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Making Unbiased TCM Benefits Estimates with Klamath River Basin TCM and Contingent Use Data

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ABSTRACT

Several northern California coastal rivers provide important regional social and economic 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. The benefit-cost estimates of the current analysis provide baseline TCM estimates of $2.026531 billion ($7.327008 billion) per annum. Restoration benefits for the Klamath River (of the Klamath-Trinity system) are estimated by combining the baseline TCM estimates with survey based contingent use (CU) data. The combination of these two data types facilitate a comparison of the benefits and costs of improving the water quality of the Klamath River and the freshwater harvests of the Klamath-Trinity system.

1. Introduction

We use the travel cost method (TCM) and survey data to estimate the nonmarket recreation benefits provided by California's lower Klamath River. We also present a new "alternative" TCM consumer surplus model. We argue that conventional TCM techniques overestimate aggregate trip expenditures and regional employment effects. On the other hand, conventional TCM consumer surplus (CS) estimates have a negative bias. This particular set of issues comes to the forefront in the Klamath and Trinity River (Douglas and Taylor, 1999) TCM benefits estimates because aggregate recreation trip expenditures for these rivers are quite large and have a notable economic impact.

The TCM data were gathered from a survey distributed to users of the lower Klamath River and its major tributaries in the winter and spring of 1997-98. A similar Trinity River recreational survey was distributed in this 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".

The headwaters of the Klamath River are in southern Oregon above Klamath Lake (see Figure 1). 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). The Klamath River Development Project (project) has major adverse water quality impacts on both the upper and lower basin (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; in 1999 roughly 199,000 acres were irrigated with 400,000 acre-feet of water. The value of the irrigated crops produced on project lands in 1999 was $104 million ($112.3 million in 2002 dollars) (U.S. Bureau of Reclamation, 2000).

The project drains land in the lower Klamath and Tule Lake regions, diverts and stores irrigation water supplies, and prevents flooding on the drained lands (U.S. Bureau of Reclamation, 2000). The Lost River provides substantial quantities of project water although the Klamath 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, 2001).

Water Resource Management Issues

The mainstem of the Lower Klamath River is about 190 river miles in length (Quinn and Quinn, 1983). The major tributaries of the Klamath--the Trinity, Shasta, Scott, and Salmon Rivers--are northern California Rivers (see Figure 1). 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, 2001).

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, 63.6 miles in the Scott, and 43.6 miles in the Shasta River. Dozens of small creeks and streams flow into the Shasta, Scott, Salmon and mainstem of the Klamath River. Hence, there are more than 400 water miles in the lower Klamath River Basin. There are no impoundments on the mainstem of the lower Klamath River.

The recreational activities provided by the lower Klamath River and its tributaries include 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 Klamath River (Quinn and Quinn, 1983). The hatchery output has helped sustain regional tribal, marine, and sportfishing harvests. However, 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 freshwater anadromous sport fish harvests below Weitchpec in the 1950's rose to more than 100,000 fish per annum. The Klamath River Basin survey notes that in 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).

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 surveys 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 (CVM) willingness-to-pay (WTP) questions. The phone survey was administered "cold"; respondents 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 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 follow-up phone survey administered to non-respondents. 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 were used in the economic analyses. After 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.* = (382)/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 Nevada, California, Oregon, and Washington (e.g., 800 households in the western U.S.) and asked if they had been to the Klamath River in the last 3 years. The participation rate is the positive response rate percentage divided by 3. The participation rate(s) are 0.5% for Nevada, 1% for California, 9% for Oregon, and 0% for Washington.

There were 676,000 Nevada households, 11,446,000 California households, and 1,286,000 Oregon households in 1998 (U.S. Bureau of the Census, 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

Foregone Wages

The mean income of the respondents was $64,880.24 (668 cases) in 1997 (1997 dollars). The conventional estimate of mean per trip 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. For TCM studies the estimation of aggregate foregone wage (FW) is problematic. A graduate textbook notes that: "Another difficulty with the travel cost approach is the unobservable value of time involved for site visits. The greater the travel distance, the less attractive a site becomes, not only because of direct monetary expense but also because of time spent driving, and so on." "Appropriate valuation of user costs necessarily involves determination of leisure time foregone; otherwise, user costs do not adequately reflect true marginal benefits" (p. 292; Just *et al.*, 1982).

We use a household wage rate in this paper. Contractual rigidities that prevent an individual from adjusting his hours worked in response to economic factors do not prevent a family from making large shifts in hours worked through entrance into and exit from the labor force by household members.

Transient Visitors

"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. All survey "transient" respondents made at least one recreation trip since 1990. 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. We imputed a small number of trips for transients, thereby adjusting the original estimate of 7.5520 trips per annum upward to 10.0646 trips (697 cases).

There were 571 non-transient respondents and 128 transients; 56% of the transients 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 "zeros" (e.g., cases with positive costs and zero trips) (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. If a transient lived within 50 miles of the site, she was imputed 5 trips. If she lived more than 400 miles from the site, she was imputed 1 trip. Respondents who usually made trips to the site and lived within 50-miles of the site made about 50 trips per annum (sample mean).

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). Although no transit time data are available, time on-site data are available for all three sub-samples and we used these data to estimate the value of aggregate foregone wage (FW). We used 6,000 hours on-site--about 8 months and one week--as the cutoff point for 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 assume that 25% of proprietary income is a return to capital. Hence foregone hourly wages are \$5.84195. Because we deduct property income from foregone income, we did not attempt to weed out retiree income. Thus, the use of the conventional methodology indicates that the mean time on-site was 2045.5001 hours, and mean annual FW was \$11,949.7015 (547 cases). However, the conventional methodology produces a sharp upward bias in the estimate of aggregate FW.

5. A New Approach to Making TCM Consumer Surplus Estimates

The Definition of Consumer Surplus; the TCM and Consumer Surplus

The consumer surplus (CS) is a generic measure of the benefits provided by a market good or service. The TCM estimates the CS for recreation trips. 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 (p_e) be (the equilibrium) price, q be the number of items purchased per unit time, and $f(p)$ be the demand curve. If $U > p_e$ is the choke price shuts off demand, the CS is the definite integral

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

Let *y* be the trips in the last-12-months, *d* be roundtrip travel distance in miles, *e* be trip expenses, $tc = (c*d)$ be "travel cost" in dollars, and 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 price variable is an "auxiliary variable". To evaluate the definite integral, the product of the estimated coefficients of the auxiliary variables and the respective sample means are added to *K* to form a grand constant $G = K + \sum(b_i)(\overline{x}_i)$. Because *tc* is the active price for most TCM studies, Douglas and Taylor (1999) multiply $(CS)_e$ by *r*, $r = tc_m/e_m$, $0 < r < 1$ to convert $(CS)_e$ into a number comparable to $(CS)_{tc}$. We also use this procedure, and for the Klamath River data C.F. = *r* = ($166.261/$469.131) = 0.354401939 (the Trinity C.F. = 0.3086566).

If the choke price is infinite we could use the largest sample value of *tc* as the upper limit of integration because everyone who makes a trip receives at CS of at least a dollar (Douglas and Taylor, 1999). However, because the largest value varies sharply across data sets, Douglas and Taylor (1999) suggest setting the upper limit of integration so that it is 55%-75% of the maximum sample value.

A Source of Upward Bias

Let $E_s(tc)$ be the mean travel cost for the sample, $E_s(y)$ be the mean number of trips per household for the sample, $E_s[(tc)(y)]$ be the sample mean value of annual household trip expenditures, *TE* be aggregate expenditures for the sample, and N be the number of households making trips. An unbiased estimate of total expenses is

$$TE_u = N\{E_s[(tc)(y)]\} . \qquad (3)$$

However, economists estimate TE as $(TE)_b = \{(N)[E_s(tc)E_s(y)]\}$. If COV(tc, y) is the covariance of *tc* and *y*, the conventional estimate of TE is biased;

$$TE_b = TE_u - COV(tc, y) = N\,E_s[(tc)(y)] - COV(tc,y) . \qquad (4)$$

Because COV (tc, y) < 0, the conventional estimate of TE has an upward bias. Moreover, the conventional estimate of the CS underestimates benefits. We estimate p_e, the cost of a trip, as $p_e < E_s(tc)$;

$$p_e = \frac{E_s[(tc)(y)]}{E_s(y)} . \qquad (5)$$

The use of this formula increases the estimated value of the TCM CS. If the demand curve is fixed and the supply curve shifts to the right because the social cost of producing the good decreases in a competitive market, the same number of items can be purchased with smaller aggregate expenditure and the social cost of supplying the good decreases (see Figure 3). The CS "triangular area" will increase (see Figure 3). Because the TCM CS is a simulation of a competitive market CS, the decrease in expenditures for trips should generate a correlative increase in the TCM CS. Note that we can and do make unbiased estimates of aggregate foregone wages by estimating the sample mean for the product of time on-site, household wages, and trips.

6. Klamath River Regression Models

The Household Regression Models

We provide regression results for household level and aggregated household data because household level TCM models often produce mediocre fits (Mitchell and Carson, 1989; Hof and King, 1992). We experimented with little success with linear and log-log ordinary least squares (OLS) models as well as Poisson, negative binomial, and Box-Cox maximum likelihood household data models. The Klamath River inverse price model does have high t-values (see Table 1). All of the regressions were run in Limdep^{TM} (Version 7 for DOS; see Greene, 1995). The small finite choke price of the semi-log model precludes using the model to make CS estimates.

We recalculated the Trinity River *CS* with new limits of integration for a

Table 1. Household data OLS TCM regression models for the Klamath and Trinity Rivers. Usual trips is the dependent variable; t-values, p-values (two-sided test), and adjusted R^2 are listed in parentheses.

Klamath Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 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
Trinity	--------	--------	--------	--------
Inverse price (617 cases)	1.9984 (t = 2.833) (p = 0.00461)	9.6996 (t = 11.566) (p = 0.00000)	60.686 (t = 10.305) (p = 0.00000)	0.38800 (0.38600) F = 194.63

new inverse price model so that the Klamath and Trinity River CS estimates are comparable. Thus, we use the same \$0.31 per mile *tc* for both data sets (Douglas and Taylor, 1999). A dollar is added to the expenses variable and \$0.155 is added to *tc* for both data sets to avoid dividing by zero. The lower limits of integration are determined by equation (5) for both data sets.

The grand constant *G* can be estimated in two ways with an inverse price model. Namely, the coefficient of the passive price variable can be multiplied by the inverse of the mean value of the price or by the mean value of the inverse. If the latter procedure is used to estimate *G*, the model passes through the means of the variables. The former method typically produces estimates of aggregate trips and the CS that have a downward bias. The original Trinity River CS value is the average of a large unbiased CS estimate and a biased estimate equal to roughly 50% of the unbiased value (Douglas and Taylor, 1999). We use the unbiased estimates.

The Aggregated Data Models

One set of aggregated data was generated by 33 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. The last data point for the aggregated models was generated by the mean values for respondents whose mean expenses are greater than $4,000. The intervals used for this type of aggregation are called "bins". For this data set, only 33 bins had both trips and expenses data.

The distance counterparts to the aggregate expenses models have 36 data points. For this data set, there are (potentially as many as) 40 data points formed by estimating mean values for (usual) trips, expenses, travel cost, one-way distance, and income for bins formed by 15 mile increments. The final bin was composed of data from households whose one-way travel distance was greater than 600 miles. However, only 36 bins had both trips and distance data for the relevant interval (see Tables 2 and 3).

Table 2. Two weighted Klamath River 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 Klamath River OLS TCM regression models. The data are the mean values for trips, expenses, travel cost, and income for 36 groups defined by 15 mile distance 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)	--------	0.63253 (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

7. Aggregate Expenditures, Foregone Wages, and Data Alignment

Recall that the product of the sample means for trips and expenses produces a biased estimates of mean household trip expenditures. Unbiased estimates of household and aggregate trip expenditures can be obtained as the sample mean value of the product of expenses and trips. If the mean sample size of the groups visiting the river is greater than the size of the average household, the CS and aggregate expenditures must be adjusted downward.

On the other hand, a correlative inverse upward adjustment must be made to FW. The sample mean size of the Klamath River trip groups is 4.16496 people and the mean size of respondent households is 2.88344. Thus, aggregate expenditures and the CS must be adjusted by multiplying the household values by (2.88344)/(4.16496) = 0.69230917. The FW must be adjusted by (4.16496)/(2.88344) = 1.4444614. The correlative values for the Trinity River are 3.331524 (household size) and 3.986322 (group size), and the adjustment factors are 0.83573881 and 1.1965461 (see Table 4).

We made an inflation rate adjustment of 1.11073 for the Klamath and 1.24498 for the Trinity River and a population growth adjustment of 1.129168 for the Trinity. We used population growth data for California, Nevada, and Oregon to estimate the Klamath River user household population for 2002 (246,041). Our recent inflation data came from the U.S. Department of Labor's online consumer price index (CPI) inflation calculator (http://www.bls.gov.cpi). Recent population data are also online (Family Education Network; http://www.infoplease.com) (both sites accesed in November,

Table 4. Conventional and unbiased estimates of annual household trip expenditures and FW in 1993 (Trinity) and 1997 (Klamath) dollars; conventional and unbiased aggregate expenditures and FW in 2002 dollars and population base for both rivers; and the present value of the 2002 Klamath-Trinity unbiased expenditure estimates (discount rate of 7.5%; cases are in parentheses).

Klamath River	Expenditures	Foregone Wages
Conventional household	$4,721.6382	$11,949.702
Unbiased household	$1,969.8817 (676)	$2,560.8692 (560)
Conventional aggregate	$893,316,485	$4,717,127,450
Unbiased aggregate	$372,696,095	$1,010,899,423
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Trinity River		
Conventional household	$3,312.3886	$5,742.3965
Unbiased household	$1,353.3667 (634)	$2,238.0771 (1172)
Conventional aggregate	$2,769,233,443	$8,714,047,949
Unbiased aggregate	$1,131,445,861	$2,636,090,854
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Unbiased Klam.-Trin. P.V.	$20,055,226,080	-----------

2003). Population and price data data are also available in the *U.S. Statistical Abstract* (U.S. Bureau of the Census, 2000) series. We assume that the growth in households is proportional to the growth in overall population.

We use the number of respondents per bin as weights for weighted regressions for the aggregated data sets. Weighting is widely used in situations similar to ours in which the precision of the dependent variable increases with the number of cases. The weighted mean of trips is equal to the mean of the trips variable in the original data set.

We also apply a linear transform to the observations of the independent variables so that they have mean(s) equal to their original counterparts. For the linear and inverse price models the transform did not affect any model statistics--including R^2, *t*-values, and *F*-statistics--but there was a slight effect on the statistics of the log-log models. The back-transform is an "ad hoc" procedure for the log-log models. We use the expenses-to-travel cost C.F. to estimate the lower limit of integration for *tc*. Aggregate CS estimates based on the assumption that each trip is made by a household must be adjusted downward by the ratio (2.88344)/(4.16496) = 0.69230917. The lower limit of integration for the household CS expenses (tc) estimates for the Klamath is $195.72379 ($69.364883) and for the Trinity it is $226.27010 ($69.839750) (see equation (5)).

8. Contingent Use (CU) Data and Benefits Estimates

In the ensuing benefit versus cost analysis we use $2.0265312 billion per annum (1997 dollars; see Tables 5 and 6) as the baseline benefit estimate for the restoration of the Klamath River and its major tributaries (except for the Trinity River). The counterpart value for the Trinity River is $7.1298250 billion per annum in 1997 dollars.

The Klamath River 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. These queries provided our contingent use (CU) data Note that the maximum feasible improvement in chlorophyll loading in the

Table 5. Annual per household CS estimates for Klamath and Trinity River TCM models household data models in 1997 dollars, and Klamath River aggregated data TCM model CS estimates in 1997 dollars.

Klamath Models	Raw Benefits	Expenses C.F.	Log C.F.	Final Version
Exp. CS values				
Table 1. Inv. Exp	$9,241.8248	0.354401939	-------	$3,275.3206
Table 2. log-log	$2,681.3058	0.354401939	2.17880109	$2,070.4274
Table 2. Inv. Exp	$2,128.5013	0.354401939	-------	$754.3450
TC CS values				
Table 1. Inv. tc	$7,188.8191	-------	-------	$7,188.8191
Table 3. log-log	$1,148.5356	-------	2.79436340	$3,209.4265
Table 3. Inv. tc	$1,084.9498	-------	-------	$1,084.9498
Trinity Model				
Table 1. Inv. Exp	$15,306.6411	0.308656555	-------	$4,724.4951
Table 1. Inv. tc	$7,594.6240	-------	-------	$7,594.6240

Table 6. Aggregate annual CS, FW, and total benefits estimates for recreation trips to the lower Klamath and Trinity Rivers in 1997 dollars and population levels. System benefits are the sum of values in rows 3 and 6.

Klamath River	Consumer surplus	Foregone wages	Total
Table 1. Inv. Exp.	$529,650,705	$864,030,335	$1,393,681,040
Table 1. Inv. tc	$1,162,500,888	$864,030,335	$2,026,531,223
Trinity River	-----------	-----------	-----------
Table 1. Inv. Exp.	$3,011,274,739	$2,289,202,039	$5,300,476,778
Table 1. Inv. tc	$4,840,622,949	$2,289,202,039	$7,129,824,988
Klamath-Trinity	CS	FW	Total
Grand sums	$6,003,123,837	$3,153,232,374	$9,156,356,211

waters of the lower Klamath River Basin is 45% (Campbell, 2001). Chlorophyll produces algae blooms which create malodorous waters, painful skin rashes on contact, and fish kills.

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% (small 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 $2.0265 billion per annum. We have information about the qualitative importance of the various restoration activities, but no quantitative data about the impact of the various activities. Therefore, we simply sum the costs for four major restoration activities and compare them with the sum of the present values (see Table 7) of the CU-TCM benefits estimates for a 45% water quality improvement and a 100% sport fish harvest enhancement.

9. Habitat Restoration Costs

We estimated the present values in 1997 dollars 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. We used 1992 and 1997 data in Table 1103 of the *U.S. Statistical Abstract* for 2000 to estimate the cost of acquiring the 240,000 acres project farmland. In 1997, there were 17.4 million acres of Oregon farmland with a value of $16.316 billion. Hence the mean value of an acre was $16,316 million/17.4 million acres = $937.70 per acre. We multiplied

Table 7. Klamath River CU-TCM values in 1997 dollars. Annual values are 10.0646 for trips and $2.0265 billion for the CS plus FW.

Amenity Improvement	Increment in trips	90% Confidence limits	CU-TCM benefit increment in millions
45% increase in water quality	1.3449929 (13.3636%)	±0.3336213 (±24.8047%)	$270,817,529
50% increase in angling harvest	1.5176829 (15.0794%)	±0.3190164 (±21.01902%)	$305,589,074
100% increase in angling harvest	2.2468121 (22.32391%)	±0.5200510 (±23.1462%)	$452,400,978
45% increase in water quality plus 100% increase in harvest	3.591805 (35.6875%)	--------	$723,218,506

$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 published value 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 complex as that provided by the Trinity River Bureau of Reclamation complex. 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 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%.

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. 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 (Giles, 2001). We used $1200 (buffer strips) and $800 (steep slopes) per acre as acquisition costs (Frey, 2001; see Table 8).

The present value (7.5%; 1997 dollars) of the costs for 3 minor habitat restoration activities are: (1) $50,000,000 for channel management (U.S. Bureau of Reclamation, 1997), (2) $25,000,000 for wetland and farmland re-vegetation and restoration, and (3) $25,000,000 for the removal of project infrastructure and dam alterations (Bartholow, 2001; Campbell, 2001; Flug, 2001; Henriksen, 2001).

The Trinity River CS plus FW estimates for putting more water down the Trinity should be included in our analysis. The Trinity River annual TCM baseline benefits estimate listed in Table 6 is $7.12982499 billion. The annual CU-Trinity increment is 33.9639447% of total benefits, hence the annual Trinity River CU-TCM incremental value is $2.4215698 billion. The annual

Table 8. Present values for benefits and costs of major water quality improvement and aquatic habitat restoration activities in 1997 dollars.

Major activity	Cost	Klamath River TCM-CU benefit P.V.
Acquire Project farmland	$225,048,276	$9.64291342 billion
Acquire forest land	$522,208,000	$9.64291342 billion
Trinity River water	$634,965,398	$9.64291342 billion
PacifiCorp hydropower	$324,067,176	$9.64291342 billion
Total habitat restoration cost	$1.7062889 billion	$9.64291342 billion

Klamath-Trinity system CU-TCM increment is $3.1447883 billion; the present value of the Klamath-Trinity CU-TCM increment is $41.93051095 billion (7.5% discount rate; 1997 dollars).

We include an estimate of the cost of a 24-month fishing moratorium. This ban would be similar to those of the 1992-95 period which--with limited exceptions--closed commercial marine salmonid harvesting from the Oregon-California border to Point Arena. The ban would include freshwater harvests. Annual ceremonial tribal harvests would be limited to 200-300 freshwater fish, and hatcheries would be operated in a mode designed to increase self-reproducing stocks of fish. If the fishery responded quickly to the habitat restoration measures, no ban would be imposed.

Karuk, Yurok, Hoopa Valley, and Klamath tribal members and commercial fishermen would be compensated (see Table 9). The target is \$12,500 for every tribal member--hence a family composed of four tribal members would receive \$50,000--and \$16,665 for every commercial fisherman. We estimated payment costs for 15,000 tribal members including 13,617 members in the four principal tribes and 1,139 members of 5 smaller tribes (Risling, 2002). However, we did not verify the willingness-to-accept a 2-year fishing moratorium in exchange for our payment proposals with any tribal or commercial fishing organizations. There are 19,817 fishing related jobs in California, and we estimated payment costs for 20,000 workers in 1997 dollars (U.S. Bureau of Labor Statistics, 2001a, 2001b; see Table 9).

10. Statistical Reliability

The statistical reliability of TCM CS estimates has rarely been discussed in the literature. Let $\overline{x}$ be the sample mean value of x, S_x be the standard deviation, and $(S.E.)_x$ be the standard error of x. Formulas for $(S.E.)_x$, and $(C.L.)_x$ are

$$(S.E.)_x = \frac{S_x}{\sqrt{N-1}}; \qquad (C.L.)_x = \bar{x} \pm [(S.E.)_x] t_{(\alpha/2)}. \tag{6}$$

Bootstrap C.L.'s of CS can be constructed with a computer by generating hundreds of virtual replicates of the original data set by drawing samples with replacement (Efron and Tibshirani, 1993). We computed bootstrap C.L.'s for our original CS estimates for the Klamath and Trinity Rivers. However, Limdep^{TM} (ver. 7 for DOS) provides estimates of the standard deviation of the

Table 9. Costs of major, 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 (1997 dollars).

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	$520,800,000 million	-------	------
Present value of benefits and all costs	$2.3270889 billion	$32.2875982 billion	$41.9305100 billion

unbiased estimates of the foregone wages and expenditures and we use the output in conjunction with the C.L. estimates for the CU-increments to make bottom-of-range estimates for the unbiased estimates of FW. The lower edge C.L. (90%) for the CU trips increments are 27.205579% (Klamath) and 29.714035% (Trinity). For the Klamath, the bottom-of-range C.L. (90%) estimate of aggregate annual foregone wages (FW) is $190,198,408 and the present value is $2.535978768 in 1997 dollars. The bottom-of-range present value for the CU linked FW increment for the Trinity is the $8.107475616 billion (1997 dollars, 1998 population), and for the Klamath-Trinity system it is $10.64345438 billion in 1997 dollars (see Table 10).

Unfortunately, we had no bootstrap C.L.'s for the CS for our revised CS estimates. However, our perusal of the bootstrap programming results indicate that: (1) the higher the R^2 (multiple correlation coefficient) the tighter the C.L.'s, and (2) the bottom edge of the C.L.'s span a range of about 25%-75% of the mean. If we use a lower C.L. that is 33% of the value of the point estimate of the CS for the Klamath-Trinity system, the C.L. for the CS has a present value of about $7 billion.

We used Limdep™ standard deviation estimates for trip expenditures to estimate a bottom-of-range C.L. (90%) for the CU expenditure increment generated by the restoration of Klamath-Trinity system water quality and fish stocks. The present value of the lower C.L. value is $4,929,243,541 in 2002 dollars for a 2002 population base (see Table 10).

10. Policy Implications and Concluding Remarks

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. Moreever, the policy implications of the controversial large CVM existence benefits estimates of river restoration by other economists (Loomis *et al*., 1990; Welsh *et al*., 1995; Douglas and Taylor, 1999) are supported by the present study. User CVM benefits are comparable to marginal TCM benefits as measured by survey CU data. Existence benefits are roughly comparable to CS TCM baseline benefits estimates. The Klamath-Trinity system annual baseline CS TCM estimate of $6.0031238 billion (1997 dollars and population) is large even by <u>national</u>

Table 10. Lower 90% C.L.'s for the Klamath-Trinity CU increment in trips expenditures (2002 dollars and population) and benefits (FW) in (1997 dollars, 1998 population) at 7.5% discount rate, and total restoration cost in billions of 1997 dollars (cost in billions of 2002 dollars in parentheses).

1997 (2002) Habitat Restoration Cost	2002 P.V. of CU Expenditure increment	1997 P.V. of CU Benefits Increment
$1.7062889 ($1.8952203)	$4.929243541	$10.64345438
----------	----------	----------
Habitat plus leasing		
$2.3270889 ($2.584759283)	$4.929243541	$10.64345438

survey existence benefits standards.

The Trinity River draws a large number of recreation trips from the large San Francisco-Oakland Bay Area. 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 can generate large TCM non-market benefits estimates.

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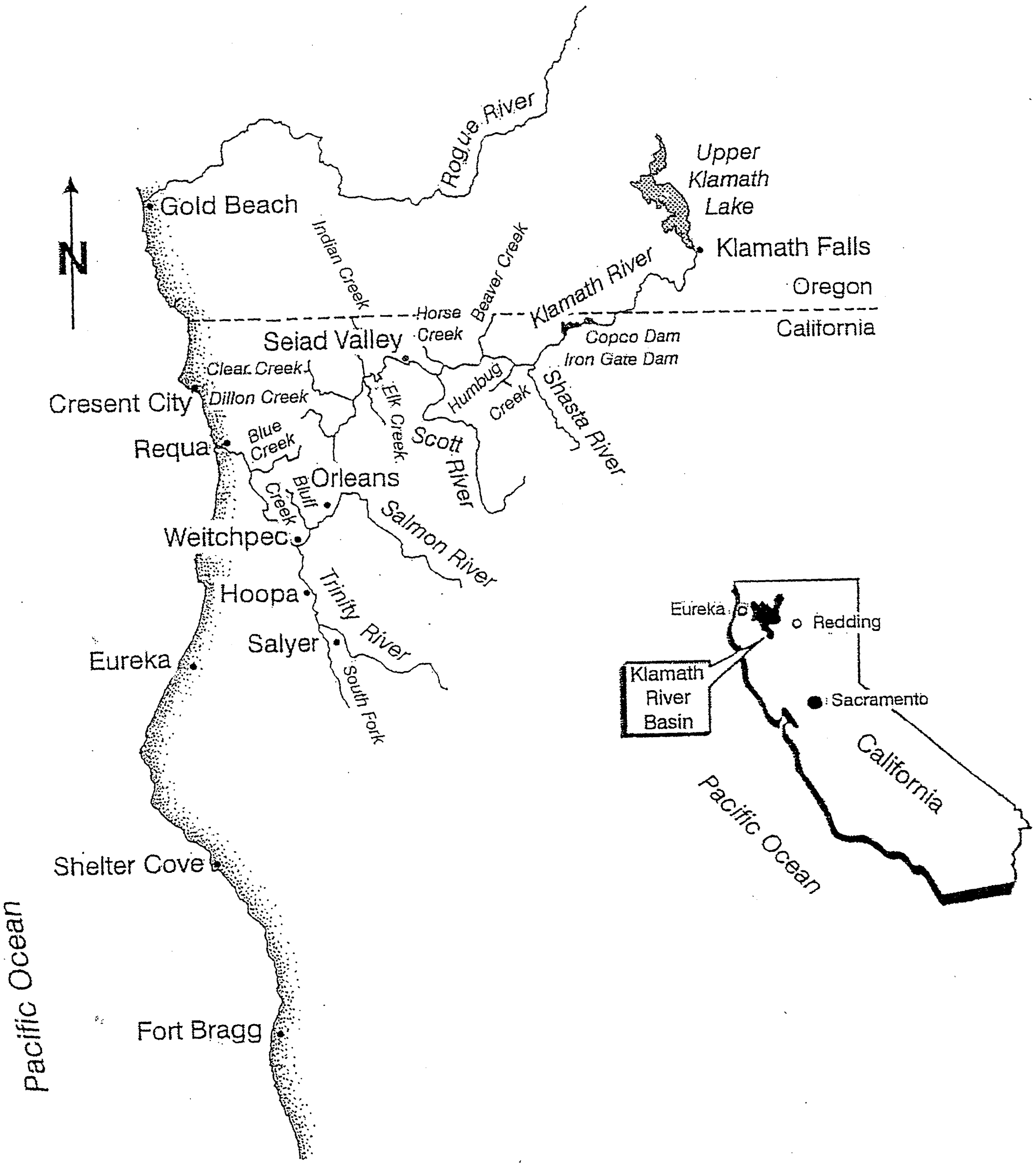

Figure 1. Map of Lower Klamath River Basin, the coastal zone, and major tributaries of the Klamath River.

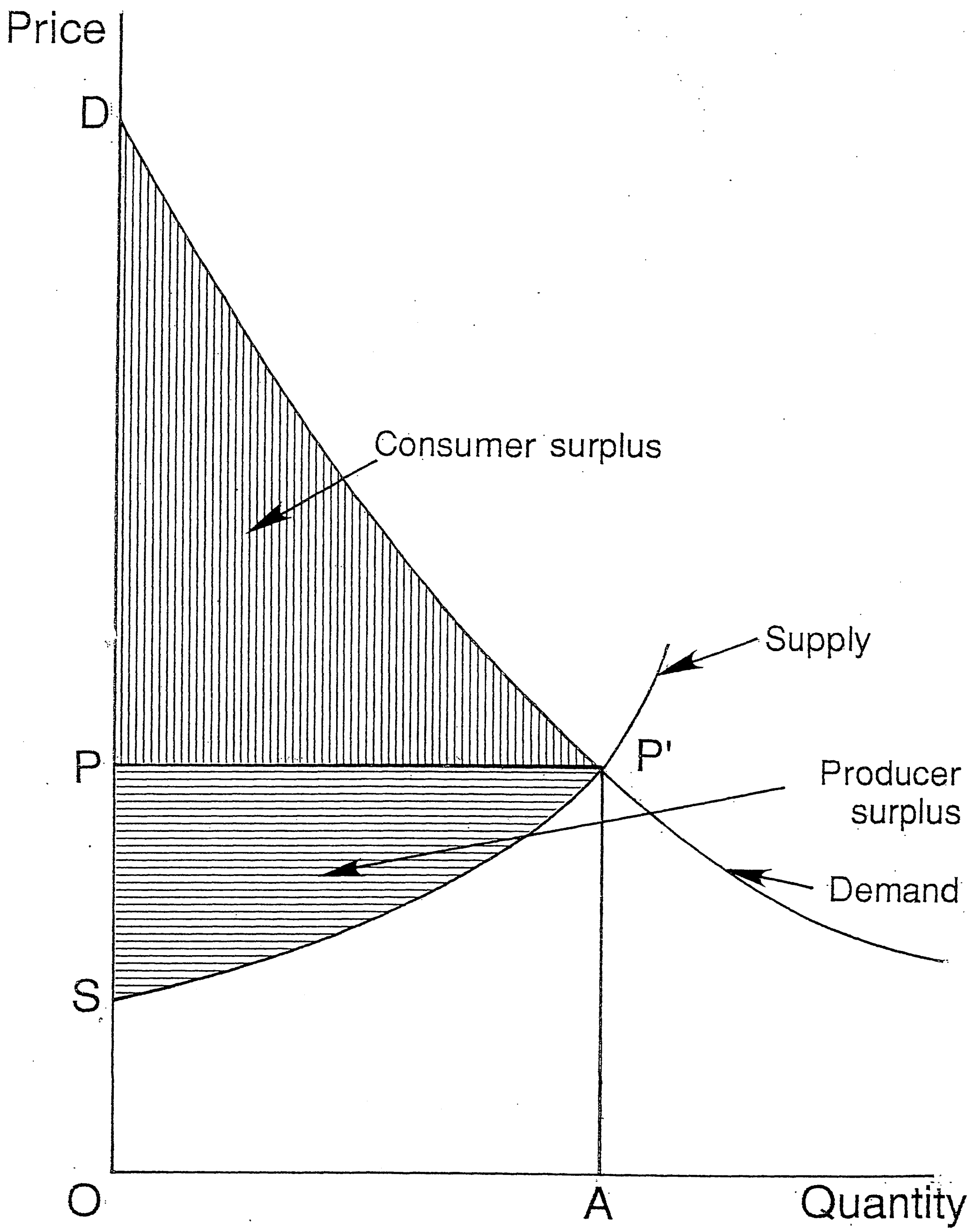

Figure 2. Diagrammatic representation of the consumer surplus and producer surplus components of the social benefits provided by a natural resource using market supply and demand curves.

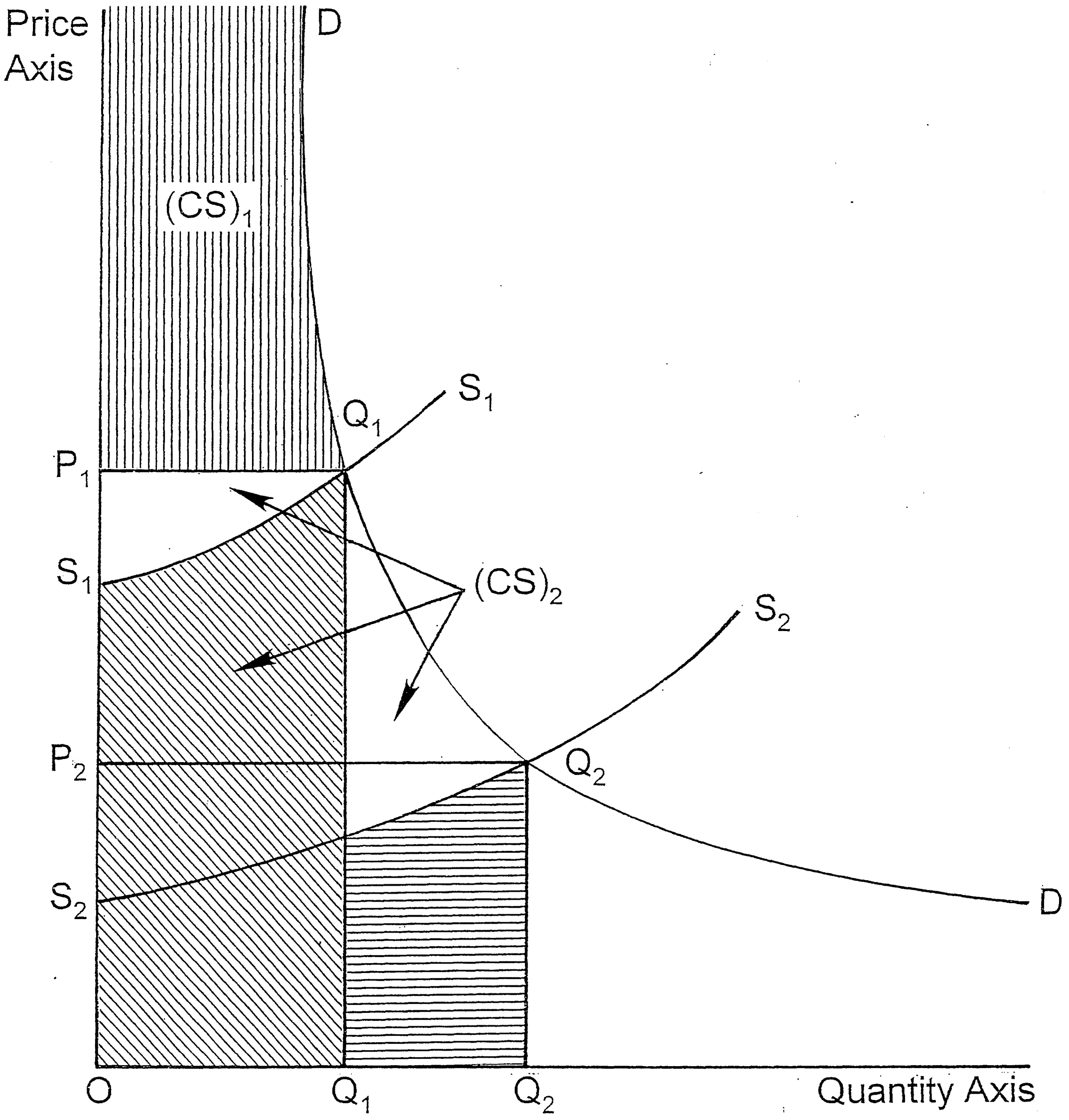

Figure 3. The supply curve shifts from S_1S_1 to S_2 S_2 but the demand curve DD remains fixed; the initial equilibrium price and quantity are $P_1$and Q_1. The area under DD above the horizontal line P_1Q_1 is the consumer surplus $(CS)_1$. The shift in supply increases CS to $(CS)_2$, the sum of CS_1 plus the 3 areas designated by arrows. The initial social cost is the area under S_1S_1 bounded by the line Q_1Q_1; the increase in supply shifts social cost to the area under S_2S_2 bounded by the vertical line Q_2Q_2. Thus, the social cost of output Q_1 decreases and the CS generated by producing Q_1 sharply increases.