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The Economic Value of Trinity River Water

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ABSTRACT *The Trinity River, largest tributary of the Klamath River, has its headwaters in the Trinity Alps of north-central California. After the construction of Trinity Dam in 1963, 90% of the Trinity River flow at Lewiston was moved to the Sacramento River via the Clear Creek Tunnel, a manmade conduit. Hydropower is produced at four installations along the route of Trinity River water that is diverted to the Sacramento River, and power production at three of these installations would diminish if no Trinity River water were diverted to the Sacramento River. After Trinity River water reaches the Sacramento River, it flows toward the Sacramento–San Joaquin Delta and San Francisco Bay. Trinity River water is pumped via Bureau of Reclamation canals and pumps to the northern San Joaquin Valley, where it is used for irrigated agriculture. The social cost of putting more water down the Trinity River is the sum of the value of the foregone consumer surplus from hydropower production as well as the value of the foregone irrigation water. Sharply diminished instream flows have also severely affected the size and robustness of Trinity River salmon, steelhead, shad and sturgeon runs. Survey data were used to estimate the non-market benefits of augmenting Trinity River instream flows by letting more water flow down the Trinity and moving less water to the Sacramento River. Preservation benefits for Trinity River instream flows and fish runs are $803 million per annum for the scenario that returns the most water down the Trinity River, a value that greatly exceeds the social cost estimate.*

Introduction

In 1963 the Trinity Division of the Central Valley project, including Trinity and Lewiston dams, was completed (US Bureau of Reclamation, 1980). In 1964 about 90% of the mean annual 1.2 million acre-feet of the Trinity River outflow from Trinity Dam was diverted to the nearby Sacramento River and the Central Valley Project for hydropower, agricultural and other uses (US Bureau of Reclamation, 1980). We present results from data collected with contingent value method (CVM) survey instruments that focused on the non-market benefits provided by sending more water down the Trinity River[1]. The data set also provides information on expenditures and public perception of the resource, but our analysis only compares non-market Trinity River instream flow benefits with benefits provided by market uses of the diverted water. For a thorough discussion of the biotic and hydrologic impacts of the diversion, see the *Environmental Impact Statement on the Management of River Flows to Mitigate the Loss of the Anadromous Fishery of the Trinity River* (US Fish and Wildlife Service, 1980).

The Trinity River once provided north-central California with major rec-

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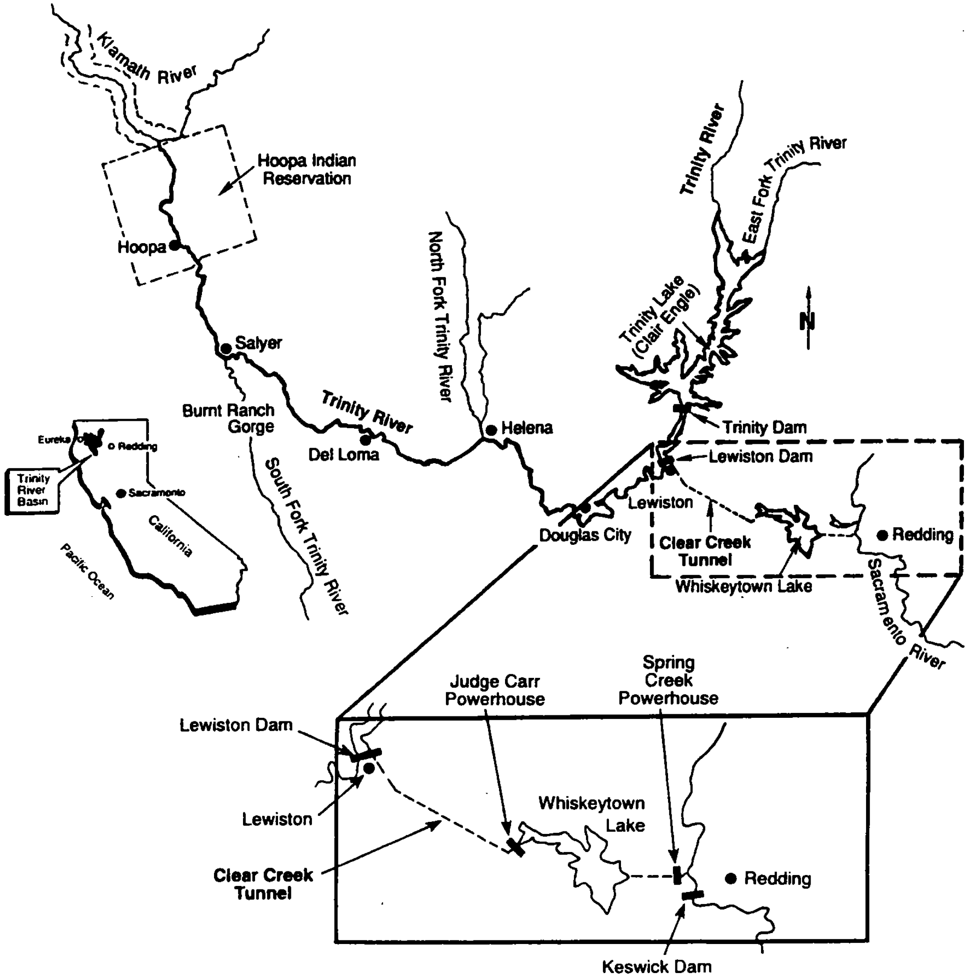

Figure 1. Map of the Trinity River Basin with the route of the diverted water shown in detail.

reational and fishery resources (Hubbell, 1973). Its headwaters are in a mountain range near the Oregon border called the Trinity Alps, and it is the largest tributary of the Klamath River (Figure 1). At one time, the only Pacific Coast rivers in the lower 48 states that produced more anadromous fish than the Klamath–Trinity system were the Columbia and Sacramento River systems (Pacific Fishery Management Council, 1995). Damming the Trinity River resulted in a loss of 109 miles of salmon and steelhead habitat above Trinity and Lewiston dams (personal communication, T. Stokely, Trinity County Planning Department, Natural Resources Division, Weaverville, CA, 1995). As a result of the loss of fish habitat and a substantial portion of the Trinity River's flow at Lewiston, anadromous fish stocks declined by 90% after 1964. Returning fall chinook salmon runs in the Klamath–Trinity system failed to meet minimum species preservation goals set by the Pacific Fishery Management Council for 1990–94 (National Marine Fisheries Service, 1994).

The point of the diversion on the Trinity River is Lewiston Dam, where water from Lewiston Lake can be released to the Trinity River or diverted via the Clear Creek tunnel to the Sacramento River (US Bureau of Reclamation, 1980). The Sacramento River is 1400 feet lower than the Trinity River at Lewiston Dam, and gravity powers the 20-mile transbasin movement of water (US Geological Survey, 1976). After reaching the Sacramento River, the former Trinity River water flows south until it reaches the delta region of San Francisco Bay (US Fish and Wildlife Service, 1980). Pumps propel the water from the delta to the northern San Joaquin Valley, where it is used to irrigate crops (US Bureau of Reclamation, 1980). The fraction of Trinity River water transported to the Sacramento River declined to below 90% during the early 1980s, and remained there throughout the 1980s because of several Department of the Interior decisions. Nonetheless, the impact on Trinity River fish stocks of removing an average 75–80% of the flow seems to be severe (Ridenhour, 1995). Since a 1991 decision by the Secretary of the Department of the Interior, Trinity River minimum flows have been 340 000 acre-feet per annum or about 28% of the average annual inflow to Trinity Lake. In 1992, the Secretary's 1991 Trinity River minimum flow decision for 1992–96 was codified in P.L. 102-575, Section 3406(b)(23).

The construction of Trinity Dam made 50% of the historic spawning habitat in the Trinity River inaccessible to chinook salmon and steelhead, thereby sharply augmenting the adverse impacts of diminished streamflows (Hubbell, 1973). The economic impacts of the decline in the fishery are only partially ameliorated by the operation of a fish hatchery at Lewiston that produces millions of chinook (king) salmon, coho (silver) salmon, and steelhead fingerlings. According to a congressional report (US House Committee on Merchant Marine and Fisheries, 1984), the hatchery should "provide for mitigation of habitat loss above Lewiston Dam" but not "significantly impair efforts to restore and maintain naturally reproducing fish stocks within the basin". The data for 1986–88 indicate that the hatchery cannot sustain the marine commercial, ocean sport, inland sport and tribal harvests. The hatchery operation cannot supplant the need for increased streamflows (US Fish and Wildlife Service, 1980; Pacific Watershed Associates, 1993; personal communication, J. M. Bartholow, fishery biologist, Biological Resources Division (BRD), US Geological Survey, Fort Collins, CO, 1995). Indeed, adequate instream flows are an important complement to hatchery operations (personal communication, J. M. Bartholow, 1995).

The relation between the construction of the dam and the recreational resources provided by the river before 1964 is multifaceted. For example, after the construction of the dam, recreational fishing on Trinity Lake for bass became an important outdoor activity. Similarly, boating, swimming and shoreline activities in Trinity Lake partially supplant these activities on the Trinity River. Thus, the availability of readily accessible substitutes for the residents of northern California may have a sharp negative impact on the total social benefits provided by enhanced instream flows on the Trinity River (US Fish and Wildlife Service, 1980).

There are four installations that produce Trinity River hydropower along the route of the diverted water, but production at only three of these installations including Spring Creek, Carr Powerhouse and Keswick would diminish if all the water flowed down the Trinity River (US Bureau of Reclamation, 1980). Thus the social cost of moving more water down the Trinity River includes both foregone hydropower and irrigation water. On the other hand, there are some site-specific non-market Trinity River recreation benefits. Some anadromous fish preservation benefits—existence benefits—are not closely tied to any specific river (Loomis *et al.*, 1990). These existence benefits are related to declines in the viability of many Pacific Coast anadromous fish runs (Lichatowich *et al.*, 1995).

Pacific Coast anadromous fish runs have been plagued by numerous problems, including stream diversions, pollution, sediment, dams and overfishing (Lichatowich *et al.*, 1995). Scarcity creates high marginal value. Hence, the restoration value of the Trinity River anadromous fish runs rests in part on the paucity of robust Pacific Coast anadromous fish stocks. An agent has a positive off-site or existence value for an environmental amenity if he is willing to pay to preserve the amenity without using the environmental good for recreational or aesthetic purposes (Mitchell & Carson, 1989). Existence values that are much higher—and more controversial—than the more familiar CVM use values have been recorded in the literature (Mitchell & Carson, 1989; Loomis *et al.*, 1990). Recreationists may have existence values as well as the more conventional use values. Thus, in the current paper, we distinguish data from Trinity River recreationists with the term 'user survey', and data from a random sample of residents of the four state region formed by Nevada, Oregon, Washington and California with the term 'household survey' (Walsh *et al.*, 1984).

A careful discussion of the geopolitical setting of the problem is useful in assessing the validity of the application of the cost-benefit analytical framework that we establish with the survey data. Gross mishandling of the conventional marginal principle—if non-market flow-related (marginal) benefits exceed (marginal social costs), flows should be increased—is likely to arise from inadequate consideration of the social and physical factors that underlie the water allocation issue. Moreover, the current study, approved by the Trinity River Task Force, a federally funded agency charged with determining the causes of the decline of the fishery, should not be viewed as a case study because the water allocation arena is quite open ended.

Survey Design and Research Issues

During the winter of 1993–94 we mailed out Trinity River user surveys to gather data to estimate the non-market benefits of improved Trinity River streamflows and fish runs for Trinity River recreationists. The Planning Department of Trinity County mailed out household (existence benefits) survey questionnaires to Pacific Coast region residents.[2] The list of names and addresses of Trinity River recreationists was gathered from information supplied by guides and outfitters to the Trinity County Planning Department; everyone on the list was mailed a survey. The names of the recipients of the household survey were randomly chosen from a list of 5000 names of California, Nevada, Oregon and Washington residents supplied by R. L. Polk, Inc. The Dillman method (1978) for maximizing response rates was used with both surveys with mixed success. This method employs an initial mail-out, a follow-up postcard and a final mail-out. Trinity County mailed out 2717 surveys and we mailed out 2044.

We asked the Center for the Resolution of Environmental Conflicts at Humboldt State University (CRED) to make a telephone survey of randomly chosen users who had been sent the survey but had not responded. This telephone survey encountered difficulties caused by the somewhat dated list of users that

Trinity County obtained for the user mail-out survey. The CRED survey also led to a major empirical correction in the calculated response rate of the user survey. Without any adjustment for the 308 address unknown postal returns and the address unknowns detected by the CRED telephone survey, the 'naive' response rate would have been estimated to be about 54%. The 308 postal returns plus the unknowns estimated from the CRED data indicate that 563 of the 'non-responses' were actually address unknowns. The estimate of 563 total address unknowns rests, in part, on the fact that only 53% of California households have listed phone numbers (personal communication, Brenda Flood, Product Manager, Pacific Bell, San Francisco, CA, 1995).

There were 1106 usable mail-back responses from the user mail-out survey. Exactly 200 surveys were handed out on the Trinity River, and only 41 usable responses were obtained; the Dillman (1978) method could not be applied to the surveys handed out on-site because the addresses of potential respondents were not obtained. On the other hand, the 43 usable follow-up phone surveys obtained from one of the phone survey modules were included in the grand total of 1190 usable responses to the user mail survey. Thus the response rate for the user mail-back survey was $[1190/(2244-563)]\cdot 100\% = [1190/1681]\cdot 100\% = 70.79\%$.

Exactly 2054 household surveys were mailed out to California residents, who provided 525 usable mail-back responses and 457 usable phone responses. The non-California component was composed of a mail-out of 221 surveys to each of the states of Washington, Oregon and California. There were 700 usable household written surveys, and the overall mail-back response rate for the household survey was 28%. There were 18 California postal unknowns, and 164 unknowns from the Washington, Oregon and Nevada mail-out. About 24% of the household surveys were sent to non-California households; the response rate for the out-of-state mail-back was 35%. Because of low response rates, the household mail-back survey was supplemented by an extensive telephone survey conducted by CRED. The phone numbers were chosen randomly from the non-respondents to the mail-back survey. Because all of the data for the household benefits estimates were gathered from the same list of households, the effective total response rate for the telephone and mail-back surveys was calculated as $[1157/(2717-182)]\cdot 100\% = [1157/2535]\cdot 100\% = 45.64\%$.

Survey Instruments and Data Sets

The description of the water resource issue in the survey stressed the costly trade-off between non-market benefits and development uses of Trinity River water. Key question blocks for both surveys included the valuation questions, cross-validation queries and questions about the sociodemographic background of the respondents. The user survey also included queries about visitor satisfaction, frequency of use, site selection and trip expenditures. The user survey had 37 questions in a 12-page booklet; the household survey had 27 questions in an eight-page booklet. The surveys were titled on the front covers; the household surveys indicated sponsorship by Trinity County, and the user surveys indicated sponsorship from both Trinity County and the US Fish and Wildlife Service. A signed covering letter accompanied all of the surveys. The front cover of the survey booklets displayed a map of the region depicting the Trinity, Sacramento and Klamath Rivers, as well as the Clear Creek Tunnel, Trinity Lake, the Hoopa

Valley Tribe Indian Reservation, and the towns of Redding, Lewiston and Douglas City. The sociodemographic questions were also identical for all of the surveys and elicited information on the respondent's zip code, age, marital status, gender, ethnic group, education, household size and income. The second page contained a description of the Trinity River and the water conflict. Five flow-related scenarios were included in the block of contingent valuation items. These five scenarios were reproduced in each survey booklet. A completed survey had five willingness-to-pay (WTP) bids.

The willingness-to-pay items used augmented monthly utility bills as payment vehicles and refer to five distinct flow levels in terms of the percentage diverted to the Sacramento River, the number of adult spawning anadromous fish, and the quality of recreational boating on the Trinity River. The lowest flow level was indexed by a 90% diversion to the Sacramento River, 9000 adult spawning anadromous fish, and very little recreational boating. The next flow level was indexed by an 80% diversion to the Sacramento River, 35 000 adult spawning anadromous fish, and minimal rafting but good open canoe recreation. At the highest flow level, there would be a 30% diversion to the Sacramento River, 105 000 adult spawning anadromous fish on the Trinity River, and optimum boating recreation. The flow versus fish-run relationship was treated as a deterministic relation; the stochastic nature of the estimated relation was not explicitly introduced to the respondent. Rather, we used our judgement to delineate a plausible 'bottom-of-range' relation (see Arrow *et al.*, 1993).

The concept of a usable response is a bit of an abstraction. A survey might include good CVM data, but poor travel cost method (TCM) data, rendering it usable for one application, but not for a similar application. Usable surveys with missing data on the valuation questions can be treated in several ways. The conventional lower bound for non-responses involves assuming the all non-responses are zero. The conventional upper bound for non-responses is based on the premise that the non-responses are equal to the mean value for the (non-missing) responses. We calculated an upper and a lower bound data set, a tedious procedure for much of our analysis because we averaged the two types of values before calculating the aggregate benefits.

There are several variants of the user and household surveys. Various payment formats, survey administration formats, or sampling frames generate the variants. There are five user-survey variants including card (user with card) versus (user open-ended) non-card variants. There are also a handout on-site mail-back variant (user on-site), and two user phone survey variants. One user phone variant (phone I) gathered data from 159 respondents who had never been sent the questionnaire through the mail. A second user phone variant (phone II) is a group of 43 surveys from respondents who were sent the user survey and failed to respond. The three household survey variants include a California mail component, a mail-back component with responses from Washington, Oregon and Nevada, and a phone module (California phone).

The respondents were informed that the mean annual flow into Trinity Lake is 1.2 million acre-feet. They were also informed that 90% of the inflow was diverted from 1964, when Trinity Dam was built, to the 1980s, when Trinity River diversion levels fell to 80%, and that in 1991 they fell to about 70%. The 15 payment card sums ranged from $0 to $80 per month, and respondents were informed that they could insert one of these 15 sums or a different number as their response to the valuation questions. The variation in fish run sizes with flows is one of the most critical data supplied to respondents and is based on the best available scientific evidence (Hubbell, 1973; US Fish and Wildlife Service, 1980; personal communications: C. Stalnaker, Supervisory fishery biologist, BRD, US Geological Survey, Fort Collins, CO, 1993; J. M. Bartholow, 1995). Also, the numbers in the survey are based on current marine commercial and sport harvesting regulations. Marine harvesting regulations affect the size of the ocean harvest, which in turn has a major impact on the size of the runs (US Fish and Wildlife Service, 1980; Ridenhour, 1995). The user survey had open-ended and payment-card formats. Only payment-card surveys were used for the household survey, the phone surveys and the on-site hand-out survey.

Estimating the Aggregate Benefits

One way to establish global estimates for the aggregate willingness to pay for the two surveys is to determine a weighted average for upper and lower bounds for these two numbers from the various mean subsample willingness-to-pay estimates. These weights should be proportional to the subsample sizes. The upper and lower bound aggregate values were averaged to obtain point estimates. Another conventional technique is to establish aggregate willingness-to-pay estimates based on regression models. The regression model technique (Loomis *et al.*, 1990) is applicable to the estimation of household benefits, but not user benefits. The sample drawn for the household benefits is taken from the population for which the benefits estimates are to be established. The populations of California, Nevada, Oregon and Washington have sociodemographic characteristics that are known from recorded US census data. The magnitudes of these sociodemographic parameters can be inserted into the regression model to make point estimates of the aggregate willingness to pay. For the user survey, corresponding data on the universe of Trinity River users is not available. We used the weighted average technique for the user and the household survey estimates. We also estimated upper and lower bound user and household regression models, and the household equations were used to make benefits estimates. However, we list neither the regression model coefficients nor the numerical benefits estimates for the household regression model here.

In our models, the quantity of the environmental amenity was called the *availability* variable, A, and was treated as a continuous variable that took on the values 1, 2, 3, 4 and 5. The model indicates that respondent bids are a stable, monotonically increasing function of the environmental amenity if A has significant explanatory power. The coefficient of this variable was always highly significant in all of the regression models at the $\alpha = 1\%$ (two-tailed test) significance level when sociodemographic variables such as income, age, education level, race or gender that were significant at the 5% level were included in the model.

In our models, each observation of WTP had to be treated as an independent observation so that the array of observations of the dependent and independent variables would be rectangular. But each observation from a given respondent had only one set of sociodemographic variables and, in effect, five WTP observations. The degrees of freedom of the model are artificially padded, albeit in a fashion that impacts on the relationship between the dependent and the explanatory variables in a symmetric fashion in these ordinary least squares (OLS) models. Hence, the fact that A is highly significant in all of the models is still valuable information. However, the coefficients of the model cannot be compared directly with those obtained with conventional models.

There are other problems with the regression model, including: (1) The R^2 of the models is adequate by Mitchell & Carson's (1986) criteria, but the models flatten the functional relation between WTP and the *availability* variable; (2) constant-term and interactive dummy variables had to be used to model the effects of gender, ethnic origin and marital status in the models, and the coefficients of the dummy variables are hard to interpret; (3) the large number of zero observations of WTP should be modelled explicitly, but we could not find any efficient estimators for the type of two-stage logit (or probit) OLS models that might have been used for this purpose. The upper bound regression model for the household survey can be used to illustrate the 'flattening effect' of the regression models. Alternative 5 has a flow that is seven times as great as alternative 1, but more than ten times as many spawning adult fish. The global mean willingness to pay for Alternative 5 for the household survey is 7.5 times as great as the willingness to pay for alternative 1. However, the regression model predicts that the benefits ratio for alternative 5 to alternative 1 is only 3.15.

The WTP estimates for the users were calculated by multiplying the mean monthly values from the data by 12 and by the number of annual visitors. The number of households visiting the Trinity River in 1993 for recreational purposes was 711 585. This number was estimated by extrapolating to the state or region the percentage of respondents to the household survey who had visited the Trinity River. Information from the user survey was used to estimate the fraction of Trinity River Basin recreationists who used Lewiston Reservoir or Trinity Lake. This fraction was about 24% of the visitation total, and therefore in 1993 only 76% of the visitors were assumed to actually use the river. Global mean monthly values were produced by averaging weighted mean values for the upper and lower bounds for the households. Aggregate WTP estimates for the household survey are presented in Table 1.

The Reliability of the Results and some Qualitative Inferences

The use of weighted means for producing point estimates is one method for producing 'response' weighted-benefits estimates. Average weighted mean values for the household user survey are presented in Table 1. The mean WTP from a source is weighted by the fraction of usable valuation responses from this source in calculating these weighted means. Response-weighted benefits estimates were used to obtain all of the aggregate benefits estimates presented here.

Even if one survey administration format seems to be superior to the others, it may not be possible to rely solely on that format in any given situation for several reasons, including budgetary constraints. We think that a technique that uses all of the data in making aggregate estimates of the willingness to pay is superior to approaches that use only subsets of the data. However, the NOAA panel (Arrow *et al.*, 1993) suggested that telephone survey data are more reliable than data from mailback responses, and it is possible to make aggregate estimates from single sources with the Trinity River data sets (see Douglas & Taylor, 1996).

Table 1. Annual household benefits for Trinity River streamflows

Scenarios: the fish run sizes are biologists' estimates	Flows in acre-feet per annum; size of the annual fish run	Mean values from data (millions)
Alternative 1	120 000 AF; 9 000 fish	$106.698
Alternative 2	240 000 AF; 35 000 fish	$128.613
Alternative 3	360 000 AF; 75 000 fish	$249.265
Alternative 4	600 000 AF; 85 000 fish	$514.812
Alternative 5	840 000 AF; 105 000 fish	$803.638

Note: Estimates are made from global mean values calculated from the data. Fish-run sizes are biologists' estimates (pers. comm. C. Stalnaker, 1993).

The phrase pseudo-users describes Trinity River recreationists who were administered the household survey. The mean bid (e.g. sum offered as the willingness to pay) from the pseudo-users was less than one-half of the average bid from recreationists who were administered the user survey. For example, for the high-flow alternative (scenario 5), the mean monthly bid for the pseudo-users was $5.40; for the user survey the mean response-weighted average monthly bid for the high-flow alternative was $23.01. There were 15 non-California pseudo-user households, and 61 California pseudo-user households in the household survey data set. For the purposes of calculating the household benefits of improved streamflows and fish runs, the pseudo-users were treated as respondents to the household survey. But for the purpose of estimating user benefits, only data generated by the user survey were used to make aggregate value estimates. Table 2 presents response-weighted benefits estimates for the user survey at various participation levels.

Proximity to the resource may increase the willingness to pay for non-market uses of instream flows and wildlife resources (Loomis *et al.*, 1990). However, for the Trinity River household survey, the propinquity factor was negligible. The phone surveys have higher response rates and lower mean willingness to pay than the written surveys for the household and user surveys. Note that the user phone survey I had a higher mean monthly WTP ($15.41) than user phone survey II ($9.98), which queried only non-respondents to the written survey. These results indicate that first-round non-respondent valuation data enhance the validity of the final results even if initial response rates are as great as 70%.

Equation 1 shows the increase in the reliability of the point estimates of the willingness to pay for improved streamflows for the Trinity River as the sample size increases. This standard formula assumes that the sample values are

Table 2. Annual user benefits for the scenarios at the estimated annual participation rate; and at 20%, 40% and 60% of the estimated rate

Scenario	Benefits at 20% of rate (millions)	Benefits at 40% of rate	Benefits at 60% of rate	Benefits at full rate
Alternative 1	\$1.3464	\$2.6928	\$4.0392	\$6.7320
Alternative 2	\$3.6155	\$7.2309	\$10.8464	\$18.0773
Alternative 3	\$11.4552	\$22.9104	\$34.3655	\$57.2759
Alternative 4	\$23.4237	\$46.8474	\$70.271	\$117.1184
Alternative 5	\$37.1556	\$74.3112	\$111.4668	\$185.7780

randomly normally distributed about the true (finite) mean. Then, the $(1-\alpha)$ confidence limit for the point estimate for the mean, x_m is

$$\text{C.L.} = x_m \pm (\text{S.E.})\cdot t_\lambda; \quad \lambda = \frac{\alpha}{2}, \quad \text{S.E.} = \frac{\sigma}{\sqrt{n}} \tag{1}$$

where the sample standard error is S.E., n is the sample size, σ is the sample variance, and t_λ is Student's t-statistic (Fomby *et al.*, 1984). Mitchell & Carson (1989) suggested that only surveys with sample sizes of at least 600 usable responses have standard errors that will allow the data to be used to make benefits estimates that have sharp policy implications. In Table 3 we present 90% confidence limits for the user survey and household survey response-weighted mean annual per capita benefits.

Information that we did not give the respondent about the decline of Pacific Coast fish runs may underlie the disparity between the regression predictions and the global means from the data. The viability of the self-reproducing component of the fishery is greater at the higher flow levels than at the low-flow levels (US Fish and Wildlife Service, 1980; US House Committee on Merchant Marine and Fisheries, 1984). In other words, the hatchery is providing a modest harvest even at low flows. But the likelihood that the operation of the hatchery will protect the self-reproducing component(s) of Trinity River fish stocks is increased by increasing flow levels. Respondents who had background information about Pacific Coast anadromous fish stocks and were concerned about the genetic viability of these stocks might attach zero value to the low-flow alternatives, but positive willingness to pay values to the high-flow alternatives.

The user survey queried respondents about the amount of water they would send down the Trinity River as a percentage of the inflow into Trinity Lake. For the user survey, the mean percentage flow down the Trinity River chosen by the respondents was 69%, and the median value was 70%. Hence, Alternative 5 would have won a plurality-based referendum among the users. The household survey queried respondents as to their preferred alternative and asked respondents about the level of flow they would send down the Trinity. The preferred alternative is an integer ranging from 1 to 5. The mean value for the preferred alternative for the household survey was 3.89, the median value was 4, and the mode was 5. Alternative 5 would have won a referendum designed to pick the preferred alternative. Despite discrepancies between the concepts, the willing-

Table 3. Ninety per cent confidence limits for the annual willingness to pay for the user and household surveys

Survey	User	Household
Mean, Alt. 1	$9.461	$7.719
Interval	±35.789%	±23.329%
Mean, Alt. 2	$25.404	$9.304
Interval	±18.671%	±17.251%
Mean, Alt. 3	$80.491	$18.032
Interval	±10.631%	±12.247%
Mean, Alt. 4	$164.588	$37.243
Interval	±16.161%	±11.788%
Mean, Alt. 5	$261.076	$58.137
Interval	±12.290%	±12.308%

ness to pay and the preferred flow items corroborate a strong preference for enhanced Trinity River flows.

Monitoring Water Development and the Policy Implications of the Study

Resource management agencies rarely undertake socioeconomic monitoring of a water-development project in the United States. Nevertheless, it is useful to view the current study as an effort to provide socioeconomic monitoring of one part of the Central Valley Project (CVP). The CVP was approved by California voters in a 1933 state referendum (Hundley, 1986). However, several aspects of the Trinity Division of the CVP could not have been anticipated by even well-informed pre-Second World War California voters. In particular, the decline in Pacific Coast anadromous fish stocks could not have been readily anticipated by the public in the 1930s. Also, there has been strong recent growth throughout the nation in demand for outdoor-related recreation activities (US Bureau of the Census, 1996). Several social and technical developments indicate the need for reassessment of the California public's attitude toward the CVP. These include the use of aquaculture for commercial harvest of salmonids, changes in marine harvesting technology, changes in the demographic profile of the nation (including rapid population growth in California), and the development of more efficient crop-irrigation technologies.

Development and environmental interests tend to regard the outcome of a cost-benefit analysis for water-resource allocation as a terminal point in a zero-sum game (Fisher & Ury, 1983). One side wins and therefore the other side loses from an application of the cost-benefit criterion (Fisher & Ury, 1983). If resource managers could adopt a 'socioeconomic monitoring' stance toward the application of the study in question, the value of the information provided by cost-benefit non-market environmental amenity studies would be enhanced. The socioeconomic monitoring perspective takes cognizance of the potential need for future project assessment despite the fact that the project may have been based on valid socioeconomic information.

The genesis of a project may have been some truly democratic demand for key goods and services. However, conjoint shifts in socioeconomic variables and water-based technologies may give rise to an equally genuine need for a reassessment. Moreover, if the development project in question leads to a sizeable reallocation of resources and economic activities, the redistributive effects of the project may need to be re-examined with a set of socioeconomic studies. Projects that lead to shifts in the geographic locale of the resource and (or) long-run concentrations of economic activity in a small area or enhance the revenues of a small class of agents need to be examined carefully at periodic intervals. If long-run resource allocations based on contentious development projects are to receive adequate public support, the public may need periodic empirical reviews of the social and environmental consequences of a project in conjunction with a sequence of referendum decisions.

The cost-benefit estimates presented here do not represent the decision criteria for allocating Trinity River water. Information on Trinity River recreation-related expenditures and jobs would be quite useful. Data on visitation patterns and contingent changes in visits and trips expenditures induced by improved streamflows would also provide key insights. Consideration of non-monetary metrics can take cognizance of fundamental differences in the values different groups attach to resources that are universally recognized to be valuable and unique (Fisher & Ury, 1983).

Comparing Costs and Benefits and Policy Implications

Table 4 presents a comparison of the consumer surplus for Trinity River recreationists of Trinity River instream flows and the social opportunity costs of providing these flows. The average annual production of 1040 million kilowatt-hours of production for 1981–91 (Colman, 1991) generated a consumer surplus of $23.4 million in 1991 dollars (Colman, 1991; US Bureau of the Census, 1994). These revenues were adjusted for the 3% inflation in Western region domestic energy prices that occurred between the beginning of 1991 and the end of 1993 (US Bureau of the Census, 1994) so that they would be comparable to non-market benefits supplied in 1993. They were further adjusted for the hypothetical reallocation of water in the scenarios in a simple linear fashion. For alternative 5, 30% of the water was diverted, and the consumer surplus loss was assumed to be 70% of the inflation-adjusted value. Gibbons (1986) listed the values used to calculate the cost of foregone irrigation water. All of the values listed in Gibbons (1986) for San Joaquin Valley irrigation water were used to obtain an inflation-adjusted average value of $30.98 an acre-foot. The inflation adjustment factor for water that was used for this calculation is from the total crude materials column of Table 753 of the *Statistical Abstract of the United States* (US Bureau of the Census, 1994).

There are some high-value but low-quantity municipal and industrial Sacramento Basin uses of Trinity River water whose values are difficult to estimate and are not included in this paper. Moreover, the valuable Trinity River marine sport and commercial fisheries are also neglected. Perhaps the most critical missing value is the value of the Trinity River fishery to certain tribes including the Hoopa Valley Tribe and the Yurok Tribe. The Indians have harvesting rights whose value can be estimated. But no dollar metric can capture the multi-faceted value of the fishery to these tribes.

The current study indicates that the non-market dollar benefits of sending more water down the Trinity River are greater than the social costs. The per annum household benefits are $803 million for the alternative that sends the

Table 4. Consumer surplus from hydropower and agriculture, and non-market user benefits for improved streamflows and fish runs for the Trinity River in millions of dollars per annum

Scenario	Lost hydropower benefits	Marginal value of irrigation water	Foregone hydro plus foregone irrigation	User benefits at 100% participation rate
Alt. 1	$2.410	$3.718	$6.128	$6.732
Alt. 2	$4.821	$7.435	$12.256	$18.077
Alt. 3	$7.231	$11.153	$18.384	$57.276
Alt. 4	$12.052	$18.589	$30.641	$117.118
Alt. 5	$16.873	$26.024	$42.897	$185.778

Source: Colman (1991); US Bureau of the Census (1994).

most water down the Trinity River, while the annual opportunity cost is less than $43 million for this alternative. However, the economic factors presented in the current study are salient but not decisive. The net economic benefit of a proposed water resource (re-)allocation is a pertinent socioeconomic metric, but other economic, social and biotic information is relevant to the determination of the best Trinity River flow alternative. Information on regional economic impacts, including Trinity River recreation-related expenditures and jobs, is highly pertinent. A review of the panoply of social impacts of the decline in the fishery should consider the degree to which the social fabric of Trinity Basin communities is adversely impacted by the decline of fishery and river-related eco-tourist expenditures. However, the cost-benefit data in Tables 3 and 4 are important pieces of empirical evidence that should be considered in arriving at an allocation decision.

Notes

1. The Trinity River 'user survey' was distributed by the US Fish and Wildlife Service to Trinity River recreationists, and received Office of Management and Budget approval (OMB approval number 1018-0085).
2. Trinity County is a member of the Trinity River Task Force.

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