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Valuing the Protection of Minimum Instream Flows in New Mexico

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Currently, New Mexico law does not provide any legal avenue of protecting instream flows. A change in the status quo requires that a prima facie case be made—establishing sufficient evidence of the public benefits from maintaining instream flows to warrant consideration, or standing, in future water policy deliberations. Using the contingent valuation (CV) method, we investigate the nonmarket benefits of protecting minimum instream flows in New Mexico. Results from a dichotomous choice CV telephone survey show significant nonmarket values for protecting instream flows that are sensitive to a change in scope and insensitive to a group-size reminder.

Key words: contingent valuation, endangered species, instream flows

Introduction

Western states differ substantially in the mechanisms available for protecting instream flows. New Mexico (NM) has no legal avenue for protecting instream flows (Bokum, Gabin, and Morgan) and has been historically resistant to change (DeYoung; Nelson, Horvack, and Soloman). A change in the status quo requires that a prima facie case be made—establishing sufficient evidence of the public benefits from maintaining instream flows to warrant consideration, or standing, in future water policy deliberations. As one piece of empirical evidence, this study uses the survey-based contingent valuation (CV) method to estimate nonmarket values for protecting minimum instream flows in NM rivers.

In the case of fully appropriated river systems, maintaining minimum instream flows is often in conflict with long-standing diversions to irrigated agriculture and rapidly growing municipal demands. However, across the West, there is accumulating evidence on the nonmarket benefits of protecting instream flows (e.g., recreation, water quality, fish and wildlife habitat, biodiversity). In New Mexico, minimum instream flows and associated riparian habitats are critical to the preservation of a number of endangered and at-risk native fish species.

The CV method is a valuable tool for measuring the economic value of nonmarket environmental goods (Arrow et al.). Continued refinement of CV requires formal hypothesis testing and the accumulation of evidence across differing survey instruments and experimental designs. The CV telephone survey instrument used here includes a dichotomous choice format: respondents accept or reject a specified payment amount,

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which is varied across the sample, to a hypothetical trust fund used to buy or lease water for protecting instream flows.

The prima facie case for the nonmarket benefits of instream flow protection is strengthened if CV survey results pass some minimum tests of validity. To provide further evidence, we conduct two split-sample hypotheses tests. First, we test for sensitivity in valuation responses to a change in the scope of the good. The specific scope test compares values for protecting minimum instream flows for a single endangered fish in a 170-mile river stretch versus protecting minimum instream flows on four major NM rivers with eleven threatened and endangered fish species.[1] Second, we test for sensitivity in valuation responses to a brief reminder on the group-size supporting the public good. Both of these hypotheses tests directly address recent concerns over the validity of CV survey results (Green, Kahneman, and Kunreuther; Kahneman and Knetsch).

Background on Instream Flow Protection and Values

Like all western states, NM water law is based on the prior appropriation doctrine. While transferable, prior appropriation rights must be put to beneficial use, or the right can be revoked. New Mexico does not recognize instream flows as a beneficial use of water and provides no explicit mechanism for their protection (DeYoung). Instream flow is water in its natural channels without diversion. DeYoung cites long-standing historical arguments that NM water rights system provides sufficient de facto protection of instream flows. Such a system is open to abuse and is in contrast to accumulating evidence of degraded and dewatered riparian ecosystems (Bestgen and Platania; Crawford et al.; Rinne and Platania).

Given that beneficial use requires that water be diverted from the streambed, voluntary private market transfers to provide instream flows are unavailable in NM and generally restricted in most western states.[2] In the other prior appropriation states, a variety of alternative protection mechanisms have been explored (Bokum, Gabin, and Morgan; McNalley and Matthews), including applications of the common law public trust doctrine and explicit public interest clauses in state statutes. Further, in some states a single public agency may purchase water rights to protect instream flows, typically restricted to some minimum requirement.

Although not specifically directed to instream flows, NM State water statutes were amended in 1985 so that all new appropriations and transfers of both ground- and surface water are subject to public welfare considerations. Protest of any appropriation or transfer is allowed for "legitimate" public welfare concerns (Bokum, Gabin, and Morgan). Based on this public welfare clause, the state engineer could hypothetically deny an application that would deplete instream flows required for fish or that threatened riparian habitats.

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[1] There are a range of nesting and sequencing phenomena loosely referred to as scope effects, or alternatively, as "part-whole" and "embedding" effects (Brown and Duffield). Following Carson and Mitchell's categorization, we conduct an external (split-sample) scope test of component sensitivity for geographically nested goods. This corresponds to Kahneman and Knetsch's concept of perfect embedding.

[2] Griffin and Hsu derive theoretical conditions for an efficient water market that accommodates both diversionary and instream interests. Necessary conditions include a public agency for facilitating transfers and recognizing the presence of instream flow interests and full identification of return flow coefficients for all diversion and consumption uses. Achieving efficiency is also complicated by the public good characteristics (nonrivalness and nonexclusiveness) of instream flow protection (Colby 1993).

However, the public welfare clause is ambiguous; it has rarely been used, remains undefined by either courts or legislature, and has not been previously employed to protect instream flows.[3]

There is also a federal presence in the consideration of NM instream flow protection. The U.S. Forest Service (USFS) has sought, unsuccessfully, to use the public trust doctrine and implied reserve right arguments to obtain NM water rights for instream flows (Ranquist).[4] The U.S. Fish and Wildlife Service (USFWS) has long advocated that instream flows should be recognized in NM as a beneficial use of water (e.g., Nelson, Horvack, and Soloman).

Against this backdrop, in August 1994 the silvery minnow (*Hybnognathus amarus*) was listed as an endangered species by the USFWS. This tiny fish (approximately 3½ inches in length) was once abundant throughout the Rio Grande system but now lives in 5% of its original habitat—relegated to the 170 miles composing the Middle Rio Grande.[5] Maintaining the minnow's habitat depends partly on instream flows (Bestgen and Platania). Low flow is a critical threat to the silvery minnow, which is considered a bio-indicator of the health of warmwater riverine ecosystems in the Middle Rio Grande (Crawford et al.). More than 40% of the native fish species of the Middle Rio Grande are either completely or locally extinct (Rinne and Platania). The silvery minnow is one of eleven threatened or endangered fish species in New Mexico as identified by the USFWS in 1994.

There is a need to value the benefits of instream flow protection. Empirical evidence on such nonmarket benefits comes in a variety of forms. Loomis argues that dollar values for instream flows can be reasonably estimated using nonmarket techniques and often compare favorably against the value of water in traditional beneficial uses. Colby (1990, 1993) also finds strong economic arguments for providing instream flows that enhance recreation and fish and wildlife habitat. Published studies on recreational use values associated with instream flows continue to accumulate (e.g., Duffield, Neher, and Brown; Harpman, Sparling and Waddle; Loomis and Creel; Ward). Both Loomis and Colby recognize the importance of both use and nonuse values associated with instream flows. Nonuse values may be especially important for unique environments or endangered species.

It is expected that the nonmarket values investigated in this study will be mostly composed of nonuse values. Our focus is on the protection of minimum instream flows (not recreational optimal flows) and endangered and threatened fish species that are not legally or preferentially targeted by anglers.[6] A nontrivial portion of the sample may currently recreate (e.g., hiking and birding) in riparian areas (e.g., the "bosque" of the Middle Rio Grande), and the recovery of riverine ecosystems may enhance future rec-

[3] Gomez cites the NM state engineer's chief water lawyer as questioning whether public welfare can be quantified in any objective manner, and whether social factors should even be considered. For counter perspectives see Bokum, Gabin, and Morgan and Dumars and Minis.

[4] In a key interpretation of the implied reserved right principle, a 1978 Supreme Court ruling (*U.S. vs. New Mexico,* 438 U.S. 696) determined that federal agencies cannot generally appropriate water for instream flows, unless the state establishes an instream flow act or provision (Ranquist).

[5] The Middle Rio Grande runs from Cochiti Dam south through the greater Albuquerque area and on to Elephant Butte Dam. Annual discharge is highest during the spring runoff between March and June and lowest from July to November when irrigation and municipal demands peak. In low flow years, portions of the mainstem of the Middle Rio Grande will run dry for extensive periods.

[6] The silvery minnow is not directly pursued by sport anglers but rather is preyed on by larger fish and other birds and river mammals (e.g., heron and otters). As a warmwater species it is generally not found in the same aquatic habitats as preferred target species such as trout (Crawford et al.; Rinne and Platania).

reational opportunities (including angling). However, we make no attempt to decompose total value estimates, which may in part reflect current or expected future use.

Theoretical Considerations

The household's maximum willingness to pay (WTP) to protect minimum instream flows can be defined as the Hicksian compensating variation (HCV) measure of the welfare change:

$$(1) \qquad WTP^{HCV} = e(p, Q^1, U^0) - e(p, Q^0, U^0),$$

where $e(\cdot)$ is the household's expenditure function, p is a vector of prices for market goods, Q is the level of instream flow protection, and U is the level of utility. A minimum protection level for instream flows is represented by Q^1, against an initial lack of protection, Q^0. Thus, WTP^{HCV} is an income adjustment that represents the household's maximum willingness to pay to acquire the change in instream flow protection from Q^0 to Q^1 ($Q^1 > Q^0$), while maintaining utility at the initial level, U^0. It also implies that the property right is not currently held by those valuing instream flows, as is the case in New Mexico.

In the specific case of minimum instream flows, the protection outcome Q^1 can be thought of as a vector of geographic locations (different rivers or river stretches) or components q_j^1, $Q^1 = \{q_1^1, \ldots, q_n^1\}$. As a theoretical condition, imposing weak monotonicity on the valuation of any single geographic component (e.g., the Middle Rio Grande) relative to any larger set, or in this case, the full set of major rivers implies

$$(2) \qquad WTP^{HCV}(q_j^1) \leq WTP^{HCV}(Q^1).$$

Strong monotonicity implies the strict inequality and is a testable hypothesis (Carson and Mitchell); it provides the basis for the test of scope investigated here.

Considerable discussion has centered around several CV studies that have shown insensitivity to changes in the scope of the good (e.g., Kahneman and Knetsch). However, it is unclear what was tested in some cases, and whether the results were simply anomalies (Carson and Mitchell; Smith). In a series of recent papers, Kahneman and colleagues argue that there are two competing models of how individuals answer valuation questions: the purchase model and the contribution model (e.g., Green, Kahneman, and Kunreuther; Kahneman and Ritov).

In the purchase model, willingness-to-pay (or be paid) responses are interpreted as valid measures of welfare change for given changes in a public good. In the contribution model, individuals view public goods as good causes that need support, where willingness-to-pay responses express only a general attitude and entail low sensitivity to changes in scope (Kahneman and Ritov). Further, Green, Kahneman, and Kunreuther argue that the purchase model should be invariant to a reminder of the number of potentially contributing households, whereas the contribution model posits that such a reminder may be influential. In the initial test of this hypothesis, Green, Kahneman, and Kunreuther identify highly significant reminder effects that lowered valuations for several public

Table 1. Disposition Table for the February 1995 Quarterly Profile Telephone Survey

	Local	Long Distance	Total
Completed interviews	357	369	726[a]
Failure to contact (e.g., no answers, busy, and exceeded ten tries)[b]	224	184	398
Appointments not completed	58	43	101
Refusals	169	141	310
Language barriers	14	21	35

[a] Includes 28 pretest respondents not included in the survey data set of 698 observations but used by the CATI system in tracking response rates.
[b] Includes some call backs discontinued before the ten-try limit when the target number of surveys was reached.

goods by 50% or more.[7] This result has not been investigated elsewhere and thus is tested here, jointly with the test of scope.

Survey Instrument and Experimental Design

The CV survey was part of a regular quarterly profile telephone survey of New Mexico. The instrument was administered in February 1995 by the Institute for Public Policy (IPP) at the University of New Mexico. The quarterly profile is an omnibus survey conducted quarterly since 1988. The statewide survey uses a stratified random sampling approach. Proportionate sampling is used within the working ranges of all telephone number prefixes in NM to obtain a minimum target of 500 completed interviews, which provides a 4% margin of error at a 95% confidence level. For the February 1995 survey there was an oversample of 170 completed interviews for Bernalillo County (greater Albuquerque). Complete description of response rates and disposition of all numbers called are provided in table 1. The contact rate was 75% (completed + appointments not completed + refusals + language barriers / total numbers dialed); the cooperation rate was 64% (completed / completed + appointments not completed + refusals); and the refusal rate was 30% (refusal / completed + refusals). Completed surveys averaged 28 minutes. The survey included attitudinal questions on topics about NM institutions and politics, as well as numerous socioeconomic indicators.

The valuation section was pretested and refined through several iterations; the final version is presented in the appendix.[8] It begins by asking general awareness questions on NM water issues. The survey text defines beneficial use and instream flows and identifies some of the benefits (e.g., fish and wildlife, recreation, water quality) and costs

[7] This negative response effect, using an open-ended valuation question and personal interviews, was found when describing both one and ten million potentially contributing households and across alternative payment vehicles (taxes and voluntary contributions). It is not interpreted by Green, Kahneman, and Kunreuther as evidence of increased free-riding but rather of the increased salience of social norms, such as the acceptable level of contribution for a member of the collective. Our focus here is not on disentangling potential causes but rather on empirically investigating whether the effect can be replicated in a dichotomous choice CV telephone survey setting.

[8] This included two focus groups who completed written versions of the valuation section and participated in a debriefing. Then, the IPP interviewers participated in a reading and discussion of the survey. Finally, each interviewer completed several telephone pretests of the survey instrument (appendix).

(e.g., higher prices, restricted development) of protecting instream flows. Respondents are then told of the number (eleven) of endangered and threatened fish species in NM and the four separate rivers (Gila, Pecos, Rio Grande, and San Juan) where they are found. The text of a split-sample treatment includes a brief statement identifying the silvery minnow of the Middle Rio Grande as one of the eleven fish species. All respondents are told that protecting endangered fish and their habitat may require protecting minimum instream flows, and that trust funds are used in some states to buy or lease water for such purposes. Prior to the valuation section, respondents are told that they will be asked about the dollar value their household places on protecting instream flows and that there are no right or wrong answers; then they are reminded of household budget constraints and available substitutes.

Using the CATI (computer-assisted telephone interviewing) system, the valuation section employs a 2 × 2 experimental design for split-sample hypothesis testing. The two specific hypotheses to be tested are: (*a*) sensitivity to a change in the scope of the good and (*b*) sensitivity to a reminder on the group size (500,000 NM households) potentially contributing to the provision of the public good. For modeling, scope is hereafter indicated by the dummy variable, *SM,* where $SM = 1$ indicates the treatment sample that received the silvery minnow valuation question, and $SM = 0$ indicates the control sample that received the general instream flow question. The split-sample treatment for the group size reminder directly preceded the valuation question and was written to closely follow that used in Green, Kahneman, and Kunreuther. For modeling, the presence of the group size reminder is hereafter indicated by the dummy variable, *RM,* where $RM = 1$ indicates the reminder treatment, and $RM = 0$ indicates no reminder.

The hypothetical market describes a special trust fund used to buy or lease water from willing parties for the purpose of maintaining minimum instream flows. The trust fund was chosen because it is actually used to protect instream flows in some states (e.g., Montana). The voluntary contribution format is commonly used in CV studies of nonexclusive environmental goods, including the protection of instream flows (Duffield and Patterson; Brown and Duffield). Respondents are asked their willingness to contribute $A(\$)$ annually for each of five years to protect minimum instream flows. The dichotomous choice valuation question for the treatment group ($SM = 1$) is modified to identify minimum instream flows to specifically protect the silvery minnow in the Middle Rio Grande. As shown in the appendix, half of this treatment sample is crossed with the treatment for the group size reminder ($RM = 1$).

An important element of the experimental design in dichotomous choice CV is the number and size of the offered payment amounts, $A(\$)$, that are allocated across the sample. A large literature has developed around this topic, and no consensus has emerged. The pragmatic approach used here was to iteratively select nine separate payment amounts to be allocated across the expected sample of 670 completed surveys. The CATI system permits the daily monitoring of acceptance rates and allows selected payment amounts to be iteratively updated. Based on the pretest results, a single initial payment amount ($20) was selected and the observed probability of acceptance calculated for the first 50 observations. Then, alternative payment amounts were selected several at a time and randomly allocated by the CATI system, with some final sample filling using payment amounts falling in the midrange of the observed probability of acceptance distribution. This follows the Kanninen suggestion of keeping excess weight out of the upper and lower 15 percentiles. The final set of payment amounts, $A(\$) = \{5,$

Table 2. Acceptance Rates by Payment Amount and Experimental Treatment

Payment *A*($)	*SM*=1 and *RM*=1	*SM*=1 and *RM*=0	*SM*=0 and *RM*=1	*SM*=0 and *RM*=0	Totals
5	16/25	12/21	9/14	16/23	53/83
	(0.64)[1]	(0.57)	(0.64)[2]	(0.70)	(0.64)[3]
20	18/21	12/17	18/21	9/19	57/78
	(0.86)	(0.71)[3]	(0.86)	(0.47)[1]	(0.73)[4]
30	6/24	9/28	13/29	12/16	40/97
	(0.25)[1]	(0.32)[1]	(0.45)	(0.75)[1]	(0.41)[3]
40	7/18	6/17	8/19	15/21	36/75
	(0.39)[2]	(0.35)[1]	(0.42)[1]	(0.71)[1]	(0.48)[5]
50	4/13	9/25	8/17	6/19	27/74
	(0.31)[1]	(0.36)[1]	(0.47)[2]	(0.32)[2]	(0.37)[6]
75	10/26	9/12	8/19	9/21	36/78
	(0.39)	(0.75)	(0.42)	(0.43)[2]	(0.46)[2]
100	6/17	3/20	10/26	5/19	24/82
	(0.35)	(0.15)[1]	(0.39)	(0.26)[2]	(0.29)[3]
150	1/9	3/18	10/14	8/20	22/61
	(0.11)	(0.17)[1]	(0.71)	(0.40)[1]	(0.36)[2]
200	2/9	1/10	1/8	1/13	5/40
	(0.22)	(0.10)[1]	(0.13)	(0.08)[1]	(0.13)[2]
Totals	70/162	64/168	85/167	81/171	300/668
	(0.43)[5]	(0.38)[9]	(0.51)[5]	(0.47)[11]	(0.45)[30]

Notes: Numbers in parentheses are percentage rates. Bracketed numbers in selected cells give the number of unusable responses or failures to answer the valuation question and are not used in calculating acceptance rates.

20, 30, 40, 50, 75, 100, 150, 200}, was also coordinated with the 2 × 2 experimental design. Table 2 shows the observed acceptance rates to the dichotomous choice valuation question broken down by elements of the experimental design.

Model Specification and Empirical Results

Before discussing the estimation of conditional *WTP* functions, we report the results from nonparametric tests of scope and reminder effects using the observed acceptance rates shown in table 2. Wilcoxson signed-rank tests for paired difference experiments were conducted with pairings at each payment level, *A*($), forming the probability distributions (McLave and Deitrich). For the test of scope (*SM* = 1 versus *SM* = 0), the evidence rejects the null hypothesis that the probability distributions are identical (at a less than 0.02 significance level for the two-tailed test, and 0.01 for the one-tailed test). Thus, there is initial evidence of sensitivity to a change in scope. For the test of the reminder effect (*RM* = 1 versus *RM* = 0), the evidence supports the null hypothesis that the probability distributions are the same. These tests do not control for respondent characteristics, and we turn to conditional *WTP* models.

In practice, *WTP* is a stochastic variable and may be conditioned on a number of determinants. Descriptive statistics with response rates for selected variables are shown in table 3, which also includes the expected relation to *WTP*. In the dichotomous choice

Table 3. Descriptive Statistics for Selected Variables

Variable	Description	Mean	Stand. Error	Useable Re- sponses	Expected Relation to *WTP*
AGE	Age in years.	43.52	15.61	687	?
IMPORT	Importance of instream flows: scale 0–10, 0 = not important at all, 10 = extremely important.	8.16	2.10	689	+
RECOG	Believe instream flows should be recognized as beneficial use: 1 = yes, 0 = no.	0.85	0.36	657	+
ENV-ORG	Environmental organization member: 1 = yes, 0 = no.	0.13	0.33	689	+
BERN-CO	Bernalillo Country resident: 1 = yes, 0 = no.	0.45	0.50	696	?
FISH-LIC	Own fishing license: 1 = yes, 0 = no.	0.43	0.50	692	+
POL-IDEO	Political ideology: scale 1–7, 1 = strongly liberal, 7 = strongly conservative.	4.38	1.54	680	−
INC	Household income, categories 1–9 in $1,000s: 1 = (<$10); 2 = ($10–20); 3 = ($20–30); 4 = ($30–40); 5 = ($40–50); 6 = ($50–60); 7 = ($60–70); 8 = ($70–80); 9 = (≥$80).	4.10	2.28	636	+
*INC*1	Income categories 1–3.	0.47	0.49	301	+
*INC*2	Income categories 4 and 5.	0.27	0.45	174	+
*INC*3	Income categories 6–9.	0.24	0.29	161	+
AWARE	Aware of New Mexico fish species on endangered list: 1 = yes, 0 = no.	0.46	0.50	689	+
RM	Treatment for test of sensitivity to reminder of group size: 1 = received reminder, 0 = did not receive reminder.	0.49	0.50	698	?
SM	Treatment for test of sensitivity to scope of the good; 1 = instream flows for silvery minnow, 0 = instream flows for major NM rivers.	0.49	0.50	698	?
INTERACT	Interaction term: *SM***RM*.	0.24	0.43	698	?

Note: The sample size was 698.

elicitation format, *WTP* is also an unobservable variable and must be statistically inferred from the yes and no responses to the payment amount, *A*, which is varied across the sample. We follow Cameron's censored logistic approach to directly estimate the *WTP* function:

$$WTP_i = \beta' X_i + \epsilon_i, \tag{3}$$

where *X* is a vector of explanatory variables including the treatment indicators (*RM, SM*), β is a vector of coefficients to be estimated, and ϵ_i is an error term assumed to be distributed logistically with mean 0 and standard deviation *b*. The logistic distribution is further characterized by the additional scale parameter κ, where $\kappa = (b\sqrt{3})/\pi$. For the sample of individual observations the simplified log-likelihood for the censored logistic approach is

$$\log L = \Sigma\ (1 - W_i)\ [(A_i - \beta' X_i)/\kappa] - \log[1 + exp[(A_i - \beta' X_i)/\kappa]], \tag{4}$$

where W_i is a binary indicator of a yes (=1) or no (=0) response to the valuation

Table 4. Estimation Results for *WTP* Models

Variables	*WTP*-1	*WTP*-2	*WTP*-3	*WTP*-4 (Joint Model) *SM* = 1	*WTP*-4 (Joint Model) *SM* = 0
INTERCEPT	−130.73*	−126.22*	−162.04**	−75.60	−263.90*
	(−1.91)	(−1.86)	(−2.26)	(−1.07)	(−1.89)
*INC*2	47.30**	51.87**	52.57**	28.88	81.61**
	(2.18)	(2.29)	(2.25)	(1.24)	(2.27)
*INC*3	75.26***	86.34***	90.64***	56.66**	124.67**
	(3.00)	(3.38)	(3.33)	(2.11)	(2.54)
AGE	−1.26**	−1.30**	−1.29**	−1.61**	−0.58
	(−2.05)	(−2.16)	(−2.28)	(−1.96)	(−0.65)
POL-IDEO	−11.65**	−12.02**	−11.66**	−13.35*	−9.08
	(−2.02)	(−2.17)	(−2.03)	(−1.86)	(−0.96)
IMPORT	23.18***	24.01***	24.17***	19.10***	29.27***
	(3.80)	(3.88)	(3.86)	(2.74)	(2.74)
RECOG	84.18***	86.29***	87.41***	50.87	135.47**
	(2.63)	(2.67)	(2.66)	(1.42)	(2.50)
RM (reminder)	2.41	15.19	17.93	20.37	3.88
	(0.10)	(0.87)	(1.00)	(1.04)	(0.14)
SM (silvery minnow)	−67.66***	−57.10***			
	(−2.64)	(−3.03)			
INTERACT (*SM***RM*)	22.32				
	(0.69)				
AWARE	8.48				
	(0.48)				
BERN-CO	13.02				
	(0.76)				
FISH-LIC	18.55				
	(1.09)				
ENV-ORG	21.50				
	(0.80)				
κ (scale parameter)	92.38***	94.41***	98.90***	74.03***	117.15***
	(5.76)	(5.86)	(5.68)	(4.14)	(3.43)
Log-likelihood	−332.58	−334.11	−339.31	−331.34	
LR test (χ^2)	112.16***	109.10***	98.70***	114.64***	
	(*df* = 14)	(*df* = 9)	(*df* = 8)	(*df* = 16)	
McFadden R^2	0.144	0.141	0.127	0.148	

Notes: Numbers in parentheses are asymptotic *t*-statistics; one, two, and three asterisks indicate significance at the 0.10, 0.05, and 0.01 levels, respectively. The sample was 561.

question. Using (4) and the nonlinear optimization procedures in SHAZAM (White et al.), maximum likelihood estimates of β, κ, and their standard errors are obtained.

Table 4 presents the results of estimating four separate *WTP* models. *WTP*-1 is an extended model with 15 explanatory variables, and the payment amount, *A*. *WTP*-2 is a more parsimonious model that tests for the effect of deleting five insignificant explanatory variables. Comparing the first two specifications, there is little to separate them in terms of overall goodness-of-fit statistics. The evidence from separate likelihood ratio (LR) tests rejects the null hypothesis that all model coefficients are zero and shows that each model is highly significant at the 0.01 level. Each model has a McFadden R^2 value of 0.14.

The signs of significant variables are stable across *WTP*-1 and *WTP*-2. In each model the estimated coefficient on the scale parameter, κ, is positive and significant at the 0.01 level, indicating that the probability of acceptance is inversely related to the payment amount, *A* (Cameron). Estimated coefficients on the income-category dummies (*INC*2, *INC*3) are positive and significant at less than the 0.05 level. Estimated coefficients on age (*AGE*) and an index of self-reported political ideology (*POL-IDEO*) are negative and significant at the 0.05 level. Younger and more liberal respondents are more likely to contribute a given amount. Additionally, the estimated coefficients for an index of perceived importance of protecting instream flows (*IMPORT*) and a binary indicator (*RECOG*) of whether individuals feel instream flows should be legally recognized as a beneficial use are positive and significant at the 0.01 level.

The tests of scope and group-size reminder are conducted within the *WTP* models using the estimated coefficients on the treatment indicators *SM* and *RM*. The estimated coefficient on *RM* is insignificant; the evidence supports the null hypothesis of no group-size reminder effect ($H_0{:}\beta_{RM} = 0$, versus $H_a{:}\beta_{RM} \neq 0$). Further, the estimated coefficient on *SM* is negative and significant at the 0.01 level; the evidence supports the alternative hypothesis of sensitivity to a change in the scope of instream flow protection ($H_0{:}\beta_{SM} = 0$, versus $H_a{:}\beta_{SM} \neq 0$). We reject the null hypothesis that *WTP* is insensitive to a change in scope. Moreover, the negative sign supports, within a one-tailed test, the monotonicity hypothesis that the value of minimum instream flows in all major NM rivers is greater than the value of minimum instream flows to protect the silvery minnow in the Middle Rio Grande. Together, these two tests provide evidence contrary to the contribution model.

Relative to *WTP*-2, additional variables in *WTP*-1 include an interaction term (*INTERACT*) between the dummy variables testing sensitivity to scope (*SM*) and the group-size reminder effect (*RM*) and binary indicators for awareness of the endangered status of the protected fish in each sample treatment (*AWARE*), membership in an environmental organization (*ENV-ORG*), current or recent ownership of a NM fishing license by any household member (*FISH-LIC*), and residential status in Bernalillo County (*BERN-CO*), which includes the primary urban area of Albuquerque. The model estimates show that the coefficients on all five additional explanatory variables are not significantly different from zero. The evidence from an LR test using *WTP*-1 as the unrestricted model and *WTP*-2 as the restricted model supports the null hypothesis of no significant difference between models.

Specification *WTP*-4 is a joint model that allows the parameters on each explanatory variable to differ across the scope treatment (*SM*) and tests for the consistency of the insignificant reminder effect (*RM*). The model *WTP*-3 represents the extreme restriction that there is no *SM* treatment and provides a reference for the joint model *WTP*-4. It also shows that the signs and significance of all other variables are maintained when the significant *SM* dummy is dropped. Using the joint model *WTP*-4, the evidence from an LR test supports the alternative hypothesis of a significant difference (at the 0.10 level) between the separate vectors of coefficients for the two *SM* treatments ($H_0{:}\beta|_{SM=1} = \beta|_{SM=0}$, versus $H_a{:}\beta|_{SM=1} \neq \beta|_{SM=0}$).

The joint model, *WTP*-4, fits separate *WTP* functions for each *SM* treatment group, allowing all coefficients to differ across the scope of the good being valued. This is in contrast to assuming that the *SM* treatment simply results in a shift of the *WTP* function (e.g., *WTP*-2). Allowing the two sets of coefficients to vary shows changes in significance for several variables and demonstrates a larger dispersion (implicit in the estimated coefficients on κ) for the broader composite good. Conditional *WTP* for general instream flow protection on all major rivers (*SM* = 0) shows significant income effects at the 0.01 level, while age and political ideology are insignificant. Conditional *WTP* for instream flow protection for the silvery minnow (*SM* = 1) shows reduced income effects, while older and more conservative respondents are significantly less willing to contribute. However, in both *SM* treatment groups the estimated coefficient for the *RM* dummy is not significantly different from zero.[9]

In summary, across the nonparametric tests and *WTP* specifications there is significant sensitivity in valuation responses to a change in the scope of instream flow protection. The direction of this sensitivity satisfies the monotonicity hypothesis. Further, estimating a joint *WTP* model shows considerable differences in the two sets of coefficients, including increased dispersion with the increase in scope. Finally, there is no evidence of any response effect due to a group-size reminder; this holds across two different levels of instream flow protection.

Estimation and Discussion of Valuation Results

Using specification *WTP*-2 and the sample means for all variables, except *SM,* we obtain the function, $\$WTP = 82.28 - 57.10(SM)$. Using the joint model specification *WTP*-4, mean predicted annual household willingness to pay for protection of minimum instream flows for the silvery minnow on the Middle Rio Grande is \$28.73 (standard error of \$3.76, N = 284), with 71% of the predicted values positive. In contrast, also using *WTP*-4, the mean value is \$89.68 (standard error of \$5.91, N = 277) for the protection of minimum instream flows on all major NM rivers, with 85% of the predicted values positive.

The value for minimum instream flows increases for the single change in geographical scope of NM river protection by approximately 200% (\$29 to \$90). However, the 170-mile Middle Rio Grande is only a small fraction of the 1,000 plus miles for all major NM rivers. Further, the silvery minnow was identified as only one of eleven threatened and endangered fish species found in four rivers. Thus, while split samples were sensitive to the change in scope, estimated values were not linearly additive in the number of rivers (or fish species). Similarly, Brown and Duffield find diminishing marginal *WTP* for instream flow protection as the number of Montana rivers increases, which they cite as evidence of imperfect substitution.

Further context for the household *WTP* estimates of \$29 and \$90 can be provided by comparisons with other CV studies, where a variety of both higher and lower estimates can be found. In the Brown and Duffield study of Montana instream flow protection, not involving endangered fish species, a dichotomous choice format was combined with a trust fund payment vehicle and a mail survey sample. They report values in the \$3–\$23 range (in 1994 dollars), depending on the segment of population (nonuser/user) and number of rivers protected. In an open-ended CV with a mail survey of an Albuquerque NM sample, Cummings, Ganderton, and McGuckin find an annual household value of \$10 (in 1994 dollars) for protecting the threatened Colorado squawfish, which decreased

[9] While not presented here, an additional joint model was estimated that incorporated the restriction that the coefficient on the reminder (*RM*) is the same for both *SM* treatment groups. Evidence from an LR test shows no significant difference with specification *WTP*-4.

when valued as part of a package of public goods. The Colorado squawfish occurs in the San Juan River in northern NM and is one of the eleven species referenced generally in this study. The described recovery program included a hypothetical purchasing of water rights. In a review of previous nonuse value studies of western instream flows, Colby (1993) cites a range of annual household values from $40 to $80.[10] Sanders, Walsh, and McKean use mail survey results and an open-ended elicitation format with a special fund for valuing the protection of eleven selected wild and scenic rivers in Colorado. They report an estimate of $141 per household annually (in 1994 dollars). Finally, in the only test of real versus hypothetical contributions to an instream flow trust fund, Duffield and Patterson find evidence that hypothetical contributions may overestimate relative to actual contributions (ranging from 33% to 100% for different groups). The mail survey sample was drawn from licensed anglers using Montana rivers and had a low response rate.

Conclusions

The primary objective of this study was to establish the prima facie case for nonmarket benefits associated with protecting minimum instream flows. Such evidence is important in helping to determine whether instream flow concerns warrant consideration, or even have legitimate standing in future deliberations over water resources management (e.g., determining beneficial use or public welfare).

A carefully administered telephone survey shows that NM households value minimum instream flows. Further, confidence in the values estimated here is increased by their sensitivity to a change in scope and insensitivity to a reminder of group size, evidence against the contribution model of valuation responses.

With the right impetus, the prior appropriation doctrine has been responsive elsewhere in the West to changing public preferences. Economists and other social scientists can continue to contribute to this research by investigating the relative merits of alternative mechanisms for instream flow protection (e.g., water markets or public welfare intervention). Prudence and pragmatism require that such analyses be done in the context of potentially irreversible losses of native fish species.

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[10] Rather than instream flow studies, an anonymous reviewer suggests that a more appropriate comparison may be to estimated values for aquatic species. For the case of protecting minimum instream flows for the silvery minnow, the instrument was not designed to elicit the value of the isolated species. Nor can providing minimum flows for the silvery minnow be easily separated from protecting the Middle Rio Grande ecosystem.

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Appendix: Telephone Survey Description and Selected Text

This appendix provides the text for the instream flow portion of the February 1995 quarterly profile. For brevity, the text for coding answers is not provided. All question/answer codes included a Don't Know/No Answer (DK/NA) option. Each respondent was taken through a set of common text and questions, renumbered below as Q1–Q5. To implement the 2 × 2 split sample treatments, the CATI system then directs survey observations through four possible paths for the contingent scenario and valuation questions (Q6–Q11).

1. Q6, Q7, Q8 (corresponds to $SM = 1$, $RM = 1$ in table 1)
2. Q6, Q8 (corresponds to $SM = 1$, $RM = 0$ in table 1)
3. Q9, Q10, Q11 (corresponds to $SM = 0$, $RM = 1$ in table 1)
4. Q9, Q11 (corresponds to $SM = 0$, $RM = 0$ in table 1)

There were also several follow-up questions (e.g., open-ended *WTP*) to each dichotomous choice valuation question that are not replicated here.

Q1. The next series of questions concern water quality and water quantity in New Mexico. There are many competing demands for water found underground and in rivers, lakes, and streams. These demands come from cities households, agriculture and industry. How important do you think water issues are in New Mexico? Using a scale where zero is not at all important, ten is extremely important, and you may choose any number in between, please tell me how important you consider water issues in New Mexico?

Q2. Under New Mexico water law, water must be put to a beneficial use or the right to the water may be lost. Traditionally, beneficial uses include irrigated agriculture, industry, and cities. Another possible use of water is to leave it in rivers and streams. Instream flow is a measure of the water in rivers and streams. Protecting instream flows ensures a certain amount of water flowing in rivers and remaining in lakes. How important do you think it is to maintain minimum instream flows in the major rivers of New Mexico? Using a scale where zero is not at all important, ten is extremely important, and you may choose any number in between, please tell me how important you think it is to maintain minimum instream flows in the major rivers of New Mexico?

Q3. Instream flows support fish and wildlife, vegetation and habitat, recreation and viewing opportunities. Minimum instream flows can also protect water quality by diluting pollution. Maintaining instream flows may prevent costly federal government actions to protect endangered species and water quality. At present New Mexico does not recognize instream flows as a beneficial use of water. If New Mexico were to recognize instream flows as a beneficial use, private individuals and groups, and government agencies could buy or lease water to be left in rivers and streams. It is possible that the price of some agricultural commodities and municipal water rates could increase, and some development could be restricted. Do you think that instream flows should be legally recognized as a beneficial use of water?

Q4. In some states, government agencies such as Fish and Wildlife or Parks and Recreation can buy or lease water from willing parties in order to protect instream flows during low flow years. Would you vote yes or no to allow a state agency to buy or lease water from willing parties in order to protect instream flows?

Q5. There are currently six fish species listed as endangered in New Mexico, with another five fish species listed as threatened. Were you previously aware that any New Mexico fish species had been listed as endangered or threatened?

Q6. By federal law the critical habitat of endangered fish species must be protected, and this may require maintaining minimum instream flows. In New Mexico, endangered fish species are found in a number of the major rivers including the Gila, Pecos, Rio Grande, and the San Juan. The silvery minnow is a small fish found in the Middle Rio Grande and is currently listed as an endangered species.

Now I would like to ask you several questions about the dollar value your household puts on protecting minimum instream flows specifically to protect the silvery minnow. There are no right or wrong answers. Before answering, remember your household income and budget, and decide what you could realistically afford. Money spent on protecting instream flows is money not available for other goods, public programs, or other environmental programs. The establishment of a special trust fund for buying or leasing water is used in some states to protect fish species.

Q7. If a special trust fund was set up in New Mexico, and requests were made statewide, up to half a million households could contribute. So, each dollar of average household contribution produces a half a million dollars for the special trust fund.

Q8. Would your household contribute *A* dollars each year for five years to a special trust fund used to buy or lease water from willing parties to maintain minimum instream flows for the silvery minnow in the Middle Rio Grande?

Q9. By federal law the critical habitat of endangered fish species must be protected, and this may require maintaining minimum instream flows. In New Mexico, endangered fish species are found in a number of the major rivers including the Gila, Pecos, Rio Grande, and the San Juan.

Now I would like to ask you several questions about the dollar value your household puts on protecting minimum instream flows. There are no right or wrong answers. Before answering, remember your household income and budget and decide what you could realistically afford. Money spent on protecting instream flows is money not available for other goods, public programs, or other environmental programs. The establishment of a special trust fund for buying or leasing water is used in some states to protect fish species.

Q10. If a special trust fund was set up in New Mexico, and requests were made statewide, up to half a million households could contribute. So, each dollar of average household contribution produces a half a million dollars for the special trust fund.

Q11. Would your household contribute *A* dollars each year for five years to a special trust fund used to buy or lease water from willing parties to maintain minimum instream flows in the major rivers of New Mexico?