Conjoint Analysis of Groundwater Protection Programs

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Three conjoint models—a traditional ratings model, a ratings difference specification, and a binary response model—were used to value groundwater protection program alternatives. The last, which is virtually identical to a dichotomous choice contingent valuation specification, produced the smallest value estimates. This suggests that the conjoint model is very sensitive to model specification and that traditional conjoint models may overestimate economic value because many respondents are not in the market for the commodity being valued.

Groundwater is an important source of water supply for many communities, and concern about contamination combined with increasing costs of treatment and protection has stimulated substantial interest in the economic value of alternative groundwater protection programs. However, few studies of the economic value of protecting groundwater quality have been published, and the empirical results vary widely. Edwards (1988), on the one hand, reported a mean willingness-to-pay (WTP) of $1154 per household per year to protect groundwater on Cape Cod from nitrate contamination. Powell (1991), on the other hand, found a mean WTP of $70 per household per year for reducing the probability of groundwater contamination in several Massachusetts, New York, and Pennsylvania communities.[1] Although Boyle, Poe, and Bergstrom (1994) demonstrate that this variation is partially due to difference in study design, a more fundamental problem is that the contingent valuation (CV) technique, which is used to measure both use and nonuse values of groundwater quality, is often viewed with skepticism (Hausman 1993). As a result, attention has begun to focus on modifications and alternatives to the traditional CV method, such as conjoint analysis (CJ), which asks respondents to rate, rather than to price, alternatives. Although conjoint analysis may have several potential advantages relative to CV, the validity and reliability of CJ for valuing nonmarket commodities is largely untested. For example, we know of only one previous conjoint study of groundwater quality (Sparco 1995).

This paper used three different conjoint model specifications to value alternative groundwater protection programs. We begin with a brief discussion of the conjoint technique. A case study of the economic value of public and private groundwater quality program alternatives is then presented and discussed.

Background and Theoretical Considerations

Some economists suggest that when compared with CV, conjoint analysis asks respondents to make decisions in a manner that is more familiar to them (Mackenzie 1993). The potential for hypothetical bias may therefore be minimized, and since conjoint respondents can express ambivalence or indifference directly, nonresponse and protest behavior may be reduced. Moreover, substitutes are made explicit in the conjoint format, and this encourages respondents to explore their preferences and tradeoffs in detail. By focusing on the various attributes of commodities or programs, each attribute can be valued separately, and the potential for embedding, wherein an individual's willingness-to-pay is not different for goods that differ with respect to scope or scale, may be minimized. Nonetheless, CJ has not been widely used to value changes in environmental quality.

Roe, Boyle, and Teisl (1996) remind us that most CJ studies utilize an ad hoc form:

$$(1) \qquad r^i = k + b_1 q_1{}^i + \ldots + b_k q_k{}^i + b_p p^i,$$

where r^i is the ith commodity's rating, $q_j{}^i$ is the commodity's jth attribute, p^i is price, and the b's

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[1] Both WTP values are expressed in 1992 dollars (see Boyle, Poe, and Bergstrom 1994).

are weights associated with each attribute (Roe, Boyle, and Teisl, 1996; Johnson et al. 1995).

Setting the total differential of equation (1) to the point of indifference and solving

(2) $$dr^i = b_p dp^i + b_1 dq_1{}^i + ... = 0$$

yields marginal rates of substitution for the attributes q_j^i. Since the price attribute, p^i, is included, the implicit price of each attribute may then be derived:

(3) $$dp^i / dq_1{}^i = -b_1 / b_p.$$

But, as Roe, Boyle, and Teisl note, "respondents' ratings of a single commodity do not provide the information necessary to estimate the welfare gains or losses of moving from one commodity to another" (1996, p. 148).

The CJ model used in this study is based on the model recently developed by Roe, Boyle, and Teisl (1996) wherein we assume that individual utility associated with environmental quality programs is expressed by

(4) $$U^i\,(p^i, \mathbf{q}^i, m, \mathbf{z}),$$

where p^i is the cost or price of program i borne by this individual, q^i is a vector of program attributes, m is income, and $\mathbf{z}$ is a vector of individual characteristics such as age and education.

We assume that utility is related to individual ratings via a transformation function $\phi(.)$:

(5) $$r^i(p^i, \mathbf{q}^i, m, \mathbf{z}) = \phi[U^i(p^i, \mathbf{q}^i, m, \mathbf{z})],$$

where $r^i(.)$ is the conjoint rating.

A change from the status quo (program 0) to program i is given by the ratings difference, Δr:

(6) $$\Delta r = r^i(p^i, \mathbf{q}^i, m, \mathbf{z}) - r^0(p^0, \mathbf{q}^0, m, \mathbf{z}).$$

Assuming a linear, constant marginal utility of income:

(7)
$$\Delta r = r^i(\mathbf{q}^i, \mathbf{z}) + a(m - p^i) - [r^0(\mathbf{q}^0, \mathbf{z}) + a(m - p^0)],$$

where a is constant. From (7):

(8) $$\Delta r = r^i(\mathbf{q}^i, \mathbf{z}) - r^0(\mathbf{q}^0, \mathbf{z}) - a(p^i - p^0).$$

As Roe, Boyle, and Teisl (1996) show, by parameterizing equation (8) and adding an error term to represent unobserved individual behavior, the Hicksian compensating variation associated with a change from the status quo to program i can be derived by adding or subtracting dollars from $(p^i - p^0)$ until $\Delta r = 0$.

A binary response model can also be derived from the conjoint formulation presented in equation (8). Suppose, for example, that individuals are asked to rate alternative groundwater protection programs, including the status quo, on a scale of 1 to 10, with 10 indicating the program, if any, the individual would *definitely undertake.* As Roe, Boyle, and Teisl (1996) argue, this formulation follows the standard random utility model:

(9)
$$\Pr\,(\text{program } i \text{ chosen}) = \Pr(U^i(p^i, \mathbf{q}^i, m, \mathbf{z}) + \epsilon^i > U^J(p^J, \mathbf{q}^J, m, \mathbf{z}) + \epsilon^J),$$

where ϵ^i and ϵ^J are random errors. This binary format is therefore essentially the same as dichotomous-choice contingent valuation (Roe, Boyle, and Teisl, 1996).

It is important to emphasize that the conjoint model set forth in equations (4)–(8) differs from the standard approach summarized in equations (1)–(3) in that the dependent variable in (8) is the ratings difference from the status quo and the independent variables are changes in program attributes, including price, from the status quo. As shown above, this specification provides estimates of Hicksian surplus, as opposed to implicit prices of attributes (see also Mackenzie 1990 and Johnson et al. 1995).[2]

Roe, Boyle, and Teisl (1996) recently applied the model outlined in equations (4)–(8) to evaluate Atlantic salmon management options.[3] The results were compared with those derived from three alternative specifications—a traditional ad hoc CJ model (equation [2]), a CJ rankings model created from the CJ ratings data, and a binary response model (see equation [9]) in which "a response equals '1' if the commodity received a higher rating from the status-quo commodity and equals '0' otherwise" (p. 151). These authors conclude that the different approaches produced mixed results, suggesting that "clearly, conjoint is not a panacea" for the problems being debated regarding CV (p. 145).

The approach employed in this study differs from that of Roe, Boyle, and Teisl in that our CJ question structure allows us to estimate a ratings difference model, an ad hoc CJ model, and a binary response model defined such that a response equals 1 if the individual would *definitely undertake* (buy) the program and 0 otherwise. This difference is important because most CJ surveys do not ask respondents whether they would actually buy the commodity being studied. This omission may bias CJ responses upward. And, since the binary re-

[2]Another important aspect of the ratings difference model is that in the traditional specification different respondents tend to center on different ranges of the rating scale. Roe, Boyle, and Teisl argue that "using the status quo rating as a common anchoring point for constructing the ratings difference helps remove this noise from the data."

[3]Nonlinear specifications were also estimated.

sponse specification defined in this study is essentially identical to a dichotomous choice CV format, an indirect comparison of CV and CJ is provided.

Case Study

A groundwater valuation survey was mailed to 1054 randomly selected residents of fifty-six western Massachusetts towns in 1995. The towns surveyed contained a mix of suburban and rural communities that rely primarily on groundwater.

Dillman's (1978) total design method was employed, and focus groups were used to develop and pretest the survey. Table 1 compares socioeconomic characteristics of CJ respondents with those of nonmetropolitan Massachusetts residents as a whole. It shows that the average age, education, and gender of the respondents was quite different from those characteristics of the average Massachusetts resident. The CJ value estimates should consequently not be extrapolated to the population as a whole.

The survey asked about each household's source of water, averting behavior, and level of knowledge about groundwater, where level of knowledge was self-reported. Results are presented in table 2, which shows that few respondents felt very well informed about their water quality. Most had not tested their water and relatively little averting behavior was reported.

The conjoint survey presented respondents with background information about five water quality protection program options—an aquifer protection district, a town-wide water treatment facility, a private pollution control device, the purchase of bottled water, and doing nothing (status quo). Information provided to respondents about these program options is presented in the appendix; the method of protection, cost, and length of payment were the key attributes of the various options. Time spans of five and ten years were chosen to test whether differences in length of payment affected program ratings. There were 4 protection options, 14 price levels, 2 levels of participation, and 2 payment schedules, which made 224 possible scenario permutations. Since attributes had different numbers of levels or alternatives, the conjoint question design was assymmetric. The use of a fractional-factorial design resulted in only 112 different combinations for consideration, because some attributes were incompatible with each other or were not realistic. To generate the protection program options used in the survey, the 112 different combinations were generated by computer, and random picks were then taken from this list four times. The random choices and a status quo option comprised the conjoint question, where the status quo option was designed to represent current groundwater quality protection efforts. To ensure sufficient variability, 60 random scenarios were created using the methods described above. These were then duplicated eighteen times for a total of 1080 surveys, of which 1054 were sent to western Massachusetts residents.

Four program options and the status quo were

Table 1. Socioeconomic Characteristics of Respondents[a]

Characteristic	Conjoint Survey	Census (1990)
Residence		
Primary	94.9	88.5
Weekend/vacation	5.1	11.5
Own home	92	67.4
Years at residence	17.7	11
Age (years)	51.9	35.0
Gender (% male)	69	48
Education		
Grade school	4	19
High school	35	57
College	39	15
Graduate school	22	9
Median household income (in $)	44,318	42,133[b]

[a]All values are percentages unless otherwise noted.
[b]Derived by using the 1989 nonmetropolitan Massachusetts median income of $31,440 and an interest rate of 5%.

Table 2. Summary Statistics of Water Knowledge Questions[a]

Question	Survey Respondents
Source of water	
Private	52
Public	46
Other	2
Water utilities source	
Groundwater	46
Surface water	15
Combination	18
Other, or didn't know	21
Averting behavior	
Installed water filter	13
Drilled new well	4
Boiled tap water	7
Bought bottled water	18
Respondents who had water tested	34
Respondent's level of water knowledge	
Very well informed	16
Know something	37
Know little or nothing	47[b]

[a]All values are percentages unless otherwise noted.
[b]This figure comprises 27% of respondents who knew little about their water and 20% of respondents who knew nothing about their water quality.

rated by each respondent on a scale of 1 to 10, with 10 indicating that the respondent would definitely vote in favor of the program, and 1 indicating that the respondent would definitely *not* vote for the program. If respondents were not sure, they were asked to use a scale of 2 through 9 to indicate how likely they would be to vote for the options presented (see appendix). After respondents completed the conjoint question, an open-ended question asked them to think about the factors considered in deciding about program ratings.

Results

The survey response rate was 51%, and 24.8% of the respondents did not answer the ratings question. Three CJ models were estimated—a traditional model with the dependent variable expressed in terms of ratings (equation [1]), a ratings difference model (equation [8]), and a binary response model (equation [9]). Since the dependent variable in conjoint analysis takes on discrete values, such as integers from 1 to 10, an ordinary least squares estimating procedure is inappropriate (see Mackenzie 1990). Because CJ ratings data may contain cardinal information, a doubly censored tobit technique was used to estimate the traditional ratings and ratings difference models. The logistic regression technique that treats the dependent variable as an ordinal ranking of preferences was used to estimate the binary response model (Roe, Boyle, and Teisl, 1996).

Independent variables are defined in table 3. We expect protection program ratings to decline with price, length of payment, respondent's rating of his/her current water quality as 6 or above on a 10-point scale (where 10 is excellent), and age of respondent. If a respondent had engaged in averting behavior, such as boiling water, we expected higher ratings for protection programs that reduce the need for averting activities. The information, home ownership, gender, education, and income variables might have either a positive or negative influence.

As table 4 shows, estimated coefficients of the traditional ratings model were generally of the expected sign and magnitude. For example, coefficients for price and program type (aquifer, plant, filter, and bottled) variables, which are essential for calculation of the implicit prices of protection programs, were all statistically significant. As expected, respondents' ratings of protection pro-

Table 3. Variables Used in Econometric Analysis of the Conjoint Data

Variable	Expected Sign	Definition	Mean	Standard Deviation
Rate diff		Elicited rating of proposed protection program minus the rating of the status quo	——	——
Ratings		Elicited rating of proposed protection program	4.56	3.43
Aquifer	+	1 if groundwater aquifer protection program, 0 otherwise	.20	.39
Price	–	14 cost levels within the range of \$0 to \$325	95.29	105.19
Plant	+	1 if water treatment plant, 0 otherwise	.18	.38
Filter	+	1 if private water filter, 0 otherwise	.14	.34
Bottled	+	1 if bottled water program, 0 otherwise	.15	.36
Length	–	1 if length of payment is 10 years, 0 if length of payment is 5 years	.41	.49
Avert	+	1 if respondent engaged in averting behavior, 0 otherwise	.35	.48
Rate	–	1 if respondent rated his/her water quality greater than 6 on a 10-point scale (with 10 being excellent), 0 otherwise	.82	.38
Info1	+/–	1 if respondent was very well informed about the quality of his/her groundwater, 0 otherwise	.16	.37
Info2	+/–	1 if respondent knew something about the quality of his/her groundwater, 0 otherwise	.37	.48
Info 3	+/–	1 if respondent knew little about the quality of his/her groundwater, 0 otherwise	.27	.44
Own	+/–	1 if respondent owned home, 0 if rented	.92	.27
Gender	+/–	1 if male, 0 if female	.69	.46
Age	–	Respondent's age	51.9	15.2
Educ	+/–	Respondent's education level in years completed: 8 = grade school, 12 = high school 16 = college, 18 = graduate school	14.73	2.72
Income	+/–	Respondent's income level	44318	23116

Table 4. Traditional Conjoint Regression Results

Variable	Tobit Procedure Coefficient	Standard Error
Constant	1.2661	1.295
Price	−0.0159**	0.0016
Aquifer	5.4172**	0.5231
Plant	3.0493**	0.5417
Filter	5.0502**	0.5618
Bottled	1.2044**	0.5562
Length	−0.2756	0.3322
Avert	0.7055**	0.3202
Rate	−0.2464	0.4331
Info1	0.5921	0.5577
Info2	0.1317	0.4477
Info3	0.1624	0.4688
Own	−0.6671	0.5739
Gender	0.02849	0.3472
Age	−0.0065	0.0114
Educ	0.11473*	0.0656
Income	0.101E-4	0.7E-5
σ	5.2029**	0.1490

N = 1434, −2 Log likelihood = 5962.136
*Indicates significance at the 10% level. **Indicates significance at the 5% level.

grams declined with price and increased with averting behavior.

Results derived from the ratings difference model are presented in table 5. Compared with the traditional ratings model, the ratings difference specification yielded more significant variables. Protection program ratings differences from the status quo declined with age and education. Individuals who rated their current water quality highly gave protection programs lower ratings relative to the status quo, and ratings relative to the status quo increased with averting behavior. Also, individuals who said they were very well informed about water quality gave smaller ratings differences.

Table 5. Regression Results for the Ratings Difference Model

Variable	Tobit Procedure Coefficient	Standard Error
Constant	4.2541**	1.103
Price	−0.0111*	0.00138
Aquifer	3.7472**	0.4450
Plant	2.2313**	0.4626
Filter	3.4228**	0.4787
Bottled	1.0827**	0.4707
Length	−0.38859	0.2857
Avert	1.7225**	0.2755
Rate	−0.92012**	0.3728
Info1	−2.3100**	0.4701
Info2	−0.35618	0.3813
Info3	−0.13096	0.4000
Own	−0.48659	0.4956
Gender	0.25829	0.2974
Age	−0.05050**	0.0098
Educ	−0.03834*	0.0556
Income	−0.470E-5	0.68E-5
σ	4.7211**	0.09709

N = 1434, −2 Log likelihood = 7942.516
*Indicates significance at the 10% level. **Indicates significance at the 5% level.

Table 6. Regression Results for the Binary Choice Model

Variable	Logistic Procedure Coefficient	Standard Error
Constant	−3.1641**	0.685
Price	−0.00745**	0.001
Aquifer	1.9265**	0.260
Plant	.9957**	0.294
Filter	1.4370**	0.278
Bottled	.3675	0.339
Length	−0.3245*	0.175
Avert	0.0967	0.167
Rate	−0.00242	0.219
Info1	−0.0266**	0.263
Info2	−0.4425**	0.218
Info3	0.5220	0.236
Own	−0.00969	0.318
Gender	0.1544	0.185
Age	−0.00003	0.006
Educ	0.0473	0.036
Income	8.64 E-6**	4.247E-6

N = 1553, −2 Log likelihood = 1103.985, Ameniya's Pseudo R^2 = .11
*Indicates significance at the 10% level. **Indicates significance at the 5% level.

Results derived from the binary response model are presented in table 6. As expected, the probability that an individual would definitely pay for a protection program decreased with price, payment period, and high rating of current water quality. The probability of participation increased with education and income, which in this formulation serve as taste and preference variables.

Value estimates derived from the three CJ models are compared in table 7.[4] Values obtained from the traditional ratings model are implicit prices that were calculated by substituting the estimated coefficients for price and program alternatives (column 2 of table 4) into equation (3).

Ratings difference values for each program represent mean WTP for a change from the status quo. These values were calculated by using the estimated coefficients presented in table 5; the dummy variables representing programs other than the one being valued were set equal to 0, all other variables were set at their mean values, and as shown in equation 8, price was then increased until $\Delta r = 0$.

[4]Confidence intervals are not provided because the conjoint estimates are derived from the same data and are therefore not statistically independent.

Table 7. Comparison of Conjoint Value Estimates

Type of Protection Program	Binary Choice[a] (Average $/household/year) (10 years)	Traditional Ratings Model[b] (Average $/household/year)	Ratings Difference Model[c] (Average $/household/year) (10 years)
Aquifer protection district	$35.00 ($258.59)	$340.70	$242.70
Treatment plant	$15.92 ($133.65)	$191.78	$106.00
Private water filter	$24.04 ($192.89)	$317.62	$214.00
Bottled water	$9.05 ($49.33)	$75.75	$2.70

[a]The first set of values represents mean WTP, while estimates in parentheses are implicit prices.
[b]Implicit prices.
[c]Mean WTP values.

The binary response model is

$$E(Y) = \frac{1}{1 + e^{-\alpha-\beta x}}, \tag{10}$$

where Y equals 1 for programs that would definitely be undertaken by an individual (conjoint rating = 10) and Y equals 0 otherwise (conjoint rating = 1–9), $\mathbf{x}$ is a vector of the explanatory variables given in table 3, and α and $\boldsymbol{\beta}$ are the estimated coefficients presented in table 6. Two value estimates were derived from this model. Mean WTP was calculated by taking the area under the estimated probability function (equation [10]), for each protection program option, over the range of price ($0 to $325), with all other variables set at their mean values.[5] Since the dependent variable in this binary choice model is program rating, implicit prices were also derived (see equation [3]).

The results presented in table 7 show that lower *implicit prices* were derived from the binary choice model. Moreover, the binary model generally produced much smaller mean WTP values. The traditional rating and ratings difference value estimates are larger, in part because some respondents would not actually buy the commodity being valued. Our binary response model is defined in terms of whether individuals would pay for protection programs, and results derived from this model may therefore be more reliable than those obtained from the traditional CJ or ratings difference specifications.[6]

[5]About 14% of the sample gave conjoint ratings of 10 (Y = 1 in equation [10]). Each individual rated five program options, and consequently some individuals gave more than one 10 while others gave no 10s.

[6]Substantial debate continues to focus on whether hypothetical WTP obtained from either CV or CJ analyses reflects actual WTP for environmental commodities. Seip and Strand (1992) and Duffield and Patterson (1991), for example, found that hypothetical donations for public goods were significantly greater than actual cash contributions. In a more recent study Champ et al. (1996) compared contingent and actual donations for an environmental project along the North Rim of the Grand Canyon. Contingent values were greater than actual donations, but when the CV sample was restricted to respondents who said they were very certain to contribute, mean CV and actual donations were not statistically different.

It is also interesting to note that regardless of specification, point estimates of the value of the aquifer protection program, which includes both use and nonuse values, was higher than either the treatment plant or private water filter options. In other words, respondents were willing to pay a premium to protect source water.

The implicit prices derived from the traditional ratings and binary response models and the mean WTP estimates obtained from the ratings difference specification generally fall within the range reported in previous studies. Contingent value estimates for groundwater quality protection in New England vary between $1154 and $70 per household per year (see Boyle, Poe, and Bergstrom 1994), and a conjoint study of health risks associated with nitrate, atrazine, and coliform contamination in Sussex County, Delaware, yielded an annual implicit price of $124 per household for a one-part-per-million decrease in nitrate contamination (Sparco 1995). However, it is important to note that our binary choice WTP estimates fall well below the values reported in previous research.

Conclusions

From a conceptual perspective, CJ appears to have several advantages when compared with dichotomous choice contingent valuation. As Boxall et al. (1996) demonstrated, CV estimates may be biased upward because of "yea-saying" and because CV respondents often do not consider substitutes. CJ represents a potential improvement over traditional CV in both respects. However, this case study shows that CJ results can be very sensitive to model specification and to whether implicit prices or mean WTP values are derived. The binary logit model, which asks respondents whether they would actually pay for the program being valued, produced mean WTP estimates that were generally much lower than those derived from the ratings difference specification. We believe that the ratings difference model may overstate economic value because many respondents may not be in the market for the commodity under investigation.

References

Boxall, P.C., U.L. Adamowicz, J. Swait, M. Williams, J. Louviere. 1996. "A Comparison of Stated Preference Methods for Environmental Valuation." *Ecological Economics* 18: 243–53.

Boyle, K.J., G.L. Poe, and J.C. Bergstrom. 1994. "What Do We Know About Groundwater Values? Preliminary Implications from a Meta Analyses of Contingent-Valuation Studies." *American Journal of Agricultural Economics* 76: 1055–61.

Champ, P., R.C. Bishop, T.C. Brown, and D.W. McCollum. 1996. "The Relationship between Contingent and Actual Donations with Possible Implications for Bounding Willingness to Pay." Paper presented at the American Agricultural Economics Association meetings, San Antonio, Texas.

Dillman, Don A. 1978. *Mail and Telephone Surveys: The Total Design Method.* New York: John Wiley & Sons.

Duffield, J.W., and D.A. Patterson. 1991. "Field Testing Existence Values: Comparison of Hypothetical and Cash Transaction Values." Paper presented at the annual meeting of the American Economic Association, New Orleans.

Edwards, S.F. 1988. "Option Prices for Groundwater Protection." *Journal of Environmental Economics and Management* 15:475–87.

Hausman, J.A., ed. 1993. *Contingent Valuation: A Critical Assessment.* New York: North Holland.

Johnson, F. Read, William H. Desvousges, Erin E. Fries, and Lisa L. Wood. 1995. *Conjoint Analysis of Individual and Aggregate Environmental Preferences.* Technical Working Paper No. T-9502. Research Triangle, N.C.: Triangle Economic Research.

Mackenzie, John. 1990. "Conjoint Analysis of Deer Hunting." *Northeastern Journal of Agricultural and Resource Economics* 19(2):109–17.

———. 1993. "A Comparison of Contingent Preference Models." *American Journal of Agricultural Economics* 75: 593–603.

Powell, J.R. 1991. "The Value of Groundwater Protection: Measurement of Willingness to Pay Information, and Its Utilization by Local Government Decision Makers." Ph.D. diss., Department of Agricultural Economics, Cornell University.

Roe, Brian, Kevin J. Boyle, and Mario Teisl. 1996. "Using Conjoint Analyses to Derive Estimates of Compensating Variation." *Journal of Environmental Economics and Management* 31:145–59.

Seip, K., and J. Strand. 1992. "Willingness to Pay for Environmental Goods in Norway: A Contingent Valuation Study with Real Payment." *Environmental and Resource Economics* 2:91–106.

Sparco, J. 1995. "A Conjoint Analysis of Willingness to Pay for Changes in Groundwater Quality." Paper presented at Northeastern Agricultural and Resource Economics Association annual meetings, Burlington, Vt.

Appendix

Conjoint Survey Information: Types of Groundwater Protection Programs

On the next page, you will be asked to rank five different types of groundwater protection programs. The following is a list of program features such as cost and method of protection. Please consider the following information very carefully, even if the groundwater supply for your household or community is already protected.

I. Method of Protection
(You will be asked for your opinion about one or more of the following protection methods.)

- Creation of a town-wide groundwater protection district. Examples of possible actions include drilling new wells in areas where the water is uncontaminated and placing development restrictions on land near well fields or in groundwater recharge areas.
- Construction of water treatment facility, which would either filter or chemically treat the water as it is pumped from the ground.
- Installation of private pollution control device. Households could install a device such as a granular-activated carbon filter on their taps. These filters would clean all water delivered to the household by either the public water utility or the household's own private well.
- Purchase of bottled water. Households could purchase bottled water to substitute for the groundwater that they receive from either a public water utility or the household's private well.

II. Cost of Program

- Depending on the method of protection and other factors, the cost of groundwater protection is estimated to range from \$0 to \$325 dollars per household per year.

III. Length of Payment

- You may be asked to consider *two* alternatives: a payment *each year* for the next 5 years, or a payment *each year* for the next 10 years.

IV. Who Would Benefit

- Some programs benefit the participating household only, others benefit all households on public water, and some benefit all households. Some programs may benefit the present generation only; others have the potential to benefit future generations as well.

V. Participation

- Groundwater protection programs may either be voluntary or mandatory. Mandatory programs must be passed by a majority of voters in the community.

Q-12. Now consider the five groundwater protection programs presented below. Please indicate how you would *rank* these programs on a scale of 1 to 10. Use 10 for the program, if any, you would *definitely vote in favor of,* and 1 for the program that you would *definitely not vote in favor of.* If you are not sure, use 2 thru 9 to indicate how likely you would be to vote for the options presented.

OPTION A

- Construction of a water treatment plant.
- Present and future residents on public water will benefit.
- The program would be paid for by an increase in your household's water utility bills of $225 per year for the next 10 years
- Program mandatory if passed by a majority of voters in your town.

RANK: __________

OPTION B

- Town-wide groundwater protection district.
- All residents, both present and future, will benefit.
- The program would be paid for by an increase in your household's water utility bills or property taxes of $88 per year for the next 5 years.
- Groundwater quality would not get any worse.
- Program mandatory if passed by a majority of voters in your town.

RANK: __________

OPTION C

- No new groundwater protection program will be implemented.
- Maintain current level of protection of groundwater in your community.
- Water quality may decline over time due to economic growth and development.
- No increases in costs to you for groundwater protection.

RANK: __________

OPTION D

- Install private pollution protection device on water tap.
- Only households which participate will benefit.
- Installation, operation, and maintenance of the pollution protection device will cost your household $325 per year for the next 10 years.
- This program is voluntary.

RANK: __________

OPTION E

- Purchase bottled water.
- Only households which participate will benefit.
- Assume that bottled water to meet your household's need will cost your household $175 per year for the next 10 years.
- This program is voluntary.

RANK: __________