directly observable. However, if we assume that their choices about how to spend their income are a result of the utility maximization process, it is possible to indirectly make inferences about their utility functions based on their observed consumption patterns. There is a mathematical relationship between the demand functions and the indirect utility function. If we know one of these functions we can calculate the other. This is the essence of the analytical methods that we used.

Application of Utility Theory to Analysis of Recreation Behavior

The main purpose of this analysis is to measure how recreation benefits vary with changes in river flows in the San Joaquin Valley. The data for this task are the number of fishing, viewing, or waterfowl hunting trips each visitor took to the SJV and where in the SJV he went on his last trip. Though individuals' decisions about whether or not to take trips to the study sites, how many trips to take, and which particular sites to visit are made in an interdependent way, it is convenient at this stage to introduce some simple econometric models that treat the problems separately.

The Trip Frequency Decision. The problem of how many trips to take may be referred

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to as the trip frequency problem. One approach to modeling trip frequency is the travel cost method (TCM) (Clawson and Knetsch 1966; Ward and Loomis 1986). In the TCM, the monetary travel costs and travel time represent the prices of visiting a recreation area and allow estimation of a demand function. The qualities of recreational experiences at the rivers also influence the demand function for visits to any particular river. Higher quality will cause an individual to take more trips to a given river. Finally, we expect that an individual's personal characteristics such as income may influence demand for visits to the river.

A simple example of a linear TCM demand function for an individual's visits to one of two possible recreation sites may be written as:

$$T = \beta_0 + \beta_2 P + \beta_3 P_s + \beta_4 Q + \beta_5 Q_s + \beta_6 I + \beta_7 X + \epsilon. \quad (1)$$

In this equation, T is the number of trips to the site, P is the cost of taking a trip, P_s is the cost of taking trips to the substitute site, Q is the quality of the site, Q_s is the quality of the substitute site, I is the person's income, X is other personal characteristics, β is a set of parameters or coefficients to be estimated, and ϵ is an error term. There are several ways to estimate the β's in this model. Two common methods are least squares estimation and the method of maximum likelihood (ML). Maximum likelihood estimation (MLE) assumes a probability distribution for the error term (ϵ) and chooses the β's that maximize the joint probability of drawing the sample from this distribution.

Once we have estimated the β's of equation 1 we have an empirical demand function. This function can be used to predict how an individual's trip frequency will respond to changes in the explanatory variables such as increases in river flows.

The Site Selection Problem. In taking a recreational trip, how does an individual decide which river to visit? We refer to this as the site selection problem. A common way to model this choice problem is the random utility model (RUM). For simplicity, imagine that only two rivers exist from which to make the selection. Equation 2 shows the general form of the variables determining the utility (U) a person would receive from selecting either of the rivers to visit, where V is the systematic or deterministic portion of U and ϵ the unobservable (to the researcher) and hence, random component of utility.

$$U_1 = V_1 (P_1, Q_1, I, X, \beta) + \epsilon_1$$
$$U_2 = V_2 (P_2, Q_2, I, X, \beta) + \epsilon_2. \quad (2)$$

If we assume that the ϵ's are independently and identically distributed extreme value random variables, then the probability that an individual will choose to visit site one is given by:

$$Prob_1 = \frac{\exp(V_1)}{\exp(V_1) + \exp(V_2)}. \quad (3)$$

This is known as the multinomial logit (MNL) model of site selection (McFadden 1974). Given data on a visitor's choice between the two sites and the explanatory variables in equation 2, we can apply the ML estimation method to estimate the β's. Using this model, analysis of economic well-being at a site choice opportunity is fairly straightforward because we directly estimate individuals' utility functions rather than exploit the indirect link between the demand functions and the utility function.

DETAILS OF SITE SELECTION AND TRIP FREQUENCY MODELS

Linking Site Selection and Trip Frequency Models

Although MNL models are the most widely used site selection models for incorporating the effect of site quality on site choice, these models take trip frequency as given. Several authors (Feenburg and Mills 1980; Morey et al. 1991) have employed models that treat the trip frequency and the site selection problems jointly as a series of discrete choices.

An alternative approach is to model trip frequency separately from the site selection model, but link them via incorporation of an inclusive value term from the site selection model as a variable in the trip frequency model. In our MNL specification the inclusive value incorporates information on trip cost and quality. It therefore reflects the expected utility from visiting specific sites. By inserting the inclusive value as a variable in the trip frequency model the expected number of trips (both at the individual level and in aggregate) to the site will change with changes in site quality. This linking also allows for a pattern of interdependence between site selection choice occasions and allows for declining marginal utility of total recreational trips.

Because willingness to pay or CV at each choice occasion can be calculated from the MNL site selection model, total seasonal benefit measures can be obtained by combining the trip frequency model's prediction of trips with the site selection model's per trip benefit measures. To be more specific, we define a linear specification of the conditional (or deterministic portion) of the indirect utility function at each recreation choice opportunity as $V_{ij} = \alpha + \beta_p(I_i - P_{ij}) + \beta_q(q_j)$ where I is income, P is travel cost for individual i visiting site j, and q is the quality of site j. Then total seasonal willingness to pay (CV), conditional on T trips, takes the form:

$$CV^* = \frac{-T\left[\ln\left(\sum_{j=1}^{J} \exp(V_j(p', q'))\right) - \ln\left(\sum_{j=1}^{J} \exp(V_j(p, q))\right)\right]}{\beta_p} \qquad (4)$$

where p' and q' are the postchange prices and qualities of the sites, and p and q are the initial prices and qualities. The j's index alternative site choices. β_p is the price coefficient, which is the negative of the marginal utility of income (which is constant given the linear specification of the conditional indirect utility function). Expected total seasonal CV unconditional on T may be found by taking the expectation over T. This measure (CV') is obtained by replacing T in equation 4 by $E_T(T)$. This is the benefit measure used later in this article.

Variable Specification for the Empirical Site Selection Model

For an MNL site selection model, typical explanatory variables needed are the travel and time costs of visiting the alternative sites, and quality characteristics of the sites. Distance to each of the sites was measured by road mileage from the population center of the three-digit zipcode where the recreationist lived to the sites. Travel cost was computed by multiplying round-trip distance by \$0.20 per mile, the average cost per mile in our survey.

Also expected to be important in site selection are the travel times to the sites, because individuals face a time constraint as well as a budget constraint, and recreational trips are relatively time-intensive goods. Unfortunately, it was impractical to ask respondents for their travel times to all potential site choices in the SJV. Instead, travel time was calculated and then weighted by the opportunity cost of travel time, which is related to the wage rate (Smith et al. 1983). We computed the wage rate of individuals who were working, and used this wage to transform travel time to each of the sites into a monetary cost that was added to travel cost to form total trip cost for the site (the precise definitions of all variables are given below). However, the wage weighting approach is not justified for all individuals, particularly those who are not working or are unable to adjust their working hours. For individuals who were not even working part-time the calculation of a wage rate is inappropriate as there is no labor–leisure trade-off (Bockstael et al. 1987). Without being able to wage weight travel time, we are forced to leave calculated travel time out of the demand specification, because it is perfectly collinear with travel cost. Separate price coefficients were used for these two groups of individuals (denoted as workers and nonworkers) in both the site selection and trip frequency models.

Another important factor in the demand specification is the quality of the sites for various recreation activities. Monthly data on water flows in the rivers and water applied to National Wildlife Refuges (NWR's) and state Wildlife Management Areas (WMA's) were used as the quality measure. To allow for a relative measure of quality that could be compared across different size NWR/WMA areas and different size rivers, water flows (or amounts) in any given month (U.S. Bureau of Reclamation 1987) were expressed as a fraction of the highest

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Our site selection model attempts to explain site choices for wildlife viewers, anglers, and hunters. It is plausible that each type of user would react differently to sites' qualities (and perhaps prices). Thus, we experimented with activity-specific site-selection models. However, the sample sizes for each separate activity were often so small that model estimation via ML became difficult. We present the model pooled over all activities. Similar results were obtained with a model that separates participants in nonconsumptive recreation exclusively (wildlife and bird viewers) from participants in any form of consumptive activity (fishing or hunting). This lengthy comparison of results can be found in Creel and Loomis (1991).

To arrive at an estimatable MNL site choice model, the linear specification of the conditional indirect utility function was used in all cases. Separate price coefficients were used for persons for whom a wage rate was applicable and for those for whom a wage rate was not appropriate. Letting i index individuals and j index sites, the conditional indirect utility function was specified as

$$V_{ij} = \beta_{pw}PW_{ij} + \beta_{pnw}PNW_{ij} + \beta_q Q_{ij}. \quad (5)$$

The variables are defined by:

PW_{ij}: Price of visiting the j[th] site if wage (W) is calculable. $PW_{ij} = \$0.2 \cdot RTD_{ij} + (W_i \cdot RTT_{ij})/2$ if W_i is calculated, zero otherwise.

PNW_{ij}: Price of visiting the j[th] site if W_i is not calculable. $PNW_{ij} = RTD_{ij} \cdot \$0.2$, but $= 0$ if PW_{ij} is positive.

RTD_{ij}: Round-trip travel distance between population center of three-digit zipcode and site j.

RTT_{ij}: Round-trip travel time. $RTT_{ij} = RTD_{ij}/(45 \text{ mi/hour})$.

W_i: Wage rate. $W_i = (INC_i/HHADULTS_i)/[(2000 \text{ hr/year}) \cdot PARTIME_i)]$.

INC_i: Household income.

$HHADULTS_i$: Adult members of the household.

$PARTIME_i$: = 1 if individual worked full-time, = 0.5 if part-time.

Q_{ij}: Quality of site j during the month of individual i's visit. $Q_{ij} = W_{ij}/P_j$.

W_{ij}: Water flow or applied at site j in month i, $i = \{1, 2, \ldots, 12\}$.

P_j: Peak water flow or applied at site j over the year. $P_j = \max_i\{W_{ij}\}$, $i = \{1, 2, \ldots, 12\}$, at site j, $j = \{1, 2, \ldots, 14\}$. The regressors were $X_{ij} = \{PW_{ij}, PNW_{ij}, Q_{ij}\}$. The dependent variable is V_{ij}, a 14×1 vector, indicating which of the 14 sites was visited on the last trip to the SJV.

Theoretical Issues in Modeling Trip Frequency Demand

An important issue for the accuracy of trip predictions from the trip frequency model is that recreational trips are available only in nonnegative integer quantities (e.g., a person can take 1 or 2 or 5 trips but not 2.25 trips). This implies that the density function used to model trips should have a domain restricted to the nonnegative integers. Otherwise, the trip frequency model may give senseless predictions, such as predicting that an individual will take negative trips. This is sometimes the case when the popular normal distribution is used. This can be mitigated to a degree by employing the censored normal distribution that has no mass below the zero trip level, but this still does not restrict positive probability assignments to the set of possible events.

Count data models, which are trip frequency models based on probability densities that have the nonnegative integers as their domain, are the logical alternative and have recently seen application in recreation demand literature, including the works of Grogger and Carson (University of California, San Diego, unpublished report), Smith (1988), and Creel and Loomis (1990). The Poisson distribution is one of the most simple count data models. The density function for a Poisson random variable x is given by:

$$f(x) = \frac{\exp(-\lambda)\lambda^x}{x!}. \quad (6)$$

The single parameter of the Poisson distribution is λ, which is both the mean and the variance of the distribution of trips.

The most common way to use this distribution as an econometric model is to make the parameter λ a function of independent variables, X, and coefficients, β. The usual parameterization is:

$$\lambda_i = \exp(X_i\beta) \tag{7}$$

where $i = \{1, 2, \ldots, N\}$ indexes individuals. Given the dependent variable λ, an $N \times 1$ vector, its expected value is $E(\lambda) = \exp(X\beta)$, and its variance is $\mathrm{Var}(\lambda) = \exp(X\beta)I$, where I is an $N \times N$ identity matrix. Estimation is by maximum likelihood using the Newton-Raphson procedure. The parameter estimates on untruncated samples (such as ours) have all of the usual MLE properties, including asymptotic efficiency, consistency, and asymptotic normality.

Specification of the Empirical Count Data Trip Frequency Model

Because some people can and often do participate in more than one recreation activity on a given trip, we cannot always treat an individual's total annual trips for viewing, fishing, and waterfowl hunting as though they were distinct and separate trips. Given the three activities we are concerned with, there are seven possible distinct combinations of these activities that may be engaged in during a particular recreation trip: viewing (v), fishing (f), hunting (h), viewing and fishing (vf), viewing and hunting (vh), fishing and hunting (fh), and viewing, fishing, and hunting (vfh).

We can view the problem of multiple activity trips in annual data as a case of seven underlying discrete variables that are not observed, though the sums of three particular subsets of them are. Let the 7×1 vector $D = \{v, f, h, vf, vh, fh, vfh\}$, where D stands for the annual number of trips that a person takes of each of the discrete activities. Then the variables V, F, and H, which are total trips during which viewing, fishing, and hunting were participated in, respectively, are defined by:

$$\begin{aligned} V &= v + vf + vh + vfh \\ F &= f + vf + fh + vfh \\ H &= h + vh + fh + vfh. \end{aligned} \tag{8}$$

It is a simple matter to find the joint density for $P = \{V, F, H\}$ (P stands for participation). Specifically, if we assume that the elements of the vector D are distributed as independent Poisson random variables, the elements of P are also distributed as independent Poisson random variables. Assume that the elements of D are distributed as shown in equation 9, where λ = mean number of days in the specific activity:

$$\begin{aligned} v &\sim Pois(\lambda_v) \\ f &\sim Pois(\lambda_f) \\ h &\sim Pois(\lambda_h) \\ vf &\sim Pois(\lambda_{vf}) \\ vh &\sim Pois(\lambda_{vh}) \\ fh &\sim Pois(\lambda_{fh}) \\ vfh &\sim Pois(\lambda_{vfh}). \end{aligned} \tag{9}$$

Then the distributions of the elements of P are given by equation 10:

$$\begin{aligned} V &\sim Pois(\lambda_v + \lambda_{vf} + \lambda_{vh} + \lambda_{vfh}) \\ F &\sim Pois(\lambda_f + \lambda_{vf} + \lambda_{fh} + \lambda_{vfh}) \\ H &\sim Pois(\lambda_h + \lambda_{vh} + \lambda_{fh} + \lambda_{vfh}). \end{aligned} \tag{10}$$

The elements of P are independently distributed, so the joint distribution of the vector P is simply the product of the distributions of its elements. This is given by equation 11:

$$\begin{aligned} f(V, F, H) &= e^{(-\lambda_v-\lambda_{vf}-\lambda_{vh}-\lambda_{vfh})}(\lambda_v + \lambda_{vf} + \lambda_{vh} + \lambda_{vfh})^V \\ &\cdot e^{(-\lambda_f-\lambda_{vf}-\lambda_{fh}-\lambda_{vfh})}(\lambda_f + \lambda_{vf} + \lambda_{fh} + \lambda_{vfh})^F \\ &\cdot e^{(-\lambda_h-\lambda_{vh}-\lambda_{fh}-\lambda_{vfh})}(\lambda_h + \lambda_{vh} + \lambda_{fh} + \lambda_{vfh})^H \\ &\cdot \frac{1}{V!F!H!}. \end{aligned} \tag{11}$$

This formulation eliminates any double counting of visits by estimating the seven underlying latent distinct variables, but it does have limitations. First, we are attempting to estimate the parameters of seven demand equations when only three combinations of the goods are observed. We may expect a good deal of variability in the estimators, and a low degree of fit in the model. This problem seems unavoidable, however, given the survey design discussed below.

Variables in the Trip Frequency Model

Equation 11 defined a joint density function for the vector P as a function of the

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seven λ's, which are the parameters of the distributions of the latent discrete participation variables (e.g., recreation days in one of the seven activities). An estimable econometric model may be obtained by parameterizing each of the seven λ's as functions of explanatory variables, and maximizing the likelihood function implied by equation 11. The λ parameters of equation 11 are the mean participation in each of these activities, which must be nonnegative. As noted earlier, an often-used parameterization is $\lambda = \exp(X\beta)$. Here, we are considering seven activities (the elements in D). We need to define seven X_d and seven β_d, such that $\lambda_d = \exp(X_d\beta_d)$, with $d = \{v, f, h, vf, vh, fh, vfh\}$.

It is clear that λ_d should be a function of a constant and the person's income level. We also expect that it should be a function of the travel costs and travel times to the recreation sites in the SJV, and of the sites' qualities. There are 14 sites included in this study. Clearly, it is impossible to include the travel cost, travel time, and quality of each individual site as separate regressors. Because λ_d is mean participation in activity d without regard to which site(s) in the SJV are visited, it seems appropriate to use a weighted combination of the sites' travel costs, travel times, and qualities. Recall from the discussion of the site selection models that expected utility per trip is given by the MNL site selection model. From the MNL equation we can calculate an inclusive value (IV). Because IV is closely related to the expected utility of a trip, it is a natural factor to include as an explanatory variable in a model of trip frequency. This has been done in several previous studies, including Bockstael et al. (1985) and Carson et al. (1987). The IV obtained from the site selection model is a weighted combination of travel costs, travel times, and qualities of each of the 14 sites in each of the 12 months. Because the trip frequency model is on an annual basis, we calculate the annual average of the monthly IV's for each individual.

The variables used in the trips frequency model are:

C: A constant term.
INC_i: Household income.
IV_i: Annual average of monthly inclusive values.
DV_i: A zero–one dummy variable, equal to one if person *ever* views wildlife.
DF_i, DH_i: Analogous to DV_i except for fishing and hunting.
DVF_i: $DV_i \cdot DF_i$.
DVH_i, DFH_i: Analogous to DVF_i.
$DVFH_i$: $DVF_i \cdot DH_i$.

The specification of the i^{th} person's conditional mean participation in the discrete activity combination is given by:

$$\begin{aligned}
\lambda_{vi} &= DV_i[\exp(X_i\beta_v)] \\
\lambda_{fi} &= DF_i[\exp(X_i\beta_f)] \\
\lambda_{hi} &= DH_i[\exp(X_i\beta_h)] \\
\lambda_{vfi} &= DVF_i[\exp(X_i\beta_{vf})] \\
\lambda_{vhi} &= DVH_i[\exp(X_i\beta_{vh})] \\
\lambda_{fhi} &= DFH_i[\exp(X_i\beta_{vfh})] \\
\lambda_{vfhi} &= DVFH_i[\exp(X_i\beta_{vfh})] \qquad (12)
\end{aligned}$$

where $X_i = \{C \mid INC_i \mid IV_i\}$.

The trip frequency model is specified and estimated consistent with the site selection model. Thus, because the MNL site selection model pools all of the seven discrete activities together, so does the trip frequency model. Hence, the β_d are set equal to each other. The inclusive value in the trip frequency model is calculated using the coefficients of the site selection model.

DATA SOURCES

The data used to estimate both the trip frequency and site selection models are from a survey of California households made during the spring of 1989. The survey asked about wildlife viewing, fishing, and waterfowl hunting participated in during the last 12 months (June 1988–July 1989). If someone had visited the SJV in the last 12 months for recreation, detailed questions were asked about the most recent trip. These questions included specific location and month of visit to allow linking of trip location and trip frequency to water flows at that time of year. To aid in recall of SJV locations, a map showing National Wildlife Refuges, Wildlife Management

TABLE 1
Visitation pattern within San Joaquin Valley

Area	% Visitors
Kesterson NWR	1.7
Kern NWR	15.8
Los Banos WMA	3.5
Mendota WMA	5.2
Merced NWR	5.8
Pixley NWR	1.7
San Luis NWR	2.3
Volta WMA	1.7
San Joaquin River, North	13
San Joaquin River, South	9
Merced River	13
Stanislaus River	8
Tuolumne River	7.6
Kings River	10.5

Areas, the San Joaquin River (including its tributaries the Stanislaus, Tuolumne, and Merced rivers), and the Kings River was provided. Demographic questions were also asked.

Survey Administration

The overall sample was split into two groups: one received a mail survey and the other was interviewed over the telephone. To ensure accurate information, the people interviewed over the phone were first sent the same questionnaire received by people in the mail survey. The dual approach was used because of budget limitations.

To achieve a reasonable response rate, we used the Dillman (1978) Total Design Method for both the mail and telephone surveys. For the mail survey, a second replacement survey was mailed to those not responding within the first four weeks after the first mailing.

Sample Design and Sample Sizes for Telephone and Mail Surveys

The original sample frame was provided by Survey Sampling, Inc., and was a representative sample of California households. The sample was carefully designed for overall statewide representation and to ensure that residents of the SJV were adequately represented in the sample. For the telephone survey 1,960 households were contacted. One thousand and four households completed interviews, yielding a response rate of 51%. For the mail survey, 3,500 residents were selected. Of the 3,084 deliverable surveys, 1,069 were returned, resulting in a response rate of 35%. This is somewhat low for household population surveys, but not unusually low for California (Hageman 1985). Chi-square tests for differences between the mail and telephone samples show no statistical difference in waterfowl hunting participation and only a small difference in fishing participation, which was not statistically different at the 0.05 level. In the models and statistics that follow, the mail-only and telephone/mail-combination survey data were aggregated.

Descriptive Statistics on Visitation to the San Joaquin Valley

Table 1 shows the distribution of visitor use at the primary outdoor recreation destinations in the SJV included in the models. Note that relatively speaking, rivers were an attractive destination for wildlife viewing and, of course, fishing. The San Joaquin River and its major tributaries supported more than 50% of the wildlife viewing and nearly 75% of the fishing at the 14 sites shown in Table 1.

STATISTICAL RESULTS AND INTERPRETATION

Site Selection Models

Table 2 presents the estimation results of the site selection model. The pseudo-R^2 reported in Table 2 is Cragg and Uhler's pseudo-R^2 as discussed in Madalla (1983). This takes the sample proportions visiting each site as the point of reference from which contributions to model fit are measured. The site selection model gave correctly signed and statistically significant coefficient estimates for all coefficients (prices are negative and quality is positive).

TABLE 2
Estimation results of multinomial logit (MNL) site selection model

Variable name	Estimate	Asymptotic t-statistic
PW	−0.173	−6.46
PNW	−0.0621	−4.22
Water quantity	0.822	3.05
Log-likelihood	−347	
Pseudo-R^2	0.107	

TABLE 3
Estimation results of trip frequency model

Variable name	Estimate	Asymptotic t-statistic
C, working	−0.941	−13.93
INC, working	−0.0141	−0.18
IV, working	0.667	23.94
C, nonWorking	0.125	1.53
INC, nonWorking	−1.16	−5.17
IV, nonWorking	0.661	15.77
Log-likelihood	−833	
R^2, view	0.0633	
R^2, fish	0.0978	
R^2, hunt	0.0694	

Trip Frequency Models

The estimation results for the trip frequency model are given in Table 3. The table reports R^2's, where this measure is defined as one minus the error sum of squares over the total sum of squares. As noted above, we did not expect a very good fit because of the unobserved latent dependent variable problem.

The coefficient on the inclusive values is of the correct sign (positive), and is strongly significantly different from zero. The results for the constant and income are more mixed, but we have no strong prior beliefs about the signs of these coefficients. If the assumptions of the Poisson model are violated, the asymptotic t-statistics may well be inflated.

POLICY ANALYSIS AND BENEFIT MEASUREMENT

Defining the Benefit Measure

Total utility of the seasonal recreation trips is the product of utility per trip times the number of trips. Because utility per trip and total trips are stochastically independent, for the specification used in this study, the expectation of total utility is the expectation of utility per trip times the expected number of trips. Recall that for the site selection models, the nonstochastic part of utility per choice occasion (*CV*) for a specific site is given by equation 4. This equation is also a valid formula for the expected utility per choice occasion. The expected level of trips of each of the discrete activity types is found in equation 12. Finally, recall that the marginal utility of income is constant for all of the specifications, as is implied by the use of the linear conditional indirect utility specification in the site selection model.

Using this information, we propose a welfare measure that divides the difference in expected utilities before and after the price or quality change by the constant marginal utility of income. Let p' and q', and p and q indicate site prices and qualities before and after the change, respectively. The expected participation in a discrete activity is given by λ, which is defined as in equation 12, and the per trip expectation of indirect utility is given by $IV(p, q) + C$. Recall that $IV(p, q)$ is the inclusive value and C is a constant of integration. Then the dollar value of the total expected change in utility for a discrete activity type is given by CV', as defined in equation 13:

$$CV' = -\left(\frac{\lambda(p', q')\cdot(IV(p', q') + C) - \lambda(p, q)\cdot(IV(p, q) + C)}{\beta_p}\right). \quad (13)$$

This welfare measure is for participation in one of the seven discrete activity types. Because the levels of participation in each of the seven activity types are specified as stochastically independent, the total expected welfare change for an individual is

TABLE 4
Per participant annual benefits under existing conditions in the San Joaquin Valley

Activity	Value
Viewing	$128
Fishing	$137
Waterfowl hunting	$159
Viewing and fishing	$403
Hunting and fishing	$451

the sum of CV' over each of the seven discrete activity types. Of course, some individuals do not participate in any of the seven discrete activities. In this case, the model assigns a zero level to $\lambda(p', q')$ and $\lambda(p, q)$, so that CV' is zero for the activities that have no participation.

When we examine improvements in river flows, we need to account for the fact that individuals' participation levels have not actually been observed at the contemplated improved levels of qualities. Those who did not participate in the period of the sample may participate under the new qualities. Therefore, it is reasonable to base a welfare measure on expected behavior, rather than the realized level of participation in a given time period.

Estimated Total and Per Participant Benefits in the Sample

Table 4 presents expected per participant annual use values for each of the activity types. A participant in an activity is defined as a person who either did or is expected to visit one of the 14 sites to engage in one of the three activities. These are not people who necessarily visited a SJV site in the period of the survey. The values in the table are the sample average of estimated total values for each discrete activity divided by the number of participants in each discrete activity, which differ by activity. Estimated total use benefits were calculated by raising the prices of each site to a choke price such that there was virtually no predicted visitation to any site for any individual. As Table 4 suggests, the annual benefits to people who engage in multiple activities on visits to the SJV are substantially higher than those who engage in only one activity. This makes some sense. For example, the amount that someone would bid for access to a river to fish and view wildlife is greater than one would bid to just fish.

Sample Expansion to Total Recreation Benefits

To calculate the total recreation benefits received by all potential visitors to these 14 sites, it is necessary to expand the sample results to the population. Usually this is done by multiplying the sample benefits by the inverse of the sampling rate. This, of course, puts a premium on the sample representativeness and statistical precision of the sample.

Before the sample expansion factor can be calculated we must adjust for the survey response rates of 35% to the mail and 51% to the telephone. If we take an ultraconservative approach and assume that nonrespondents to the survey are also nonparticipants in wildlife viewing, fishing, and hunting, we will understate recreation benefits. Nevertheless, we will adopt this conservative assumption here.

The next factor is whether to expand the sample to account for all households in California or just those residing in the SJV. Although the samples were of all residents in California, both demand models (site selection and trip frequency) are credible models primarily for choices within the SJV. Competing substitute sites for households in Southern California are not explicitly modeled, although their presence is reflected in the reduced number of trips households in Southern California take to the SJV, as compared to other areas in California. Expanding to just SJV households is again ultraconservative as we know that well over half of the visitors to the SJV sites live outside the SJV and our original sample is of California. However, to determine which sample expansion area to use, we compared our resulting expanded visitation totals to published statistics on viewing, fishing, and waterfowl hunting in the SJV. The fishing and waterfowl hunting comparisons were based on the U.S. Fish and Wildlife Service National Survey (1988). The wildlife/bird viewing was based on results of a mail survey of California households (Cooper and Loomis 1988). Comparison of the fishing and waterfowl hunting estimates would suggest that the California-wide sample expansion would be reasonable. However, the wildlife viewing use statistics would suggest only an SJV resident sample expansion would be warranted. Given the uncertainty about which sample expansion to use, the benefit estimates for current quality conditions will be developed for both sample expansion factors.

Benefits of Increasing Water Flows to the San Joaquin and Stanislaus Rivers

The first simulation involved estimating the benefits of providing a little over 60,000 acre feet of additional water to the south and north portions of the San Joaquin River (between Friant Dam and Stockton). This amount is approximately what is required for dry year outmigration of San Joaquin River spawned juvenile salmon plus adult returning salmon (Jones and Stokes 1989: 26). Four alternative timing patterns of river flow augmentation were investigated. The first is to release the flows through much of the year, but with flows concentrated in spring and fall for juvenile outmigration and adult return migration. The benefit estimates are obtained by substituting the new monthly water supply levels into the site selection (the quantity variable) to calculate new benefits per visitor and then employing the increased inclusive value in the trip frequency models to predict new visitation levels. Water quantity here is acting both as a proxy for fish/wildlife habitat (and hence harvesting success) and overall aesthetics of the river. This process is repeated for the remaining three monthly timing patterns of the same quantity of flow releases into the San Joaquin River. This was done specifically by adding the same amount of water spread over July and August, in just July, or in just August. Given the increased benefits per visitor (e.g., anglers, viewers, and waterfowl hunters) and the associated increase in number of visitors, we can calculate the increase in total benefits associated with increasing water and then express it on a per acre foot basis. Table 5 presents the per acre foot benefits for the four different timings of increased flow. Unfortunately, our model structure did not make it possible to include the substantial

TABLE 5
Incremental recreational values per acre foot of water

Timing pattern of flow release	San Joaquin River (62,800 acre feet)	Stanislaus River (10,000 acre feet)
Spread over year	$ 45.22	$10.83
Spread over July/August	$ 71.25	$12.82
All in July	$104.00	$12.94
All in August	$116.43	$13.45

additional downstream values these added flows in the San Joaquin River likely provide to visitors to the Delta or San Francisco Bay. It should also be noted that if the California-wide sample expansion factor is used, the values per acre foot would be about 10 times larger than reported above.

Nevertheless, the values of water in the San Joaquin River are fairly high and are competitive with most agricultural uses. That is, even the lowest San Joaquin River value is greater than the net economic value of water derived from growing barley, alfalfa hay, safflower, and sugar beets in the San Joaquin Valley (Gibbons 1986:38). The recreation value of water developed in Table 5 for summer augmentation of the San Joaquin River is about two-thirds of the price for which available water was selling in the State of California Water Bank during the summer of 1991. Thus, just the recreation value of fish and wildlife flows is in the same general range as municipal buyers are paying.

The same type of simulations were performed for increasing flows by 10,000 acre feet in the Stanislaus River. The values in the Stanislaus River average around $12–13 an acre foot and may be competitive only with low-value agricultural uses such as irrigated pasture. However, there may be a cumulative value of water released into the Stanislaus River if it is allowed to flow downstream into the San Joaquin River. Thus, the 10,000 acre feet provide $13 per acre foot benefits if released into the Stanislaus River during the summer and maintained in the river to the confluence with the San Joaquin River where the increased water flow would provide an additional $104 per acre foot of benefits. The cumulative or total recreation benefits, therefore, would be $117 per acre foot. The possibility exists with this model structure for estimating cumulative benefits of downstream flows within the San Joaquin Valley. This evaluation of cumulative downstream benefits emphasizes the need for quantification of Francisco Bay/Delta benefits, which would represent added downstream benefits.

One of the strong features of our model structure also evident from Table 5 is the ability to quantify the economic value of increased flows in different months. This allows determination of the influence of timing of water releases on the economic value of water.

CONCLUSIONS

We presented empirical models for quantifying the benefits of wildlife/fishery recreation in the San Joaquin Valley. Several alternative water augmentation policies were analyzed, which allowed the calculation of values per acre foot of water to the San Joaquin and Stanislaus rivers.

Because of data limitations, we used a conservative approach to expand the sample estimates to total recreation benefit estimates. In spite of this conservatism, the estimated increases in benefits that would result from improved habitat conditions implied a use value per acre foot of water that is competitive with its economic value in some agricultural uses.

A very useful feature of the models used in this study is that they allow estimiation of the benefits that would result from various allocations between rivers and over the course of a year of a given amount of water. This allows one to search for the economically optimal allocation of water over quite a range of alternative sites and timing of water releases. Of course, the actual allocation used must take into account biological needs, which have a dynamic impact an economic benefits. This modeling approach, particularly with the inclusion of downstream San Francisco Bay/Delta benefits, would be directly useful for evaluating water recontracting and minimum flows for the Friant Dam component of the Federal Central Valley Project. The primary suggestion for future research is to gather more complete visitation data for the San Francisco Bay/Sacramento River Delta as it is an important destination that is omitted in this study.

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