THESIS

OPPORTUNITY COST OF WATER IN THE SOUTH PLATTE RIVER; COMPARING ECONOMIC VALUE DERIVED FROM STATED AND REVEALED PREFERENCES

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ABSTRACT

OPPORTUNITY COST OF WATER IN THE SOUTH PLATTE RIVER; COMPARING ECONOMIC VALUE DERIVED FROM STATED AND REVEALED PREFERENCES

The assessment of model choice is important in the valuation of ecosystem services because of the implications it has on policy decision making and public perception of natural resources. Values derived from the Contingent Valuation Method and the Travel Cost Method were compared using the South Platte River as a case study. Two surveys were distributed in order to find willingness to pay for increased fishery quality. In the Contingent Valuation model, individuals were asked if they were willing to pay an increased fishing license fee in order to improve fishery quality. The median willingness to pay for increased fishery quality amounted to $77.07 per individual. In the Travel Cost model, individuals were surveyed at fisheries of varying quality along the South Platte River, using their cost of travel, fishing-trip-specific purchases, and the fisheries' quality measure to determine willingness to pay for increased fishery quality. In this model the annual willingness to pay for an increase in quality from quality 1 to quality 2 is $83, while the willingness to pay for an increase in quality from quality 2 to quality 3 is $153. Finally, the willingness to pay for an increase in quality from quality 3 to quality 4 is $481, while the willingness to pay for an increase in quality from quality 4 to quality 5 is $2639. Both models showed that, even at their lower bound, gross willingness to pay exceeded the cost to restore ecosystem services and improve fishery quality.

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INTRODUCTION

Valuing ecosystem services is an important and controversial endeavor because assigning values to non-market goods has potentially large impacts on policy decisions and public perception of natural resources (Loomis et al. 2000). Non-market methods must be used to value public goods because they are not privately consumed or purchased. Due to the contentious nature of valuing quasi-public goods, it becomes increasingly important to evaluate model choice. Stated preference and revealed preference models are two common methods for valuing non-market goods. The objective of this study aims to show how stated preference and revealed preference differ in their valuation of non-market goods using the South Platte River as a case study.

Contingent valuation, a stated preference model, utilizes survey questions to determine consumer willingness to pay for improved quality or willingness to accept diminished quality of a resource. The survey asks respondents to react to a new hypothetical market with a new level of quality for a good, and make their decision regarding their value for the difference in environmental quality (Hanemann 1989). Contingent valuation measures both use value and bequest value of a resource. Bequest value can be used to determine the satisfaction an individual gains from knowledge that there is a healthy population of a species of animal or the satisfaction gained from the knowledge that a resource will be available for future generations (Loomis et al. 1996).

In contrast to the stated preference method, the travel cost method derives values for non-market goods based on the costs incurred to experience the good. The principle of this model is that users respond to changes in travel cost as they would respond to a change in access fee.

According to this theory, the higher the cost of travel, the fewer trips the user will take (Martinez-Espiñeira et al. 2008). This method derives consumer welfare associated with a visit to a site but does not include the bequest value, nor can it value anything but the current state of a resource.

Both methods have been widely used in estimating value for non-market resources but have rarely compared quality change using a complete data set. Some studies have used these methods in tandem, such as a study conducted by T. Cameron (1992); however, Cameron's paper used these methods in conjunction not as a comparison.

The South Platte River is an ideal candidate for this case study because it is one of the most heavily fished rivers in Colorado, yet it suffers from negative environmental externalities. The most pressing problem is the effect of low seasonal instream flows, which increase fish kill, utility loss to fisherman, and a significant negative impact on ecosystem services. Low instream flows limit vegetation growth along the river banks which impacts natural water purification and erosion control (Loomis et al. 2000).

Pollutants are carried into the river from historical mining sites, feedlots, pesticide and fertilizer-intensive farms, as well as local industry exacerbate the strain that low instream flows have on the fish populations. Phosphorus, ammonia, nitrates, and e. coli are found to be dangerously high in the South Platte river, even when compared to other threatened rivers in the United States (Loomis et al. 2000). Pollutants are more concentrated during periods of low instream flows, making these periods exponentially more harmful to fish populations.

These negative externalities are unpriced in the South Platte Basin watershed because they exist outside of the market and are therefore not included in the price consumers pay for water. The South Platte River it is comprised of agricultural, municipal and commercial/industrial users operating under prior appropriation, a water rights-based institution (Payne et al. 2014). Under prior appropriation there are large initial fixed costs associated with building infrastructure and buying water rights, but there is little marginal cost. This is reflected in low municipal water costs, which represent cost of delivery and not the opportunity cost of water. Externalities associated with consumptive use of water are not reflected in the price of this resource and undervalue instream flows because the marginal value of water is not market determined.

I compare the difference in value derived from the contingent valuation method and travel cost method of marginal fishery quality improvements in the South Platte River. The results from both methods will be weighed against the cost of alleviating the negative externalities facing the area. Although this study uses the South Platte River as an example, the primary goal of this study is to compare the contingent valuation and travel cost methods. The results help to better understand model choice evaluation by providing comparative insight on methods for valuing non-market resources.

LITERATURE REVIEW

Loomis et al. (2000) provided an in-depth scientific study on the South Platte River, researching how recreational users and local businesses endured non-market losses due to fish kill caused by low instream flows. Loomis et al. found that the main causes of ecosystem service loss stemmed from agricultural withdrawals, pollution from agricultural return flows, feedlot runoff, and inflows from the Denver sewage treatment plant. Improving on the work done by Costanza et al (1997), Loomis et al. used the contingent valuation method to derive consumer willingness to pay for increased instream flows and the restoration of ecosystem services for a 45 mile stretch of the South Platte River, using an increase in respondents water bill as the mechanism. The study concluded that the social willingness to pay outweighed the cost of improving ecosystem services, but it is pertinent to revisit this study due to the age of the data, as well as the further deterioration of ecosystem services in the South Platte River. Where the Loomis et al. (2000) paper used an increased water bill as the mechanism for determining willingness to pay, I used an increase in the fishing license fee as the mechanism as I thought it a more direct path to evaluating willingness to pay for increased recreational fishing opportunities. Loomis et al. (2000) provided compelling evidence for the South Platte as a strong candidate for non-market valuation, by explaining its importance both as a fishery and in agriculture. By using the South Platte as the subject of comparison between stated and revealed preference methods, I seek to improve upon the study conducted by Loomis et al. (2000) by targeting anglers directly and adding a second valuation method. These diversions from the original paper results in research with increased applicability to valuing fisheries in other areas.

Whereas the models above have been examples of stated preference models, Alvarez et al. (2014) used a revealed preference model to calculate recreational fishing losses. Alvarez et al. (2014) utilized a random utility model (RUM) to evaluate loss due to the Deepwater Horizon oil spill. Their model included metrics measuring travel cost, expected catch, popularity of the site, and presence of oil. This study is important in the field of non-market valuation, and my study on the South Platte River, because it was used to value recreational losses and shows the impact non-market valuation can have on policy. This model can only calculate losses due to pre-existing externality and was used to inform the government on damages caused by the Deepwater Horizon spill. The utilization of both the contingent valuation model and the travel cost model gives my study a more versatile approach to calculating recreational fishing losses. Like the Alvarez et al. (2014) study, the travel cost model I use can only value pre-existing conditions or attributes of the resource, whereas the contingent valuation model can elicit values on hypothetical improvements in river quality beyond those observed in recent history.

Another example of a study covering a revealed preference technique is Martinez-Espiñeira and Amoako-Tuffour's (2008) paper, which uses the travel cost method to value Gros Morne National park in Newfoundland Canada. This paper shows how an individual's travel expenses and lost income can be used to assess the value of a recreational site, where users of a site respond to changes in travel cost as they would respond to changes in an entrance fee. Martinez-Espiñeira and Amoako-Tuffour (2008) evaluate the effects that overdispersion, truncation, and endogenous stratification have on willingness to pay estimates using a travel cost model. My data also suffer from overdispersion, truncation, and endogenous stratification and I incorporate the specification recommended in Martinez-Espiñeira and Amoako-Tuffour (2008).

I am expanding upon the research into model choice through a comparative study of the travel cost model and the contingent valuation model.

A study using both stated and revealed preference models is Cameron (1992), which uses the contingent valuation method and the travel cost model in a joint model. The contribution of this model was primarily theoretical, as it utilized a prototype model. However, it did also use a case study on recreational fishing but had very limited travel cost data. The only metric used for travel cost was the question "How much will you spend on this fishing trip from when you left home until you get home." I am building on this dual model method by utilizing more complete travel cost data and aim to contribute to this field through employing different approach. Where Cameron used these models in tandem, I am doing a comparative study to analyze the how these models operate apart from each other. This diversion aims to inform on model choice and compare the differences in how the methods value non-market goods.

DATA

Data collection began with the distribution of contingent valuation (CV) surveys to fishing retailers around the state of Colorado where fishing licenses are sold. Patrons were then asked by staff if they would be willing to participate in a brief survey regarding the South Platte river. The surveys were then recollected after a three-month period. I also obtain data on 2015 fishing license purchases from the Colorado Department of Parks and Wildlife. I use the fishing license data to calculate gross mean willingness to pay for increased instream flows across the state. Finally, I used data from West Water Research to calculate water leasing costs using 2015 acre/feet prices. Scientific data and figures were collected from Loomis et al. 2000. Fish count data was supplied by the Colorado Division of Parks and Wildlife: (Waterton Canyon)- 418.57 trout per mile, (Elevenmile Canyon)- 2,536.02 trout per mile, (Deckers)- 4,808.35 trout per mile.

CONTINGENT VALUATION METHOD

4.1 Survey Description

The contingent valuation method is a stated preference model used to determine consumer willingness to pay for increased ecosystem services. I chose this model as my stated preference method because it is capable of valuing marginal quality changes that have not yet happened. This method measures peoples' use value and non-use value, which contrasts the value derived from revealed preference methods, which exclusively measures use value. In this section the contingent valuation method is used to calculate consumer willingness to pay for increased fishery quality in the South Platte River, which was obtained through collection of survey data, regression of the observations, and calculating mean user willingness to pay.

The question design in this study is based on the expert opinion of biologists (Loomis et al. 2000), which identifies the environmental damages caused by low instream flows. Loomis et al. outlined a plan that would provide the maximum benefit to the South Platte river, consisting of restoring vegetation buffer strips, increasing instream flows, and changing land management. The increase of instream flows in the South Platte River is expected to make harsh seasonal conditions survivable for aquatic life and help dissipate pollutants in the river. Increased flows in the South Platte river will be obtained through leasing or purchasing water rights from agricultural users. The management plan outlined in Loomis et al. (2000) consists of a government purchase of environmental easements along a 45-mile stretch (300,000 acres) of the South Platte River over a ten-year time period. Environmental easements would keep land in private ownership, but the government would pay agricultural users to improve wildlife and water quality through restoring natural and native grasslands. Revegetated stream banks would help to fight erosion of the riverbanks and naturally purify runoff flowing into the river (Loomis et al. 2000).

I construct a series of willingness to pay, demographic, and opinion-based questions derived from questions asked in (Loomis et al. 2000) and 1997 Colorado Angler Survey conducted by the USDA Forest Service and Colorado State University. I then conducted a series of interviews; asking potential survey takers about their willingness to pay threshold for a fishing license fee increase, and their reaction to demographic and opinion questions. Through this process I derived an initial mean willingness to pay to base my value dispersion for my WTP questions. This same process allowed me to narrow down potential demographic and opinion-based questions according to what interview participants found to be most important.

Survey participants receive a statement about the current conditions of the river prior to responding to the questionnaire:

"The South Platte River is located near Denver, Colorado, and extends north past Ft. Collins and southwest into the mountains. The South Platte River is heavily utilized because of its proximity to residential areas such as Denver, Boulder, Loveland, Greeley, Longmont, and Ft. Collins. By 2050, this area is projected to almost double in size from 1.6 million to 2.6 million people (State of Colorado census).

The South Platte River is home to some of the most popular fishing areas in Colorado such as Decker's and the Dream Stream. However, the South Platte suffers from seasonal low instream flows, primarily because 75% of instream flows are withdrawn for agricultural use. A significant percentage of remaining instream flows are a product of agricultural return flows, outflow from the Denver sewage treatment plant, and feedlot runoff. These low instream flows have led to a lack of vegetation along the stream banks, which has increased bank erosion and limited natural return flow filtration. This has caused significant pollution in the South Platte, which ranks first in ammonia and nitrate contamination, and second in phosphorus contamination when compared to 20 major rivers in the United States. Due to decreasing levels of instream flows, water quality, and fish habitat, all six remaining native Colorado fish are being considered for the endangered species list."

Survey participants then face a hypothetical referendum to improve ecosystem services outlined above though the means of a proposed fishing license price increase, which read:

"To mitigate deteriorating conditions in the South Platte River, Colorado Parks and Wildlife has planned an increase in annual fishing license prices. This increase in fishing license fees will improve environmental services to the South Platte River, lessen instances of fish kill, and increase fishery quality. As a reference to fishery quality, alleviating low seasonal flows is expected to increase the fishing conditions rating by one unit on the meter above. For example, if the fishing is rated "Just OK" with low seasonal flows, the proposed referendum will increase the rating to "Good."

To summarize, we ask you to vote yes or no on a hypothetical referendum. If this referendum passes, then:

- Each fishing license will be more expensive by a certain amount (the exact number of this amount is provided to you in the survey)
- The money generated from the increased price of fishing licenses will primarily go towards:
    1. Leasing water from willing agricultural users.
        - Leasing water rights will help to alleviate low seasonal flows
        - Disperse the highly concentrated pollutants that are currently in the river.
    2. Restoring riparian buffer areas along the river banks.
        - Restoring the riparian buffer zone will allow for natural water filtration and provide more habitat for local wildlife.
    3. Purchase of conservation easements.
        - The purchase of conservation easements will help to move feed lots and fertilizer/pesticide-intensive crops away from the river, thus lessening the likelihood of future river pollution."

4.2 Statistical Model

The survey asks participants if they are willing to pay a given amount for increased flows. The WTP amount randomly differs across respondents in the amounts of $10, $20, $30, $40, $50, $60, $80, $100, $150, $200, $250, $300. The survey also asks demographic and opinion-based questions to better understand participant responses. The logit model is used to determine the probability of a "yes" response given a certain bid amount (Hanemann 1984):

$$Pr(yes) = 1 - \{1 + exp[\beta_0 - \beta_1(\$X) + \boldsymbol{\gamma}\boldsymbol{Z}\}^{-1} \quad (1)$$

In this model, β_0 is the model constant, β_1 is the coefficient on the dollar amount that the household is asked to pay ($X), and $\boldsymbol{\gamma}$ represents the coefficients for control variables, $\boldsymbol{Z}$ explained in Table 1. From the first regression, we can derive the estimated mean willingness to pay (Hanemann, 1989):

$$Mean\ WTP = \left(\frac{1}{\beta_1}\right) * \ln(1 + e^{\beta_0 + \gamma\bar{\boldsymbol{Z}}}) \qquad (2)$$

Table 1- Contingent valuation variable descriptions

Variable	Description
Bid	Denotes is the person was or was not willing to pay the dollar amount increase in the fishing license fee (1 for a yes vote, 0 for a no vote).
AnnualRes	Denotes if respondent purchased an annual resident Colorado fishing license in the past year (1 if yes, 0 if no).
Daily	Denotes if respondent purchased a daily Colorado fishing license in the past year (1 if yes, 0 if no).
Senior	Denotes if respondent purchased a senior Colorado fishing license in the past year (1 if yes, 0 if no).
Urban	Denotes if respondent lives in urban/suburban area (1 denotes lives in urban/suburban area, 0 if lives in rural area).
Environmental	'Do you belong to any environmental organizations?' (1 denotes belonging to environmental organization, 0 denotes not belonging to environmental organization).
Flyfishing	'Do you consider fly fishing to be your preferred fishing method?' (1 denotes fly fishing is preferred fishing method, 0 denotes fly fishing in not preferred fishing method).
Resident	Denotes if respondent is a Colorado resident (1 denotes Colorado resident, 0 denotes not a Colorado resident).
WaterRights	'Do you believe that farmers should have the right to use all of the water allocated to them in their "water right," even if it has a negative environmental impact?' (1 agree, 0 disagree).
Income	Series of dummy variables indicating the respondent's income level ($10,000 to $24,999, $25,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, $100,000 to $124,999, $125,000 to $149,999, $150,000 to $174,999, $175,000 to $199,999, $200,000 to $224,999, $225,000 to $249,999, $250,000 and higher, with less than $10,000 left out of the dummy set).

4.3 Analysis

Surveys were administered in stores selling fishing licenses throughout Ft. Collins, Denver, Littleton, Golden, Englewood, and Boulder as well as in-person interviews along frequently fished sections of the South Platte River. In-person interviews were conducted along stretches of the river in the South Platte river basin in Elevenmile Canyon, Deckers, Cheesman Canyon, and Waterton Canyon during the spring and summer, when the river sees its highest density of fishermen. This time period is popular with anglers because of optimal weather and fishing conditions. These locations were chosen to get a data set that captures informed respondents who have purchased a fishing license, thus getting a more accurate representation of willingness to pay for improved fisheries. I distributed 1,100 surveys to 11 retail locations selling Colorado fishing licenses for a total of three months. 117 surveys were completed at the end of the three-month time period, which resulted in a response rate of 10.6%. I collected an additional 126 surveys via in-person interviews during the end of spring and beginning of summer of 2018. All in-person interviews were conducted by a single interviewer.

Table 2- Responses at each bid amount

	$10	$20	$30	$40	$50	$60	$80	$100	$150	$200	$250	$300
Yes	4	13	26	21	17	13	21	10	10	2	1	0
No	0	2	8	14	4	8	12	10	17	19	4	5
%yes	100	87	76	60	81	62	64	50	37	9	20	0
Response Rate%	22	24	37	38	23	21	33	20	27	21	9	18

Table 2 represents the number of yes and no responses at all bid amounts, along with the percentage of yes responses at all bid amounts. The distribution is normal and well-behaved, with respondents having a higher percentage of yes responses at lower bid amounts and a lower percentage of yes responses and higher bid amounts, which is consistent with theory. The response rate is fairly consistent across bid amount with the exception of the $250 category.

The full statistical model outlined in equation 1 is as follows:

Table 3- Contingent Valuation Results

	Coefficient	Std. Err.	z	P-value	95% Conf. Interval	
Constant	-0.714	1.579	-0.45	0.651	-3.81	2.38
Bid	-0.018***	0.003	-5.63	0.000	-0.024	-0.011
AnnualRes	2.035	1.299	1.57	0.117	-0.512	4.582
AnnualnonRes	0.705	1.866	0.38	0.705	-2.951	4.363
Daily	1.835	1.407	1.30	0.192	-0.923	4.594
Senior	2.216	1.416	1.56	0.118	-0.560	4.993
Urban	0.621*	0.376	1.65	0.099	-0.116	1.358
Environmental	0.155	0.350	0.44	0.658	-0.532	0.843
FlyFishing	0.367	0.479	0.77	0.442	-0.570	1.306
Waterrights	-0.711*	0.369	-1.93	0.054	-1.435	0.011
Income2	-0.758	0.982	-0.77	0.440	-2.685	1.168
Income3	-0.263	0.863	-0.31	0.760	-1.956	1.428
Income4	-1.579	0.831	-0.70	0.486	-2.208	1.050
Income5	-0.074	0.856	-0.09	0.931	-1.753	1.604
Income6	-0.717	0.914	-0.79	0.432	-2.510	1.704

Income7	-0.042	1.010	-0.04	0.967	-2.023	1.938
Income8	-1.321	0.988	-1.34	0.181	-3.259	0.615
Income9	-0.335	1.780	-0.19	0.850	-3.826	3.154
Income10	1.534	1.624	0.94	0.345	-1.648	4.717
Income12	.440	1.094	0.40	0.687	-1.704	2.258
Observations:	230					
R2:	.2225					

*significant at 0.1 level

**significant at 0.05 level

***significant at 0.01 level

Table 4-Contingent Valuation Summary Statistics

	Obs	Mean	Std.Dev.	Min	Max
Bid	230	86.05809	66.42266	10	300
AnnualRes	230	0.759336	0.427766	0	1
AnnualnonRes	230	0.016598	0.127762	0	1
Daily	230	0.070539	0.256094	0	1
Senior	230	0.124481	0.330227	0	1
Urban	230	0.721992	0.450415	0	1
Environmental	230	0.365145	0.483197	0	1
FlyFishing	230	0.866109	0.340645	0	1
Waterrights	230	0.28692	0.454679	0	1
Income	230	88802.51	60420.28	5000	250000

4.4 Results

The following describes the meaning of the coefficients outlined above in Table 3 and discusses the economic impact of the variables on the model.

Bid

The 'bid' variable is statistically significant at the 1% level, and the coefficient is negative indicating that the greater the amount of the fishing license increase respondents were asked to pay, the lower probability of them responding yes. This variable is used to calculate mean WTP for the data set.

AnnualRes

The 'AnnualRes' variable is statistically significant at the 15% level, and the coefficient is positive indicating that people who purchased an annual resident Colorado fishing license have a higher willingness to pay for improved ecosystem services. This variable is a demand shifter to control for dimensions of heterogeneity.

Senior

The 'Senior' variable is statistically significant at the 15% level, and the coefficient is positive indicating that people who purchased a senior Colorado fishing license have a higher willingness to pay for improved ecosystem services. This variable is a demand shifter to control for dimensions of heterogeneity.

Urban

The 'Urban' variable is statistically significant at the 10% level, and the coefficient is positive indicating that people who live in urban/suburban areas have a higher willingness to pay for improved ecosystem services. This variable is a demand shifter to control for dimensions of heterogeneity.

Waterrights

The 'waterrights' variable is significant at the 10% level, and the coefficient is negative indicating that people who believe that farmers should have the right to use all of the water allocated to them in their "water right," even if it has a negative environmental impact, have a lower willingness to pay for improved ecosystem services. This variable is a demand shifter to control for dimensions of heterogeneity.

Table 5- WTP Calculations

	Individual WTP	Number of Fishing Licenses purchased	Gross WTP
95% confidence interval high WTP	$126.12	1,087,369	$137,140,493.20
Mean WTP	$77.07	1,087,369	$83,803,528.83
95% confidence interval low WTP	$69.36	1,087,369	$75,419,913.84

Using the formula outlined in Equation 2 and the B_0 and B_1 calculated using the logit regression shown in Equation 1, the annual mean individual willingness to pay for improved ecosystem services amounts to $77.07 with a 95% confidence interval between $69.36 and $126.12.

The estimated annual willingness to pay from the contingent valuation model is multiplied by the number of Colorado fishing licenses sold in 2015 which amounts to 1,087,369 (Colorado Parks and Wildlife). The individual mean annual willingness to pay is $77.07, which amounts to a gross annual willingness to pay of $83,803,528.83. In the Loomis et al. (2000) study, CPI adjusted, the gross annual willingness to pay was found to be $103.75 million. In that paper the mean household willingness to pay exceeded that of this study ($367), but the estimated population (281,531) was far fewer. Loomis et al. (2000) used an increased in users water bill as the mechanism, which resulted in a smaller population because of the specified user proximity to the river. However, they found a higher willingness to pay, where the WTP was split into monthly payments.

One possible pitfall of this analysis is that the results are based on stated preference valuation, which can sometimes overestimate consumer willingness to pay. However, the social willingness to pay far exceeds the funds required to pay for increased flows in the South Platte river, which is outlined in the conclusion.

TRAVEL COST METHOD

5.1 Survey Description

The travel cost method is a revealed preference model used to determine the total value derived from a recreational site. I chose to utilize this method as my revealed preference model because it has often been used to value recreational amenities such as natural parks, fisheries, and wildlife areas. This method derives consumer surplus associated with their use of ecosystem services in a location. This method does not include non-use values associated with a natural resource, which distinctly differs this approach from the contingent valuation method. Through the use of the following case study, I aim to evaluate the differences associated with this method.

Using the same personal interviews mentioned in the methods section of the contingent valuation methods section of this study, I assessed the viability of demographic and opinion-based questions for the use in the travel cost model. During the personal interview process, I asked potential respondents how they respond to the wording of questions that are specified for calculating travel cost in Parsons (2003). To solve people's discomfort with being asked for their annual pre-tax income, I asked for a respondent's income category. These categories are as follows: less than $10,000, $10,000 to $24,999, $25,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, $100,000 to $124,999, $125,000 to $149,999, $150,000 to $174,999, $175,000 to $199,999, $200,000 to $224,999, $225,000 to $249,999, $250,000 and higher. Using income levels is commonly used in collecting primary data and is accepted in the literature (Duffield et al., 2006). Respondents were approached and asked if they were willing to take a survey regarding valuing Colorado fisheries.

5.2 Statistical Model

For the travel cost model outlined in Parsons (2003) respondents were asked the following questions:

Table 6- TCM questions and their corresponding variable(s):

What is your home zip code?	t_n, d_n
How many people traveled in your vehicle including yourself?	o_n
About how many times have you visited this fishery in the past year?	Annual t_n, d_n
About how many dollars worth of fishing equipment was purchased specifically for this trip?'	$equipment_n$
What is your annual income?	i_n

Equation 3 is the most common equation used for finding the individual trip cost in the travel cost model (Parsons 2003). The Parsons model, the equation used to calculate per trip individual travel cost, was used with several alterations, including equipment cost and accounting for other passengers in the vehicle. This equation was populated with responses from the questions above.

$$P_n = \{\left(0.33 * \left(\frac{i_n}{2{,}040}\right) * t_n\right) + \left(\frac{(c_n * d_n)}{o_n}\right)\} + fee_n + equipment_n \qquad (3)$$

In Equation 3, P_n is the trip price in this TCM study, i_n represents the individual's annual income, t_n represents round trip travel time, c_n=\$0.53 (IRS) represents cost per unit mile, d_n represents round trip miles traveled, o_n represents total passengers in the vehicle, fee_n represents fees associated with accessing a fishery, and $equiptment_n$ represents the total cost of equipment purchased by an individual for the purposes of the specific trip. i_n (annual income) is divided by 2,040, the number of work hours in a year assuming a 40-hour work week, to calculate hourly income. The opportunity cost is multiplied by 33% because that is the standard percentage of the opportunity cost according to past literature (Parsons 2003). A percentage is taken of the opportunity cost to account for uncertainty in income structure, thus decreasing the overall effect of income on the model.

Count data models are the econometric model used in calculating travel, and I used the zero truncated negative binomial model from (Martinez- Espiñeira et al 2008) for this study. With a count of (y) he equation is as follows:

$$\Pr[Y = y|Y > 0] = \frac{\Gamma(y+\alpha^{-1})}{\Gamma(y+1)\Gamma(\alpha^{-1})}(\alpha\mu)^{y}(1+\alpha\mu)^{-(y+\alpha^{-1})} * [\frac{1}{1-(1+\alpha\mu)^{-\alpha^{-1}}}] \tag{4}$$

The exponential mean parameter μ is defined as: $\mu_i = \exp(x'\beta)\,, i = 1, \dots, n$, where x is the matrix of regressors and β is the matrix of estimated coefficients.

5.3 Analysis

I conduct in-person interviews along frequently fished sections of the South Platte River. I collected 122 surveys during the end of spring and beginning of summer of 2018. In person interviews were conducted along stretches of the river in the South Platte river basin in Elevenmile Canyon, Deckers, and Waterton Canyon. All in-person surveys were collected by a single interviewer.

For the individual Travel Cost Method, the single-site demand function is

$$Y_i = f(TC_i, D_i, Q_j) \tag{5}$$

where TC_i represents the travel cost, D_i represents demographic characteristics, and Q_j represents site specific quality characteristics (Martinez- Espiñeira et al 2008). In this model the dependent variable is *Visitsinpastyear*, which is the number of trips an individual has taken to the fishery they were surveyed at in the past year. The independent variables in this model include:

Table 7- Travel Cost variable descriptions

Variable	Description
Cost	The 'cost' variable represents the grand individual travel cost.
Urban	Denotes if respondent lives in urban/suburban area (1 denotes lives in urban/suburban area, 0 if lives in rural area).
Environmental	'Do you belong to any environmental organizations?' (1 denotes belonging to environmental organization, 0 denotes not belonging to environmental organization).
Flyfishing	'Do you consider fly fishing to be your preferred fishing method?' (1 denotes fly fishing is preferred fishing method, 0 denotes fly fishing in not preferred fishing method).
Resident	Denotes if respondent is a Colorado resident (1 denotes Colorado resident, 0 denotes not a Colorado resident).
WaterRights	'Do you believe that farmers should have the right to use all of the water allocated to them in their "water right," even if it has a negative environmental impact?' (1 agree, 0 disagree).
Troutpermile	The "troutpermile" variable is a measure of fishery quality, which denotes trout per mile estimates in the surveyed locations.
*Cost*Troutpermile*	This variable is the interaction between the "cost" variable and the "Troutpermile" variable.

Table 8- Travel Cost regression

	Coef.	z	P-value	95% Conf. Interval	
Constant	1.308	1.03	0.333	-1.172	3.789
Cost	-.0059***	-3.71	0.000	-.0091	-.0028
Urban	0.0476	0.13	0.897	-.6701	.7653
Environmental	0.0757	0.23	0.815	-.5577	.7092
Flyfishing	2.6301***	4.13	0.000	1.382	3.877
Resident	-1.806	-1.52	0.129	-4.14	.5272
Waterrights	-.3132	-0.89	0.373	-1.002	.3762
Troutpermile	0.00022*	1.69	0.091	-.00003	.0004
Cost*Troutpermile	.0000011***	2.95	0.003	.0000003	.0000018

*significant at 0.1 level

***significant at 0.01 level

Table 9- Travel Cost Summary Statistics

	Obs	Mean	Std.Dev.	Min	Max
Cost	121	256.57	440.024	13.76912	2269.99279
Urban	121	0.731092	0.445267	0	1
Environmental	121	0.411765	0.494234	0	1
Flyfishing	121	0.855932	0.352656	0	1
Resident	121	0.882353	0.323552	0	1
Waterrights	121	0.313043	0.465761	0	1
Troutpermile	121	3455.36	1529.267	418.57	4808.35
Cost*Troutpermile	121	926786.3	1818387	5763.34	10914919.9

5.4 Results

The following describes the meaning of the coefficients outlined above in Table 7 and discusses the economic impact of the variables on the model.

Cost

The ‘cost’ coefficient is statistically significant at the 1% level, and the coefficient is negative indicating that people with a higher travel cost have a lower probability of taking more trips.

Flyfishing

The ‘flyfishing’ variable is statistically significant at the 1% level, and the coefficient is positive, indicating that people who consider fly fishing to be their preferred fishing method have a higher probability of taking more trips.

Troutpermile

The ‘Troutpermile’ variable I s significant at the 10% level, and the coefficient is positive indicating that the more trout per mile of a site, the higher probability more visits will be taken.

*Cost*Troutpermile*

The ‘cost*Troutpermile’ variable is significant at the 1% level. The coefficient is positive indicating that the interaction between Troutpermile and cost is positive, and the more Trout per mile, the higher the travel cost individuals are willing to incur. This variable both shifts and oscillates the demand curve.

The quality measure of trout per mile is used to calculate the consumer surplus associated with the increased quality of a fishery. The estimated fish per mile of the low-quality fishery (Waterton Canyon) is 418.57 trout per mile, the estimate for the medium-quality fishery (Elevenmile Canyon) is 2,536.02 trout per mile, and the estimate for the high-quality fishery (Deckers) is 4,808.35 trout per mile (Colorado Division of Parks and Wildlife 2018). To make the quality increase comparable to the contingent valuation model, the quality measures were expanded to five levels. A level was added in between the low-quality and medium-quality fisheries with a value of 1,477.29 trout per mile, and a level was added in between the medium-quality fishery and the high-quality fishery with a value of 3,672.18 trout per mile. Going forward, the fishery quality levels will be known as quality 1 through 5, with quality 1 being the lowest level of quality and quality 5 being the highest level of quality. Besides fishery quality, there are few differences between the sites, which is represented in the comparison below.

Figure 1- Waterton Canyon, Photo Credit: Trouts Fly Fishing

Waterton Canyon is a tailwater of the South Platte River, which flows out of Strontia Reservoir. This fishery sits at an elevation of 6,002 ft and fishing is restricted to the use of flies and artificial lures only. Amenities include hiking, fishing, biking, horseback riding, and scenic views. This site does not allow overnight camping or dogs.

Figure 2- Elevenmile Canyon, Photo Credit: USDA Forest Service

Elevenmile Canyon is a tailwater of the South Platte River, which flows out of Elevenmile Reservoir. This fishery sits at an elevation of 8,193 ft and restricts fishing to the use of flies and artificial lures. Amenities include hiking, fishing, picnicking, and scenic views. This site allows camping in designated areas.

Figure 3- Cheesman Canyon, Photo Credit: Trouts Fly Fishing

Deckers and Cheesman Canyon are tailwaters of the South Platte River, which flows out of Cheesman Reservoir. This fishery sits at 6,477 ft of elevation and restricts fishing to the use of flies and artificial lures. The amenities include hiking, fishing, picnicking, and scenic views. This site does not allow overnight camping.

Using the equation specified in Martinez- Espiñeira et al 2008,

$$CS_i = \frac{-\hat{\mu}_i}{\hat{\beta}_{tc} * (\hat{\beta}_{tc*tpm} * TPM_q)} \quad (6)$$

is the annual individual travel cost for a quality level of a site, which measures the space under the demand function. In the equation, $\hat{\mu}_i$ is the predicted annual visits, $\hat{\beta}_{tc}$ is the coefficient of the *cost* variable, $\hat{\beta}_{tc*tpm}$ is the coefficient of the *Cost*troutpermile* interaction term, and TPM_q is the trout per mile estimate at a given quality. Further, $\hat{\beta}_{tc}$ and $\hat{\beta}_{tc*tpm}$ are coefficients derived from the zero truncated negative binomial model, as a part of the demand function defined in the model as y, and $\hat{\mu}_i$ is the variable described in equation 4.

Using the equation specified above, the annual willingness to pay for an increase in quality from quality 1 to quality 2 is $83 and a low 95% confidence interval of ($13), the willingness to pay for an increase in quality from quality 2 to quality 3 is $176 and a low 95% confidence interval of ($18), the willingness to pay for an increase in quality from quality 3 to quality 4 is $481 and a low 95% confidence interval of ($26), and the willingness to pay for an increase in quality from quality 4 to quality 5 is $2639 with a low 95% confidence interval of ($36). Due to the crude approximation for the high 95% confidence interval, the value is more or less infinite and overestimates the bounds. The *cost* coefficient is negative, indicating that the higher the cost of travel the fewer fishing trips individuals are going to take. Conversely, the *cost*troutpermile* interaction coefficient is positive, showing that as *troutpermile* increases so does the *cost* variable. At high quality estimates, the *cost*troutpermile* interaction value surpasses that of the *cost* coefficient, bounding the estimates by zero.

A possible shortcoming of the travel cost model is that it underestimates the total value of a resource. The travel cost model only captures the use value of a natural resource, thus providing no non-use values. The values not included are bequest, existence and option, which are explained in Loomis and White (1996).

This case study found that the willingness to pay for increased quality in the contingent valuation method netted a value of $77.07, which amounts to a gross annual willingness to pay of $83,803,528.83. The willingness to pay in the contingent valuation model represents a shift in the demand curve from quality 1 to quality 2, which is illustrated in Figure 4.

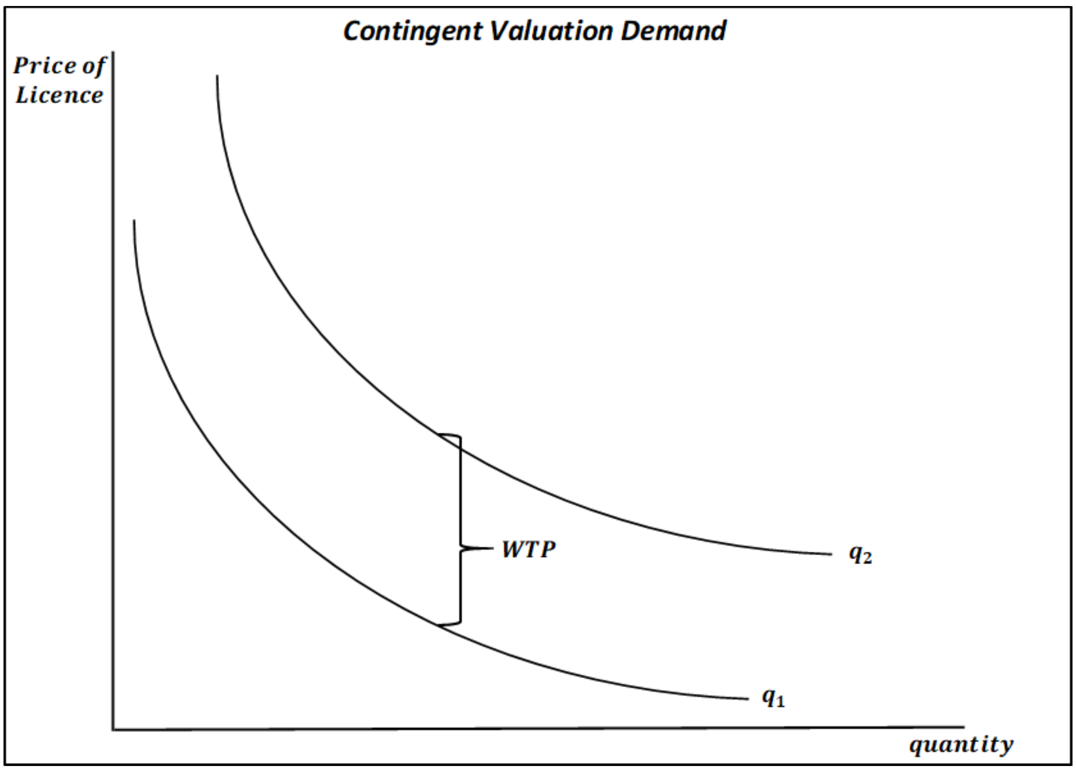


Figure 4- Contingent Valuation Method Demand

In the travel cost model, the annual willingness to pay for an increase in quality from quality 1 to quality 2 is $83 the willingness to pay for an increase in quality from quality 2 to quality 3 is $153, the willingness to pay for an increase in quality from quality 3 to quality 4 is $481, and the willingness to pay for an increase in quality from quality 4 to quality 5 is $2639. In the travel cost model, as illustrated in Figure 5, willingness to pay for increased quality of the fishery grows exponentially as the fishery increases in quality. This occurs because the Cost*Troutpermile interaction term both shifts and rotates the demand curve.

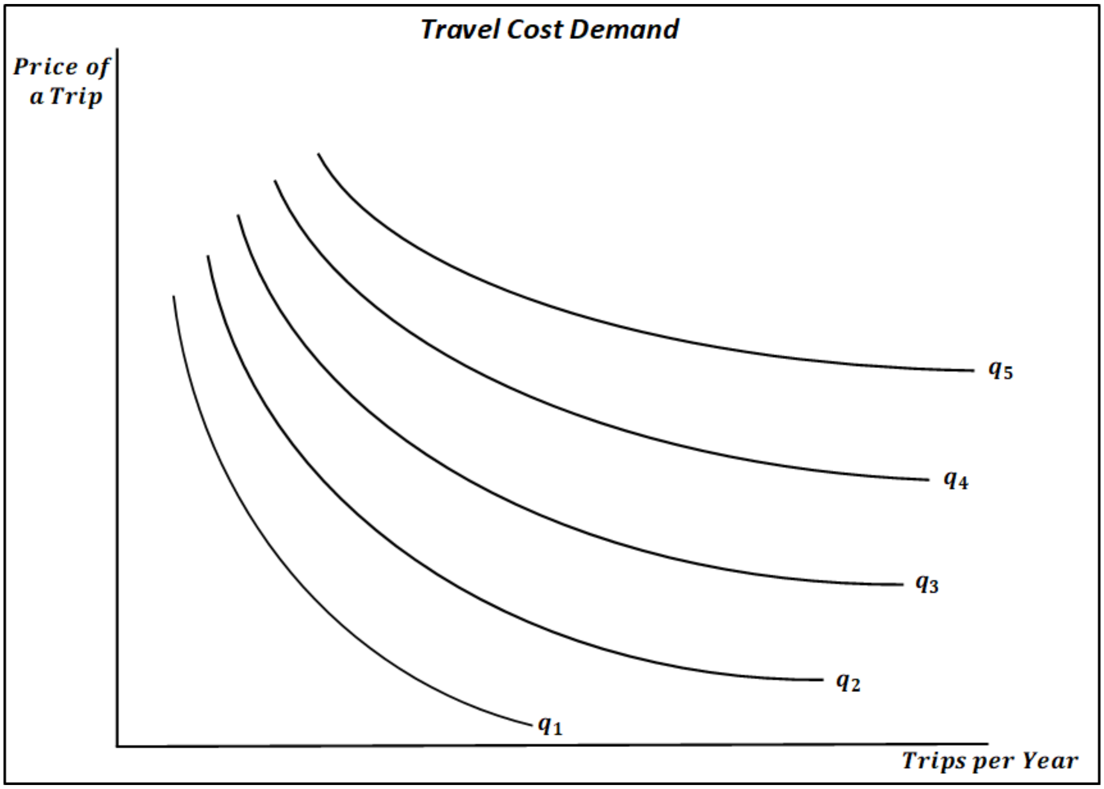


Figure 5- Travel Cost Method Demand

POLICY IMPLICATIONS

Using a willingness to pay of $77.07 from the contingent valuation method and a per acre/foot rental price of $44 per AF (West Water Research), the total possible number of acre/feet purchased is 1,904,625 AF. To be more conservative in the estimate, we multiplied the mean willingness to pay by number of fishing licenses (1,087,369) proportioned to the response rate of the survey (26%). The mean individual willingness to pay estimate is ($77.07), which results in a gross annual willingness to pay of $21,788,917.50. Using the acre/foot rental price stated above, the total possible number of acre/feet purchased is 1,714,088 AF. The river study used in Loomis et al. 2000 concluded that it would take 37,820 acre/feet of water to increase instream flows from 17% to 45%, which would sufficiently alleviate low flow conditions and make harsh seasonal conditions survivable for fish. The total cost of water needed to increase instream flows is $1,664,080. In order to address water quality and erosion concerns, according to the cited scientific study, 300,000 acres of environmental easements would be necessary. The US Department of Agriculture's conservation reserve program pays farmers to idle their land in order to increase water purity and prevent erosion. The rental rate for farms in eastern Colorado from Loomis et al. 2000, which was CPI adjusted for 2018 in this study equaled $65.82 per acre. The annual rental of the required 300,000 acres for environmental improvement would cost $19,746,000. This brings the total annual cost of land and water rental to $21,410,080. The most conservative gross annual willingness to pay estimate for the contingent valuation method is $21,788,917.50, which exceeds the funds required for leasing water to increase instream flows and the cost of environmental easements. The estimated gross annual consumer surplus in the travel model far exceeds that of the contingent valuation model, which shows that under both estimates it is economically beneficial to improve ecosystem services in the South Platte River basin. This reiterates the results from Loomis et al. (2000), showing that in this case study the social willingness to pay for improved quality of ecosystem services in the South Platte River far exceeds the cost of implementation.

CONCLUSION AND DISCUSSION

The results of this case study differ from most comparisons of stated and revealed preference because higher values are typically observed in stated preference techniques relative to revealed preference techniques. This is the case because revealed preference techniques can only capture the use value of a site, where stated preference captures both the use value and non-use value of a resource. There are several reasons why the results of this case study diverge from previous literature.

The deviation may be caused by endogenous stratification in the travel cost model, which can cause an individual's willingness to pay to be overstated. This occurs with on-site sampling because the more often an individual visits a site, the higher the probability they are sampled (Martinez- Espiñeira et al. 2008). However, the Martinez- Espiñeira et al. 2008 paper shows that the endogenous stratification resulted in an annual value increase of less than 4%. The lowest willingness to pay for an increase in quality under the travel cost model occurred when moving from quality 1 to quality 2, with a value of $83. Endogenous stratification would have to account for over a 7% increase in individual annual willingness to pay for increased quality for the travel cost model to be equal to the with the willingness to pay for increased quality derived in the contingent valuation model.

Another reason that this case study may differ from previous studies may be due to the mechanism chosen in the contingent valuation method. An increase in the Colorado fishing license fee was chosen as the mechanism for valuing quality change because it is cost that must be paid by all individuals who wish to participate in recreational fishing in Colorado. However, over the course of this study, I have found that the fishing license may not have been the best mechanism for this study. An annual Colorado fishing license costs $26, which may not impact individual's decision making on an annual basis. The cost of an annual resident Colorado fishing license is lower than the raw average individual per trip equipment purchase ($35). It has been well noted by Colorado Parks and Wildlife that the fishing license fee is not reflective of value for recreational fishing in Colorado. Colorado Parks and wildlife has been operating at a deficit since 2008 because it does not receive tax dollars and has not been allowed to raise fishing license fees (Colorado Parks and Wildlife). While surveying, I encountered many individuals who expressed a belief that the fishing license fee should be eliminated because they already paid taxes, which should allow them to fish for free. This misperception may have led to low annual willingness to pay values in the contingent valuation method of this case study.

Though there may be discrepancies between this case study and previous literature, the models do reveal information that can aid in policy decision making. A quality increase of 997.93 fish per mile from quality 1 to quality 2 in the travel cost model is equivalent to the willingness to pay for increased quality in the contingent valuation method. This metric can inform on individual's value for fish stocking in Colorado fisheries.

The results from this case study have not reflected what has been shown in prior literature but do shed light on the importance of model choice and gives insight on the innerworkings of the contingent valuation method and travel cost method in an applied study. With controversy on how natural resources should be valued and the impact it has on policy and in the public eye, this study contrasts two popular means of deriving consumer willingness to pay. Showing that the contingent valuation method and travel cost method have distinctly different ways of valuing natural resources, and model choice can have large impacts on policy decisions. The travel cost model can only be used to value a site or quality change that is observable, whereas the contingent valuation method can be used to value quality changes that are out of the realm of the observed state. This paper serves to aid researches in picking the methods that best suits their study when valuing non-market goods in the future.

REFERENCES

Alvarez, S., Larkin, S. L., Whitehead, J. C., & Haab, T. (2015). Corrigendum: A revealed preference approach to valuing non-market recreational fishing losses from the Deepwater Horizon spill. *Journal of environmental management*, *150*(2015), 516-518.

Colorado's South Platte Basin Water Rights Market. (2018). Retrieved from http://www.waterexchange.com/

Cameron, T. A. (1992). Combining contingent valuation and travel cost data for the valuation of nonmarket goods. *Land Economics*, 302-317.

Carson, R. T. (2012). Contingent valuation: A practical alternative when prices aren't available. *Journal of economic perspectives*, *26*(4), 27-42.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Raskin, R. G. (1997). The value of the world's ecosystem services and natural capital. *nature*, *387*(6630), 253.

Hanemann, W. M. (1984). Welfare evaluations in contingent valuation experiments with discrete responses. *American journal of agricultural economics*, *66*(3), 332-341.

Hanemann, W. M. (1989). Welfare evaluations in contingent valuation experiments with discrete response data: reply. *American journal of agricultural economics*, *71*(4), 1057-1061.

Duffield, J. W., Patterson, D. A., Neher, C. J., & Champ, P. A. (2006). Do Fishermen Lie? Measuring Hypothetical Bias Across Response Formats. *WESTERN REGIONAL RESEARCH*.

License Fee History. (2015). Retrieved from https://cpw.state.co.us/

Loomis, J. B., & White, D. S. (1996). Economic benefits of rare and endangered species: summary and meta-analysis. *Ecological Economics*, *18*(3), 197-206.

Loomis, J., Kent, P., Strange, L., Fausch, K., & Covich, A. (2000). Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. *Ecological economics*, *33*(1), 103-117.

Martinez-Espineira, R., & Amoako-Tuffour, J. (2008). Recreation demand analysis under truncation, overdispersion, and endogenous stratification: An application to Gros Morne National Park. *Journal of environmental management*, *88*(4), 1320-1332.

Parsons, G. R. (2003). The travel cost model. In *A primer on nonmarket valuation* (pp. 269-329). Springer, Dordrecht.

Payne, M. T., Smith, M. G., & Landry, C. J. (2014). Price determination and efficiency in the market for South Platte basin ditch company shares. *JAWRA Journal of the American Water Resources Association*, *50*(6), 1488-1500.

Sphon, J. (2018). [Limited data pull to CPW sampling stations at Deckers and within Waterton and Elevenmile canyons]. Colorado Parks and Wildlife.
Standard Mileage Rates. (2018). Retrieved from https://www.irs.gov/

APPENDIX

South Platte River Study

Background:

The South Platte River is located near Denver, Colorado, and extends north past Ft. Collins and southwest into the mountains. The South Platte River is heavily utilized because of its proximity to residential areas such as Denver, Boulder, Loveland, Greeley, Longmont, and Ft. Collins. By 2050, this area is projected to almost double in size from 1.6 million to 2.6 million people (State of Colorado census).

The South Platte River is home to some of the most popular fishing areas in Colorado such as Decker's and the Dream Stream. However, the South Platte suffers from seasonal low instream flows, primarily because 75% of instream flows are withdrawn for agricultural use. A significant percentage of remaining instream flows are a product of agricultural return flows, outflow from the Denver sewage treatment plant, and feedlot runoff. These low instream flows have led to a lack of vegetation along the stream banks, which has increased bank erosion and limited natural return flow filtration. This has caused significant pollution in the South Platte, which ranks first in ammonia and nitrate contamination, and second in phosphorus contamination when compared to 20 major rivers in the United States. Due to decreasing levels of instream flows, water quality, and fish habitat, all six remaining native Colorado fish are being considered for the endangered species list.

Proposed Referendum:

To mitigate deteriorating conditions in the South Platte River, Colorado Parks and Wildlife has planned an increase in annual fishing license prices. This increase in fishing license fees will improve environmental services to the South Platte River, lessen instances of fish kill, and increase fishery quality. As a reference to fishery quality, alleviating low seasonal flows is expected to increase the fishing conditions rating by one unit on the meter above. For example, if the fishing is rated "Just OK" with low seasonal flows, the proposed referendum will increase the rating to "Good."

To summarize, we ask you to vote yes or no on a hypothetical referendum. If this referendum passes, then:

- Each fishing license will be more expensive by a certain amount (the exact number of this amount is provided to you in the survey)
- The money generated from the increased price of fishing licenses will primarily go towards:
  1. Leasing water from willing agricultural users.
     - Leasing water rights will help to alleviate low seasonal flows
     - Disperse the highly concentrated pollutants that are currently in the river.
  2. Restoring riparian buffer areas along the river banks.
     - Restoring the riparian buffer zone will allow for natural water filtration and provide more habitat for local wildlife.
  3. Purchase of conservation easements.
     - The purchase of conservation easements will help to move feed lots and fertilizer/pesticide-intensive crops away from the river, thus lessening the likelihood of future river pollution.

Colorado State University

This survey is being conducted by Colorado State University. Your help with this survey is greatly appreciated and will allow us to better understand the value of Colorado fisheries.

***Section I*. Please complete all sections if you are taking this survey on river. If not, complete sections 1 and 2 only.**

1. Did you purchase a fishing license in the past year? **(*Check (√) one*)**
   Yes _____ No _____

2. If answered "Yes" to the last question, which of the following describes the type of fishing license purchased? **(*Check (√) one*)**

   Annual _____ Daily _____ Senior_____

3. Would you be willing to pay a $40 increase in your annual fishing license purchase to support this proposed referendum?
   For Reference, the current cost of an annual Colorado resident fishing license is $26, and the annual cost of a non-resident Colorado fishing license is $56. The cost of a senior annual Colorado fishing license is $1. **(*Check (√) one*)**

   Yes _____ No _____

***Section II.* (*Check (√) one*) for the following section.**

4. Do you live in an urban area?
   Yes _____ No _____

5. Do you belong to any environmental organizations?
   Yes _____ No _____

6. Do you consider fly fishing to be your preferred fishing method?
   Yes _____ No _____

7. Are you a Colorado resident?
   Yes _____ No _____

8. Do you believe that farmers should have the right to use all of the water allocated to them in their "water right," even if it has a negative environmental impact?
   Yes _____ No _____

9. What is your annual income?

___Less than $10,000	___$50,000 to $74,999	___$125,000 to $149,999	___$200,000 to $224,999
___$10,000 to $24,999	___$75,000 to $99,999	___$150,000 to $174,999	___$225,000 to $249,999
___$25,000 to $49,999	___$100,000 to $124,999	___$175,000 to $199,999	___$250,000 and higher

STOP HERE IF YOU ARE NOT TAKING THIS SURVEY ON RIVER

Section III. **Please fill in the answer unless prompted otherwise.**

1. What is your home zip code?

   ____

2. How many people traveled in your vehicle including yourself?

   ____

3. How many times have you visited this fishery in the past year?

   ____

4. Was fishing the primary purpose for this trip?

   ____

5. What other activities will you participate in during this trip?

   ____

6. Is this a multiday trip? (***Check (√) one***)

   No _____ Yes, how many days will be spent fishing? _____

   If "yes" to Question 6, did you stay in a hotel during this trip? (***Check (√) one***)

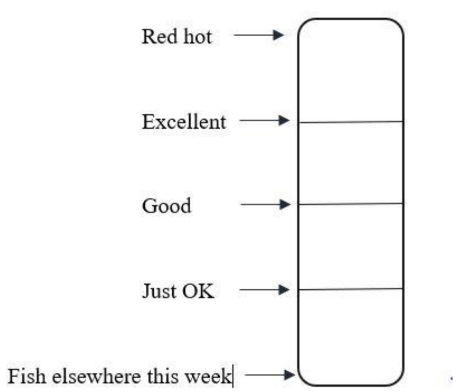
   No _____ Yes, how many nights will you be staying? _____

   What is the cost per night? ____________________________

7. How many dollars worth of fishing equipment was purchased specifically for this trip?

   ____

8. How would you rate the fishing today? (***Fill in meter up to line of chosen rating***)



Thank you very much for participating in this survey!