Estimating Recreation Trip Related Benefits for the Klamath River Basin with TCM and Contingent Use Data

By

Aaron J. Douglas

Midcontinent Ecological Science Center
U.S. Geological Survey
4512 McMurry Avenue
Fort Collins, Colorado 80525-3400

and

Andrew Sleeper

Successful Statistics LLC
1502 Mathews Street
Fort Collins, Colorado 80524

ABSTRACT

Several northern California coastal rivers provide a wide array of nonmarket recreation activities benefits. California's lower Klamath River provides recreationists with an ensemble of activities including swimming, wading, canoeing, whitewater rafting, and angling. In the early 1900's, the Klamath was widely regarded as one of the nation's finest salmonid fishing streams. In this paper we estimate the nonmarket recreational benefits provided by the lower Klamath River with the travel cost method (TCM), and compare the benefits with the costs of restoring the fishery. Klamath River anadromous fish runs have declined in size and viability during most of the post-World War II period, but the decline accelerated sharply during the 1980's and 1990's. Throughout this period, low river water quality has been a major causal factor underlying the decreases in fish stocks. In the discussion presented here, baseline TCM estimates of $3.2119081 billion per annum are combined with survey based contingent use (CU) data to estimate the benefits of improving the water quality and angling harvests of the mainstem Klamath River and its tributaries.

1. Introduction

We estimate the nonmarket recreation benefits provided by California's lower Klamath River by applying the travel cost method (TCM) to survey data. The data were gathered from a survey distributed to recreational users of the lower Klamath River and its major tributaries in the winter and spring of 1997-98. The headwaters of the Klamath River are in southern Oregon above Klamath Lake. The lower Klamath River flows from Copco and Iron Gate dams to the mouth of the river at Requa (see Figure 1). The major tributaries of the Klamath--the Trinity, Shasta, Scott, and Salmon Rivers--are northern California Rivers (see Figure 1).

A similar Trinity River recreational survey was distributed throughout the region in 1993-94. Hence survey respondents were informed that water based recreation trips to the "Lower Klamath River Basin" are trips to "the (Klamath River below Iron Gate, all tributaries of the mainstem Klamath River and any streams that flow into Klamath River tributaries—except for the Trinity River". We combine our TCM baseline benefits estimates with contingent use (CU) data to estimate the benefits of improving Klamath River Basin water quality and sport fish harvests. In the next section we discuss the salient water management Issues.

The Iron Gate and Copco Dams divide the Klamath River into lower and upper reaches; only the lower reach has anadromous fish (Quinn and Quinn, 1983), However, the water management issues of the upper and lower basins are linked. The Klamath River Development Project (project) has major water quality impacts on the upper and lower basin rivers (Klamath River Basin Fisheries Task Force, 1991; listed hereafter as "Task Force, 1991").

2. Klamath River Basin Water Management Issues

The Klamath River Development Project

Oregon and California passed legislation ceding lands to the project in 1902; construction began in 1905. The project delivers water designated by U.S. Bureau of Reclamation contracts to 240,000 acres of project land (U.S. Bureau of Reclamation, 2000). The dams, tunnels, canals, and pumping stations of the project are designed so that project waters can be reused several times. The mean per acre net use for project water is 2.0 acre-feet, and roughly 199,000 acres were irrigated in 1999 with 400,000 acre-feet of water; the value of the irrigated crops produced on project lands in 1999 was $104 million (U.S. Bureau of Reclamation, 2000).

The historic purposes of the project were to drain inundated lands in the lower Klamath and Tule Lake regions, divert and store irrigation water supplies to the farms, and prevent flooding on the drained lands (U.S. Bureau of Reclamation, 2000). The Lost River provides substantial quantities of project water although the Klamath River is the major source of project irrigation water. Contaminant loading from runoff in the upper basin has adverse aquatic habitat impacts on the lower basin (Task Force, 1991). Klamath River Basin substrate formations contain large amounts of phosphorous and the underground movement of the agricultural return flows does not lower phosphorus levels in the water (Campbell, 2000).

Water Resource Management Issues

The Lower Klamath River is about 190 river miles in length (Quinn and Quinn, 1983). Before the development of the Klamath River Basin project, the mean annual flow (maf) of the Klamath River at Weitchpec was about 1.4 million acre-feet. The maf of the Klamath River at Weitchpec is now about 1.6 million acre-feet (U.S. Bureau of Reclamation, 2000). However, before the completion of the Trinity River project in 1964, the maf of the Trinity River at Weitchpec was 1.2 million acre-feet. It is now about 340,000 acre-feet per annum. Trinity River water diversions have sharply lowered Klamath River flows below Weitchpec and produced major adverse impacts on Klamath-Trinity system fish stocks (Task Force, 1991; Bartholow, 2000).

The Klamath River Basin Act (P.L. 99-552) of 1986 notes that "floods, the construction and operation of dams, diversions and hydroelectric projects, past mining, timber harvest practices, and road-building have all contributed to sedimentation, reduced flows, and degraded water quality which have significantly reduced the anadromous fish habitat in the Klamath River system". The act authorizes funding for a 20-year Federal-State cooperative Klamath River Basin Area Restoration Program to rebuild Klamath River Basin fish stocks.

The Water Resource

Figure 1 gives one only a hint of the diversity of the water resources of the lower Klamath River Basin, There are 44.1 river miles in the Salmon, 30.1 miles in the North Fork of the Salmon River, 63.6 miles in the Scott River, and 43.6 miles in the Shasta River. However, dozens of small creeks and streams flow into the Shasta, Scott, Salmon and the mainstem of the Klamath River. Hence, the grand total number of water miles for the lower Klamath River Basin is more than 400 (miles). There are no impoundments on the mainstem of the lower Klamath River.

The lower Klamath River and its tributaries provide a panoply of recreational activities including swimming, wading, canoeing, Whitewater rafting, angling, and shoreline activities (Quinn and Quinn, 1983). A fish hatchery at Iron Gate annually releases millions of chinook (king), coho (silver) salmon, and steelhead (trout) fingerlings into the mainstem of the Klamath River (Quinn and Quinn, 1983). The hatchery output has helped sustain the regional tribal, marine, and sportfishing harvests. However, the declines in Klamath-Trinity system stocks are a major concern (Task Force, 1991),

The river provided habitat for several endemic species including American eel, green sturgeon, white sturgeon, American shad, coast cutthroat trout, steelhead trout, chinook (king) salmon, and coho (silver) salmon (Quinn and Quinn, 1983). Species native to the estuarine area near Requa include surf smelt, starry flounder, and redtail surf perch (Quinn and Quinn, 1983), The CRED survey notes that freshwater anadromous sport fish harvests below

Weitchpec in the 1950's rose to more than 100,000 fish per annum. During the mid-1980's, the average annual harvest on the mainstem was in the 8,000-12,000 fish per annum range although large harvests rose as high as 18,000 fish. The survey assumes that the mean current fresh and marine sport harvests for the lower Klamath Basin are 25,000 fish per annum and that sustained sport harvests of 38,000 (50% increase) and 50,000 (100% increase) are feasible (Task Force 1991; Bureau of Reclamation, 1998).

3. The Klamath River Survey

The Center for the Resolution of Environmental Disputes (CRED), a northern California based not-for-profit organization, distributed marine and freshwater printed survey variants in the winter-spring of 1997-98. CRED supplemented the survey data base with responses to a streamlined phone version of the survey. The phone survey omitted contingent use (CU) queries but included contingent valuation method (CW) willingness-to-pay (WTP) questions. The phone survey was administered "cold"; that is the recreationists did not see printed versions-of the survey questions before being contacted by phone calls. The entire survey was also administered over the phone to a group of mail survey non-respondents.

The marine survey preamble designated "a region around the mouth of the Klamath River Basin as being the area in which augmented Klamath-Trinity River fish stocks would have the greatest positive impact on the marine sport fishing harvest". The region stretches from Fort Bragg to Gold Beach just north of the California-Oregon border.

Response Rates

There were only 382 responses to the initial mail-out of 1010 surveys. However, an additional 234 surveys were obtained from a phone survey follow-up administered to recreationists who failed to respond to the mail-out. Finally, there were 200 responses to the streamlined version of the phone survey in the data base. Thus, 816 completed surveys were returned to CRED, and 809 responses are used in the economic analyses. Once address unknowns and mail-outs to non-user households are excluded, there were only 749 potential responses in the initial mail-out. Thus the response rate (*R.R.*) for the initial mail-out was *R.R.* = (3.82)/749 = 51.01%; for the phone survey, *R.R.* = (200)/204) = 98.03%; and for the 234 follow-up phone responses R.R. = 100%. For the composite data base, *R.R.*= (809)/(953) = 84.8898%.

Participation Rates

CRED randomly called 200 households in the states of Nevada, California, Oregon, and Washington and asked if they had been to the Klamath River in the last three years. The percentage of positive responses divided by 3 is the participation rate. The participation rate(s) are 0.5% for Nevada, 1% for California, 9% for Oregon, and 0% for Washington.

The number of households in each state times the participation rate is equals to the total number of state households visiting the site. There were 676,000 Nevada households, 11,446,000 California households, and 1,286,000 Oregon households in 1998 (U.S. Census Bureau; 2000). Hence, 233,580 households made recreation trips to the lower Klamath River in 1998 including; (1) 3,380 Nevada households, (2) 114,460 California households, and (3) 115,740 Oregon households (we estimated the number of households with 1998 data and used 1997 dollars to estimate benefits),

4. The TCM data

Household income is a key datum for estimating foregone wages (Just *et al.*, 1982). The mean income of the respondents was $64,880.24 (668 cases) in 1997 (1997 dollars). Foregone income is the product of the average trip time and the hourly family wage rate. The mean hourly income is the mean family income divided by the number of hours in 365 days (8,760 hours). The mean hourly family income was $7,4064.

Transient Visitors

Several respondents were transient users. "Transients" provided cost data for trips but did not usually make recreation trips to the lower Klamath River Basin and reported zero trips for the last 12-months. Transients made at least one recreation trip since 1990, and most of them had made a trip since 1996. If we set the number of trips for the last 12-months to zero for these respondents, then the mean number of trips in the last 12-months is 5.7307 for 792 cases and the usual number of trips is 7.5520. We tried to capture the economic impact of "transient" demand by imputing a small number of trips to a fraction of the transient respondents.

The trips variable we use for the Klamath River data survey analyses is the number of usual trips if it is available, and if it is unavailable, trips for the last 12-months is used. The mean for the TCM data set is 10.0646 trips (697 cases); this estimate includes imputed trips for "transients". There were 571 non-transient respondents and 128 transients. Moreover, 56% of the transients had made a visit less than 36-months prior to receiving the survey. The maximum number of imputed trips for the transients was 5 (imputed to 8 transients) and the minimum number was zero (imputed to 44 transients). Thus, 6.3% of the 697 cases were treated as "zeros" (e.g., cases with positive costs and zero trips).

Some economists assert that if there are no "zeros" in the data set the regression model coefficients will be biased upward due to sample selection bias (Grogger and Carson, 1987; Shaw, 1988; Creel and Loomis, 1990). The probability of imputing a non-zero value to a transient was a monotonically increasing function of the year last visited. The probability of a non-zero .value was 0.88888 for those who visited in 1997 and 0,11111 for 1990 visitors.

The transient data was smoothed a bit. If a transient lived within 50 miles of the site, he was imputed 5 trips. If he lived more than 400 miles from the site, he was imputed 1 trip. Note, however, that the mean number of trips for those respondents who usually made trips to the site and lived within 50-miles of the site was approximately 50 trips. Including transients in the TCM regression modeling data set introduced 44 "zeros" into the data set that would have been deleted if the transients had been removed from the TCM data set.

The mean (maximum) one-way distance of a trip to the usual site was 268.1628 miles (3,000 miles), and the average (maximum) cost of a trip was $469.131 ($6480). There was no estimate of the transit time available. Information on time on-site was available for all three surveys, and we used these data to estimate the aggregate value of foregone wages. We selected 6,000 hours--about 8 months and one week--on-site as the cutoff point for large outliers for total time on-site. We estimate labor's share of national income to be 78.877% of national income by averaging data from Table 700 of the 1997 *U.S. Statistical Abstract* (U.S. Bureau of the Census, 1998) for 1992-96 and assuming that 25% of proprietary income is a return to capital. Because we deduct property income from foregone income in estimating foregone wages, we did not attempt to weed out retiree income by placing a restrictive upper limit for the time on-site. Thus, the mean time on-site was 2045.5001 hours, and mean foregone wages were $11,949,7015 (547 cases).

5. The Consumer Surplus and TCM Benefits Estimates

The consumer surplus (CS) is a generic measure of the benefits provided by a market good or service. The CS is the triangular area bounded from above by the demand curve, from below by the horizontal line linking the vertical price axis to the equilibrium price, and by the price axis (see Figure 2). Let p be the price, *q* be the number of items purchased per unit time, and *f(p)* be the demand curve. Then the CS is the definite integral in equation (1);

$$CS = \int_{pe}^{u} f(p)dp. \qquad (1)$$

The equilibrium price is p_e, and the price that drives all demand to zero--the choke price--is $u > p_e > 0$. The TCM estimates a CS value for trips to an outdoor recreation site. Survey data is used to estimate a regression equation linking trips for the last 12-months (or usual trips) to mean trip expenses and the travel distance to the site.

Let *y* be the trips in the last 12-months, *d* be the roundtrip travel distance in miles, and *e* be mean trip expenses. Let $tc = c*d$ be the "travel cost" in dollars; a typical value for c = $0.31. In most TCM models, *tc* is the price variable corresponding to p_e in equation 1. Note, however, that there is no conceptual or empirical justification for using *tc* rather than *e* as the variable of integration. Let the regression model be

$$y = K + b_1(tc) + b_2(e) \; ; \quad K > 0 \; , \; b_1 < 0, \; \; b_2 < 0 \; . \qquad (2)$$

The variable of integration is the "active" price variable, and the other variable is the "passive" price variable. The product of the estimated coefficient of various auxiliary variables and the respective sample means are added to *k* to form a grand constant.

Travel expenses are a proper subset of total trip expenses, hence $e_m > tc_m$.

Because *tc* is the active price variable for most TCM studies, it is useful to convert $(CS)_e$ into a value that is comparable to the CS generated by *tc* (CS_{tc}). Douglas and Taylor (1999a) suggested multiplying $(CS)_e$ by r_1 $r = tc_m/e_m$, $0 < r < 1$ in order to convert $(CS)_e$ into a number comparable to $(CS)_{tc}$. We use this procedure in estimating the nonmarket benefits for the Klamath River; r = ($166.261/$469.131) = 0.354401939.

The upper limit of integration and the consumer surplus can be infinite (Hof and King, 1990; Douglas and Taylor, 1999a). Theoretical considerations suggest choosing the largest sample value of e or *tc* as the upper limit of integration if the choke price is infinite since everyone who makes a trip receives a dollar of consumer surplus. However, the largest value(s) in a data sample--unlike the sample mean(s)-- varies sharply across even large data sets. Therefore, Douglas and Taylor (1999a) suggest that the upper limit of integration be chosen so that the upper limit is 55% - 70% of the maximum value for the sample if the choke price is infinite.

6. Klamath River Regression Models

Household data TCM regression models often produce fits that are mediocre (Hof and King, 1990). Therefore, we provide regression results for both aggregated and household level data (Mitchell and Carson, 1989). Although the R^2 for the estimated household level models indicate mediocre fits, the *t*-values for the estimated price coefficients are robust (see Table 1). Aggregation can sharply increase the fraction of the variation in trips that is explained by the variation in the price variables across the sample, thereby increasing the statistical reliability of the benefits estimates.

Table 1 presents two household level data models. The per mile travel cost is $0.31, hence travel cost = *tc* = (0.62)*d> where *d* is one-way distance. The upper limits of integration for the inverse price and log-log models are

Table 1. Coefficients for two household level OLS TCM regression models. *N* = (usual) number of trips is the dependent variable. The t-values for the estimated coefficients and their p-values (two-sided test) are listed in parentheses as are the adjusted R^2.

Model type	Intercept	Coefficient for TC	Coefficient for E	R^z and F-statistic
Semi-log (665 cases)	76.500 (t = 13.261) (p = 0.00000)	- 14.710 (t = -12.116) (p = 0.00000)	------------	0.18128 (0.18005) F = 146.80
Inverse price (649 cases)	0.55749 (t = 0.38917) (p = 0.69716)	19.926 (t = 6.7746) (p = 0.00000)	537.91 (t = 9.873) (p = 0.00000)	0.20019 (0.19772) F = 80.85

$4000 for expenses and $1200 for travel cost. Note that $4000**r* = $4000(0.354401993) = $1417.608, hence the two upper limits are roughly equivalent. The maximum value for *tc* is $1860 and for *e* is $6480. The lower limits of integration are the sample means; thus, $166,2609 and $469.1310 and are the lower limits *for tc* and e respectively. Note the low R^2 and high t-statistics of the (coefficients of the) models. Neither the .R^2 nor the t-statistics were decreased by deleting the smoothed transient cases.

We experimented with little success with several regression model specifications including linear and log-log OLS models as well as Poisson, negative binomial, and Box-Cox maximum likelihood models. All of the regressions were run in Limdep™ (Version 7 for DOS; see Greene, 1995).

We also present some aggregated data models. One set of aggregated data were generated by groups sequestered by $100 intervals, Thus, the first point is the mean number of trips, the mean expenses, the mean travel cost, mean one-way distance, and mean income for those respondents whose (mean) trip expense *e* was between $0 and $100. Data point 41 for the models in Table 2 was generated by the mean values for respondents whose mean expenses are greater than $4,000. Because only 33 cases had trips and expenses data, the models in Table 2 were estimated with only 33 cases.

The distance counterparts to the models of Table 2 have 36 data points. For this data set, there are 40 data points formed by estimating mean (usual) trips, mean expenses, mean travel cost, mean one-way distance, and mean income for respondents in groups formed by 15 mile increments. Data from respondents whose one-way travel distance was greater than 600 miles formed data point 41. However, only 36 cases reported trips and distance (see Table 3).

7. Klamath River Benefits Estimates

To convert the total expenses CS into a travel cost CS we deflate the expenses CS by the ratio of the mean travel cost to the mean total expenses for the sample; this factor is labeled C.F. (= 0.3544019). Unfortunately, aggregation changes the "shape" of the data. For example, the mean number of usual trips for the household data set is 10.0646; the mean number of trips for the aggregation-by-distance data set is 6.7359. Mean trip expenses for the full data set is $469.1310, and for the aggregation-by-expenses data set it is $2071.3054. Hence, mean household expenditures are different for the two sets. To correct for the implicit change in the CS, we formerly multiplied the

Table 2. Two weighted OLS TCM regression models. The data points are 33 cases formed by estimating the mean values for trips, expenses, travel cost, and income for groups defined by $100 increments in expenses.

Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 and F-. statistic
Log-log model	4.1225 (t = 11,555) (p = 0.00000)	- - - - - - -	- 0.61522 (t = - 7.540) (p = 0.00000)	0.64714 (0.63576) F = 56.85
Inverse price	0.27134 (t = 0.333) p = 0.74167	- - - - - - - -	362.73 (t = 17.235) '(p. = 0.00000)	0.90550 (0.90245) F = 297.04

Table 3. Coefficients for two weighted OLS inverse price TCM regression models. The data points are the mean values for trips, expenses, travel cost, and income for 36 groups defined by 15 mile increments,

Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 and F-statistic
Log-log	5.1089 (t = 9.896) (p = 0.00000)	- 0.84447 (t = 7.650) (p = 0.00000)		0.63Z53 (0.62172) F « 58.53
Inverse price	0.11753 (t = 0.119) (p = 0.90635)	333.73 (t = 22.100) (p = 0.00000)		0.93492 (0.93300) F = 488.41

aggregate data CS by the ratio of the means of the two data sets for the relevant variable(s).

However, we now use the number of respondents per bin as weights for weighted regressions for the aggregated data sets. The precision of the estimated number of mean trips for a bin increases with the number of cases. Furthermore, the use of household weights incorporates quantitative information that improves the ability of the model to predict trips. Note that the weighted mean of the dependent variable is equal to the mean of the variable in the original data set.

We also apply a linear multiplicative transform to the independent variables so that they have mean(s) equal to the correlative means in the original data set. However, we can now distinguish between model specifications (linear and inverse price) for which the back-transform did not affect any model statistics -- including R^2, t-values, and F-statistics -- and those in which it had an slight effect on the model statistics (log-log). The back-transform is an "ad hoc" procedure for the log-log models, although the effect on the statistics is very slight.

Aggregate foregone wages are (233,580*$11,949.70151) = $2,791,211,274 per annum. We added the aggregate CS estimate of the household data inverse price model *tc* model of Table 1 to aggregate foregone wages to derive a point estimate of $3.2119081 billion per annum (see Table 4). We use this value as "the" benefits estimate in subsequent analyses. Note that the choke price for the semi-log model of Table 1 is $181.5258 while the sample maximum *tc* is $1860. The four benefits estimates listed in Table 5 include the household

Table 4. Annual per household benefits estimates for Klamath River Recreation trips for: (1) 2 household level inverted price models (2) 3 aggregation-by-expenses data models and (3) 2 aggregation-by-distance models.

Model; variable of integration	Raw Benefits	Expenses C.F.	Log transform	Final Version
Exp. CS values				
Table 1. Inv. Exp	$3,545.4514	0.354401939	- - - - - - - --	$1,257.0904
Table 2. log-log	$2,190.8107	0.354401939	2.17880109	$1,691.6812,
Table 2. Inv. Exp	$1,735.4678	0.354401939	- - - - - - - - - -	$615.0532
TC CS values				
Table 1. Inv. TC	$1,801-0823	- - - - - - - - - -	- - - - - - - - - -	$1,801.0823
Table 3. log-log	$847.2322	- - - - - - -- - -	2.79513945	$2,368.1321
Table 3. Inv. TC	$781.1255	- - - - - - - - -	- - - - - - - - -	$781.1255

Table 5. Nonmarket benefits estimates for 1997 water-related recreation trips to the lower Klamath River and its tributaries in billions of 1997 dollars.

Model	Consumer surplus	Foregone wages in billions	Annual benefits in billions
Table 1. Inv. Exp.	$293,496,737	$2.7912113	$3.0847080
Table 1. Inv. tc	$420,696,801	$2.7922113	$3,2119081,
Table 2. Inv. Exp.	$143,664,127	$2.7912113	$2.9348754
Table 3. log-log tc	$553,148,296	$2.7912113	$3.3443596

data set inverse price model ($) CS estimates of Table 1 and the highest and lowest aggregate estimates generated by the aggregate data models.

8. Contingent Use (CU) Data and Benefits Estimates

The survey queried respondents about the increments in trips generated by certain amenity improvements including; (1) a 45% increase in water quality, (2) a 50% increase in angling harvests, and (3) a 100% increase in angling harvests. This type of query provides contingent use (CU) data (Douglas and Taylor, 1999b). CU data can be validated by on-site counts estimating the change in visits induced by an amenity improvement (Duffield *et al.*, 1992).

CU non-responses were estimated at either 30% (if there were a larger number of non-respondents) or 25% of the value for respondents. To convert increments in trips to increments in benefits, the percentage increment in trips was multiplied by the baseline value of $3.2119081 billion per annum. Note that the maximum feasible improvement in chlorophyll loading in the waters of the lower Klamath River Basin is 45% (Campbell, 2000). Chlorophyll produces algae blooms which create malodorous waters, painful skin rashes on contact, and fish kills.

To conduct a benefit-cost analysis, we need to range the CU-benefits versus the costs of restoring water quality and aquatic habitat. The costs of restoring habitat and water quality were the costs of four distinct major restoration activities. However, because we have no quantitative information about the impact of the individual restoration activities on habitat or water quality, we simply summed the costs for the four restoration activities and compare them with the sum of the CU benefits for the amenities.

9. Habitat Restoration Costs

We estimated the present values for the costs of: (1) the purchase of project farmland; (2) the purchase of environmentally sensitive forested land; (3) increasing Trinity River instream flows; and (4} the removal of some Klamath River dams. The composite benefit estimate is the sum of the present values of the benefits estimates in Table 6 for water quality improvement and a 100% increase in angling harvest.

We estimated the cost of acquiring the. 240,000 acres of Klamath Project farmland from 1992 and 1997 data in Table 1103 of the *U.S. Statistical Abstract* for 2000. In 1997, there were 17.4 million acres of Oregon farmland with a value of $16,316 billion. Hence the mean value of acre was $16,316 million/17.4 million acres] = $937.70 per acre. We multiplied $937.70 by 240,000 to derive the value of project farmland.

We estimated the annual cost of increasing the Trinity River maf from 340,000 to 840,000 acre-feet per annum--$42.897 million in 1993 dollars--by adjusting the number for inflation to $47,622 million in 1997 dollars and then discounting at 7.5% (Douglas and Taylor 1998).

We imputed the same CS per kilowatt hour (KWH) for the Klamath River PacifiCorp hydropower complex as that provided by the Bureau of Reclamation complex on the Trinity River. The CS is the price differential per KWH between electric power from all sources and Trinity River hydropower times the number of KWH. The 1997 annual output of Copco #1 and #2, J, C. Boyle, and

Table 6. CU response and TCM-CU annual values. The baseline trips value is 10.0646 trips; the baseline TCM benefits estimate is $3.2119081 billion.

Amenity Improvement	Increment in trips	90% Confidence limits	Increment in TCM benefits
45% increase in water quality	1.34499Z9 (13.3636%)	±0.3336213 (±24.8047%)	$429,226,554
50% increase in angling harvest	1.5176829 (15.0794%)	±0.3190164 (±21.01902%)	$482,449,458
100% increase in angling harvest	2.2468121 (22.3291%)	±0.5200510 (±23.1462%)	$717,023,427

Iron Gate Dams was 916.676 million KWH (Prendergast, 2001). We adjusted the estimated value of $20.625 million for inflation and discounted the annual value by 7.5% (see Table 7).

There are nearly 10,000 acres of forested lands within 200 feet of the river channels of the lower Mainstem Klamath and the Scott, Shasta, and Salmon Rivers. Because there are numerous creeks that empty into the mainstem Klamath we estimated the cost of acquiring a 20,000 acre buffer strip around the rivers and streams of the lower basin.

Forested areas located on steep slopes are also environmentally sensitive areas. There are 622,760 acres located on slopes of more than 20% (rise over run) within 2 miles of the Scott, Shasta, Salmon and the lower mainstem Klamath and we estimated the cost of acquiring these forested acres (Giles, 2001). Klamath River Basin forest land ranges in value from $400-to-$1600 per acre (Frey, 2001). However, forest land on steep slopes is not as valuable as

Table 7. Present values for benefits and costs of major water quality improvement and aquatic habitat restoration activities.

Major activity	Cost	Klamath River benefit P.V.
Acquire Project farmland	$225,048,276	$15,2833331 billion
Acquire forest land	$522,208,000	$15.2833331 billion
Trinity River water	$634,965,398	$15.2833331 billion
PacifiCorp hydropower	$324,067,176	$15.2833331 billion
Total habitat restoration cost	$1.7062889 billion	$15.2833331 billion

forest land on flat areas. Hence, we used a price of $1200 per acre to estimate the cost of the buffer strip, and $800 per acre as the cost of acquiring forest land on steep slopes.

Minor Restoration Costs; Trinity River Flow Benefits

The three minor habitat restoration activities we consider include wetland and farmland re-vegetation and restoration ($25,000,000), the removal of project infrastructure and dam alterations ($25,000,000), and channel management ($50,000,000) (U.S. Bureau of Reclamation, 1997). The costs are present values for a discount rate of 7.5%. There is a consensus that the outlays would have positive impacts on aquatic habitat (Bartholow, 2001:

Campbell, 2001; Flug, 2001; Henrtksen, 2001; Williamson, 2001).

The benefits to Trinity River recreational users of putting more water down the Trinity should be added to the benefits of restoring the water quality and fish runs of the Klamath River (see Table 8). The Trinity River annual TCM baseline benefits estimates include the value of the $1,181 billion per annum (1997 dollars) consumer surplus (CS) estimate reported by Douglas and Taylor (1999a) as well as a $3.406 billion (1997 dollars) per annum aggregate foregone wage component. The annual CU-benefits are 33.968515% of the annual total TCM baseline benefits; discounted at 7.50%, the present value of the annual Trinity River CU benefits is $20.77238 billion (see Table 8).

There is also a strong consensus that habitat restoration should be complemented by a cessation fish harvesting of Klamath-Trinity system stocks for a period of 12-years in order to restore the fishery (Bartholow, 2001; Henriksen, 2001; Williamson, 2001). A 12-year ban is conformable with the 4-year life span cycle of certain fish species. This 12-year ban would include an end to all harvesting of Klamath-Trinity system stocks by commercial fishermen, a cessation of marine harvesting by tribal fishermen, and sharp declines in freshwater harvesting by tribal fishermen and recreational anglers. Small annual ceremonial tribal harvests of 200-300 freshwater fish per annum would occur throughout the period. Harvests of 200 fish every third year might be allocated to freshwater anglers by lotteries. Finally, all Klamath-Trinity hatcheries would be operated to achieve the goal of increasing the self-reproducing stocks of native fish species.

Table 8. Combined costs of major and minor habitat restoration activities, and leasing of regional fishing rights versus the benefits from Trinity River enhanced flow and Klamath River fishery and quality restoration activities.

Cost or benefit estimate	Present values for Costs	Trinity River Benefits P.V.	Trinity plus Klamath River Benefits P.V.
Minor restoration costs	$100,000,000	- - - - - - - - - -	- - - - - - - - - - -- -
Major restoration costs	$1.7062889 billion	- - - - - - - - -	-- - - - - - - - - - -
Leasing of Fishing Rights	$3.125 billion	- - - - - - - - - -	- - - - - - - - - - -
Present value of benefits and all costs	$4,9312889 billion	$20.772380 billion	$36,055713 billion

There would be no compensation for recreational anglers. Karuk, Yurok, Hoopa Valley, and Klamath tribal members and commercial fishermen would be compensated. The target compensation is $75,000 for every tribal member and $100,000 for every commercial fisherman. However, a commercial boat owner who indicated that he would retire at the end of the moratorium would receive an additional $75,000. We estimated the costs of compensation for 15,000 tribal members including 13,617 members in the four principal tribes and 1,139 members of 5 smaller tribes (Risling, 2002).

We estimated the costs of compensation for 20,000 workers. There were

460,170 workers were engaged in agriculture, logging, and fishing in the U.S., and 48,110 workers were engaged in fishing in 2000 (U.S. Bureau of Labor Statistics, 2001a). There were 189,550 California workers engaged in agriculture, logging, and fishing (U.S. Bureau of Labor Statistics, 2001b). The number of California workers in fishing related jobs is estimated as [(189,550)/(460,170)*48,110] = 19,817. Hence, the present value of moratorium payments is $4 billion in 1997 dollars.

10. Statistical Reliability .

The policy implications of the very large TCM benefits aggregate estimates produced by recent TCM studies on the Trinity River (Douglas and Taylor, 1999b) and those by the present study hinge on the statistical reliability of the results as well as the size of the point estimates. However, the statistical reliability of TCM benefits estimates has rarely been discussed in the literature. We use confidence limits (C.L.'s) to make precise statements about the statistical reliability of the estimates (Fomby *et al,* 1984).

Consider a sample of *H* measurements that produce a mean sample value of $\overline{X}$. Let S_x be the standard deviation, $(S.E.)_x$ be the standard error of the measurements, and $(C.V.)_X$ be the coefficient of variation. Then, formulas for $(S.E.)_x$, $(C.V.)_X$ and $(C.L.)_X$ are

$$(S.E.)_X = \frac{S_x}{\sqrt{N-1}}\ ; \quad (C.V.)_x = \frac{S_x}{\overline{X}} \tag{4}$$

and

$$(C.L.)_x = \bar{x} \pm [(S.E.)_x].t_{(a/2)\ ;}.\ (C.L.)_x = 100\% \left[1 \pm \frac{1.6449(C.V.)_x}{\sqrt{N-1}}\right] \qquad (5)$$

The second equality in equation (5) is the (C.L.) as a percentage for a 90% (C.L.) and a sample size of 1001. The 0.95 probability value for a *t*-distribution with 1000 degrees of freedom is 1,64486. Note that conventional C.L.'s vary with the sample size.

The standard error of the estimate (SEE) is a measure of the average error of the prediction of a regression equation (Stockburger, 2002). Let *y* be the dependent variable in a multivariate regression on *k* regressors $[x_1 \ldots, x_k)$, S_y be the standard deviation of *y* and R^2 be the multiple correlation coefficient. Then> the SEE is

$$SEE = S_y \sqrt{\frac{(N-1)(1-R^2)}{N-k}} \qquad (6)$$

The SEE C.L.'s are virtually independent of the sample size. For *N* = 1003 and 3 regressors, percentage C.L.'s for SEE at $\bar{y}$ the 90% level are

$$C.L. = 100\%\ [\ 1 \pm (1.001\ )(1.6449)\ (C.V.)\ \sqrt{1-R^2}\ . \qquad (7)$$

For the Klamath River data set, the C.L. the household data SEE for the "travel cost" inverse price model is ±690.06%. For the inverse price model of Table 3, the C.L.'s are ±100.21%; aggregation reduces the size of the C.L. by 85%. A Lake Powell TCM aggregated.survey data regression model generated SEE C.L.'s of ±29.98% (Douglas and Johnson, 2000).

A Bootstrap Approach to Reliability

The SEE is not a good measure of the statistical reliability of the consumer surplus (CS) estimates. An individual consumer's CS should never be negative, hence the aggregate CS should never be negative. Nevertheless, the tacit assumption in the literature that the reliability of the CS estimates can be measured by the magnitude of the t-values of the estimated coefficients is not well-supported.

Bootstrap C.L.'s can be constructed by using the computer to generate hundreds of virtual replicates of the original data set by drawing samples with replacement (Simon and Bruce, 1991; Efron and Tibshirani, 1993). However, programming problems preclude the construction of bootstrap C.L.'s for the CS estimates. However, For the Klamath River data, the household foregone wage point estimate is $11,949.7015 and the 90% CL's provided by the Resampling Stats™ (Windows Version 5.0) software are ($9,212,0448, $16,016.7636) or (-22.90903%, + 34.03484%). For the Trinity River data set, the household foregone wage point estimate is $4,786.0586 and the bootstrap 90% C.L.'s are ($3,540.7097, $5181.7456) or (- 25.02034%, + 8.26749%).

Combining the impact of the conventional 90% C.L. lower bound for the CU data and the bootstrap 90% C.L. lower bound for baseline foregone wages for the Klamath River generates a present value estimate of $8.0811628 billion. The correlative cost estimates have a smaller present value of $4.9312889 billion. Moreover, a moratorium on fish harvesting for Klamath-Trinity system stocks would have a positive impact on Trinity River harvests (Bartholow, 2001). Thus, a comparison of the lower bound 90% C.L. for the Klamath-Trinity system restoration action benefits with the salient costs is also relevant. The lower bound 90% C.L. for the Klamath-Trinity system benefits estimate is [$8.0611628 billion + $9.9819983 billion] = $18.0431611 billion.

The bootstrap C.L.'s for foregone wages are determined by creating 1,000 electronic versions of the files and estimating a mean value for household income, time-on-site (or travel time), and trips. These estimates were in turn used to determine 1,000 mean values for foregone wages. The C.L.'s were computed from the distribution of 1,000 values of foregone wages. In concluding our reliability analysis, we note that future discussions of the statistical reliability of the CS estimates will benefit from comparisons of the differences in reliability between the CS estimates for aggregated and household level data.

11. Policy Implications and Concluding Remarks

Large foregone wage point estimates play a critical role in our benefit-cost analyses because it is relatively easy to make statistical reliability statements for foregone wages. Note that the wide spread in the aggregate benefits estimates in Table 5 is sharply attenuated (in the aggregate benefits values) by foregone wages.

The nonmarket benefits (point) estimates of restoring the Klamath River anadromous fish runs and improving water quality are much greater than the estimated costs of these amenity enhancements. Thus, the policy implications of the controversial large CVM existence benefits estimates of previous investigators (Loomis *et al.*, 1990; Welsh *et al.,* 1995; Douglas and Taylor, 1999b) are supported by the present TCM study. User CVM benefits are typically comparable to marginal TCM benefits as measured by survey CU data conjoined to TCM baseline benefits. Existence benefits are often roughly comparable to TCM baseline benefits estimates. Thus, the Klamath and Trinity River Basin estimates are large even by existence benefits standards.

The lower Klamath River Basin does not receive the large visitation from the San Francisco-Oakland Bay Area of the Trinity River. The Klamath draws a notable visitor contingent from the smaller Portland metropolitan area. Hence, rivers that draw visits from moderate sized urban areas but have attractive amenities and qualities can generate large non-market benefits.

References

Bartholow, J, 2001. Personal communication. Fisheries Biologist, U.S. Geological Survey. Biological Resources Division (BRD), Midcontinent Ecological Science Center, Fort Collins, Colorado.

Campbell, S. 2001. Personal communication. Water quality specialists U.S. Geological Survey. Biological Resources Division (BRD), Midcontinent Ecological Science Center, Fort Collins, Colorado.

Creel , M. D. and J. B. Loomis. 1990. Theoretical and Empirical Advantages of Truncated Count Data Estimators for Analysis of Deer Hunting in California. *American Journal of Agricultural Economics,* 72: 434-41.

Douglas, A, J. and J. G. Taylor. 1998. Riverine Based Ecotourism Trinity River Non-market Benefits Estimates. *International Journal of Sustainable Development and World Ecology;* 5; 136-148,

Douglas, A, J. and J. G. Taylor. 1999a. A New Model for the Travel Cost Method: The Total Expenses Approach. *Environmental Modelling and Software;* 14: 81-92.

Douglas, A. J. and J. G. Taylor. 1999b. Resource Management and Nonmarket Valuation Research. *International Journal of Environmental Research;* 57: 1-16.

Douglas, A. J. and R. L. Johnson. 2000. Making TCM Benefits Estimates with Large Data Sets: Nonmarket Benefits Estimates for Lake Powell. Unpublished paper, Biological Resources Division (BRD), Midcontinent Ecological Science Center. Fort Collins, Colorado.

Duffield, J.W., C. J. Neher, and T. C. Brown. 1992. Recreation Benefits of Instream Flow; Application to Montana's Big Hole and Bitterroot Rivers. *Water Resources Research;* 28 (9): 2169-2181.

Efron, B. and R. Tibshirani. 1993. *Introduction to the Bootstrap.* Chapman and Hall, New York.

Flug, M. 2001. Personal communication. Hydrologist, U.S. Geological Survey. Biological Resources Division (BRD), Midcontinent Ecological Science Center, Fort Collins. Colorado.

Fomfay. T. B., R. C. Hill, and S. R. Johnson. 1984. *Advanced Econometric Methods.* Springer-Verlag, New York.

Frey, H. 2001. Personal communication. Land, Minerals, and Mining Officer. Klamath National Forest, Yreka, California.

Greene, W. H. 1995. *Limdep User's Manual*: *Version 7.0.* Econometric Software, Bell port, New York.

Giles, T. 2001. Personal communication (based on 30 meter resolution Digital Elevation Models compiled by the U.S. Geological Survey EROS Data Center downloaded from the GeoComm International Commission (http://gisdatadepot.com.dem); compilation and conversion by ARCInfo™ GIS software). GIS specialist, Johnson Controls, (contractor to) Midcontinent Ecological Science Center, Fort Collins, Colorado.

Just R. E., D.L. Hueth, and A. Schmitz. 1982. *Applied Welfare Economics and Public Policy.* Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Henriksen, J. 2001. Personal communication. Fisheries Biologist, U.S. Geological Survey. Biological Resources Division (BRD), Midcontinent Ecological Science Center, Fort Collins, Colorado.

Klamath River Basin Fisheries Task Force. 1991. *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program,* U.S. Fish and Wildlife Service, Klamath River Fishery Resource Office, Yreka, California.

Loomis, J. B., W. M. Hanneman, and T.C. Wegge. 1990. *Environmental Benefits Study of San Joaquin Valley's Fish and Wildlife Resources.* Jones and Stokes Associates, Sacramento, California.

Mitchell, R. C. and R. T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Value Method.* Resources for the Future, Washington, D. C.

Prendergast, L 2001. Personal communication. Senior aquatic biologist. PacifiCorp, Portland, Oregon.

Quinn, J. M. and J. M. Quinn. 1983. *Handbook to the Klamath River Canyon.* Educational. Adventures, Inc., Redmond, Oregon.

Risling, L. 2002. Personal communication. Indian Community Affairs Office. Humboldt State University, Arcata, California.

Simon, J. L. and P. Bruce. 1991. Resampling: A Tool for Everyday Statistical Work. *Chance;* 4(1): 22-32.

Stockburger, D. W. 2000. *Introductory Statistics: Concepts, Models, and Applications.* (URL: http://www.psychstat.smsu.edu/introbok./sbkl6m.htrn; online version accessed in December, 2000). Southwest Missouri State University, Springield, Missouri.

U.S. Bureau of the Census. 1998. *Statistical Abstract of the United States; 1995.* (115th edition). U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census. 2000, *Statistical Abstract of the United States: , 2000.* (117th edition). http;//www.census.gov/stab/www (accessed in January, 2002) . U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of Labor Statistics. 2001a. *National Occupational Employment* and *Mage Estimates; Farming, Fishing, and Forestry.* http://stats.bls.gov/ oes450000.htm (accessed in January, 2002). U.S. Department of Labor, Washington, D.C..

U.S. Bureau of Labor Statistics, 2001b. *State Occupational Employment und* Wage *Estimates; California.* . http://stats.bls,gov/oes_ca.htm (accessed in January, 2002), U.S. Department of Labor, Washington, D.C.

U.S. Bureau of Reclamation. 2000. *Klamath Project: Historic Operation.* U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office,

Welsh, M. P., R. C. Bishop, M. L. Phillips, and R. M. Baumgartnar. 1995. *GCES Non-use Value Study* (draft final report). Hagler, Bailly Consulting, Madison, Wisconsin.

Williamson, S. 2001. Personal communication. Fisheries Biologist, U.S. Geological Survey. Biological Resources Division (BRD), Midcontinent Ecological Science Center, Fort Collins, Colorado.