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VALUATION OF OPEN SPACE AS A COMPOSITE ENVIRONMENTAL GOOD VIA CONJOINT ANALYSIS

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VALUATION OF OPEN SPACE AS A COMPOSITE ENVIRONMENTAL GOOD VIA CONJOINT ANALYSIS

ABSTRACT

This paper analyzes individuals' preferences for protection of open space parcels, described by their constituent environmental amenities, within the public choice framework of a statewide open space preservation initiative. An indirect utility index estimated from these preferences yields marginal valuations of individual amenities with acceptably narrow confidence intervals.

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VALUATION OF OPEN SPACE AMENITIES VIA CONJOINT ANALYSIS

INTRODUCTION

Open space, i.e., farmland, forest and other undeveloped land, is a heterogeneous, composite environmental good. It provides scenic vistas and landscape diversity, habitat for wildlife, control of runoff, water purification and recharge, various outdoor recreation amenities, and other miscellaneous benefits. The public goods values of open space and its constituent non-market amenities underlie various public policies to assure its continued provision.

This paper demonstrates that the social choices expressed in a market-oriented open space protection program imply quantifiable economic valuations of those amenities. It develops a conjoint analysis of economic demand for open space as a composite environmental good within the social choice framework of an actual public land trust program. The conjoint method is presented as an extension of the contingent valuation method (CVM); a survey of respondents' preferences for protection of hypothetical open space parcels is described; the data from it are used to estimate an empirical indirect utility index from which marginal valuations of composite amenities, and confidence intervals for those valuations, are derived.

PRIOR ANALYSES

There are several open-ended CVM analyses of demand for farmland preservation and its associated public amenity values, including Halstead; Bergstrom, Dillman and Stoll; Beasley, Workman and Williams; and Musser, Waddington and Shortle. These analyses, like most open-ended CVM studies, were complicated by significant response bias: many respondents reported zero WTP bids, and the researchers were faced with the problem of discerning true zero bids from "protest" bids motivated by implausibility of the CVM question. Both Halstead and Musser et al. have demonstrated systematic elements in such bias, but reliable methods of correcting for it have yet to be developed.

Although methodological formalizations of closed-ended CVM (e.g., Hanemann) have increased its appeal, no applications to open space valuation appear to have been published. In positing hypothetical referenda, in which both the quality change and the payment are specified, the closed-ended approach is relatively immune to many of the biases inherent in open-ended CVM, but has lower informational efficiency since the responses are only upper or lower bounds for WTP. Some well-known applications include Bishop and Heberlein (WTP for goose-hunting) and Bowker and Stoll (WTP for whooping-crane preservation).

Opaluch et al. used a contingent pairing method to analyze preferences for alternative sitings of a solid waste management facility in Rhode Island. The site descriptions indicated the attributes which would be affected by the facility, e.g. marshland, cropland, groundwater quality and wildlife habitat. The Opaluch et al. study obtained excellent respondent cooperation and yielded robust results because it addressed a social choice problem which had already been clearly framed by local regulatory and political processes and the media, and its survey structure mimicked the actual siting decision process reasonably well. Indeed, the success of any non-market valuation study depends on how well it accords with respondents' framings of the social choice issues being addressed, and with the decision processes associated with those issues. Respondents are better accustomed to voting for environmental quality than to buying it.

METHODS

Conjoint analysis has the same methodological foundations as CVM and contingent ranking. Developed in the psychometrics literature (Luce and Tukey), and already adapted to marketing research (Green; Green and Srinivasan; Green, Carroll and Goldberg), the conjoint method involves decomposing a composite good into its constituent attributes, surveying respondents regarding their relative preferences for alternative bundles when multiple attributes are varied simultaneously, and estimating an empirical indirect utility index from which marginal rates of substitution between attributes and marginal willingness-to-pay (WTP) estimates for attributes can be derived.

Consider the indirect utility function $U = V[P,Q,Y]$ where P represents a vector of market goods prices (assumed constant), Q represents an unpriced environmental amenity or vector of amenities, and Y represents consumer income. In referendum CVM studies both the change in Q and an associated payment (WTP) are proposed. The proposal $\{Q_1,Y\text{-}WTP_1\}$ will be accepted if $V[Q_1,Y\text{-}WTP] >= V[Q_0,Y]$, and will be rejected if $V[Q_1,Y\text{-}WTP] < V[Q_0,Y]$. The proposed WTP represents a lower-bound for true WTP in the former case, and an upper-bound for it in the latter (Hanemann; Cameron). Respondent preferences define a probabilistic utility difference function embodying an implicit WTP function for Q.

If $V[Q,Y]$ has a systematic component $v[Q,Y]$ common to all respondents, and a random component e unique to each respondent, then individual i's utility is represented as $V_i = v[Q,Y_i] + e_i$. A comparison of $\{Q_1,Y\text{-}WTP_1\}$ versus $\{Q_2,Y\text{-}WTP_2\}$ (where one of these may represent the respondent's ex ante state $\{Q_0,Y\}$) determines the direction of the inequality

$$v[Q_2,Y\text{-}WTP_2] + e_2 > v[Q_1,Y\text{-}WTP_1] + e_1,$$

which can be rearranged to

$$v[Q_2,Y\text{-}WTP_2] - v[Q_1,Y\text{-}WTP_1] > e_1 - e_2.$$

Let D denote the utility difference function:

$$D = v[Q_2,Y\text{-}WTP_2] - v[Q_1,Y\text{-}WTP_1].$$

The probability that the respondent agrees to the proposed change in Q with the associated payment is a function of the utility difference, so that

$$\text{Prob}\{V[Q_2,Y\text{-}WTP_2] > V[Q_1,Y\text{-}WTP_1]\} = \text{Prob}\{(e_1-e_2) < D\}.$$

Assuming that survey responses do represent utility maximizing choices, and that the e's are i.i.d. with zero mean, the functional form (e.g., normal or Weibull) chosen for the cumulative distribution of (e_1-e_2) determines the appropriate procedure (e.g., probit or logit) for empirical estimation of the utility difference function D, which indexes the underlying indirect utility function v. A linear specification of D implies v is also linear and has the same slope coefficients (which represent marginal utilities) as D. Where WTP is simply deducted from Y, the coefficient on WTP equals the negative of the marginal utility of income, and the redundant Y is omitted from the utility difference equation and subsumed in the unknown constant of integration (intercept) in v.

In contingent ranking studies (Rae; Desvousges, Smith and McGivney) the respondent provides a preference ordering of M proposals or "cards" (subscripted to reflect that ordering):

$$V[Q_1,Y-WTP_1] >= V[Q_2,Y-WTP_2] >= \ldots >= V[Q_M,Y-WTP_M].$$

Contingent ranking has better informational efficiency than referendum CVM since the M rankings imply $M(M-1)/2$ pairwise comparisons of cards which can be used to impute the WTP function, however the likelihood of inconsistent rankings increases as M gets large. Another potential difficulty arises where no individual card in the set of cards being ranked corresponds to the status quo (i.e., no change in Q and no payment) to define the respondent's ex ante level of utility as a reference.

Contingent ranking is particularly appropriate where Q is a composite good embodying N variable attributes $Q = \{q^1,\ldots,q^N\}$. A set of M cards can be designed so that the respondent's card rankings

$$V[q^1{}_1,\ldots,q^N{}_1,Y-WTP_1] >= \ldots >= V[q^1{}_M,\ldots,q^N{}_M,Y-WTP_M]$$

trace out an indirect utility difference function from which marginal WTP's for individual attributes as well as total valuations of any permutation of Q can be derived.

As an extension of contingent ranking, conjoint analysis offers formalized methods for designing this set of cards (Green; Addelman). The simplest designs assume that utility can be expressed in a strongly separable form, i.e., as linear in the individual attributes or transforms of them. The utility function can thus be specified as orthogonal in the attributes. Attributes may well be uncorrelated in the utility function even when they are correlated in nature (Moore and Holbrook).

Suppose Q is described by N attributes $q^1 \ldots q^N$, with each attribute varying across as many as L discrete levels, so that there are as many as L^N possible cards or permutations of Q. While this is generally far more than any respondent can reasonably be expected to rank, an orthogonal design requires no more than than L^2 or N^2 cards (whichever is greater) to represent all levels of all attributes (Addelman; Bretton-Clark). Furthermore, if it is impractical for respondents to rank this many cards, an additional pseudo-attribute may be included in the design to identify equivalent blocks or subsets of cards. A pseudo-attribute with K levels ($K <= L$) defines K equivalent blocks no larger than L^2/K or $(N+1)^2/K$ cards each (whichever is greater). K different versions of the survey are then constructed and administered to equivalent groups of respondents. Most conjoint surveys actually employ Likert scale ratings of cards, which clearly imply rankings, and provide some information on relative intensities of preferences as well.

Given card ratings on a 0-to-M scale, the form of the utility difference function can be estimated via ordinal logit or probit, with M-2 separate rating interval dummies $I_2,...,I_M$ incorporated into the model, where $I_j = 1$ for an observation with rating j, and $I_j = 0$ otherwise. The default interval is subsumed in the intercept. This procedure effectively collapses the ratings to define a unit-interval indifference function.

Marginal rates of substitution between attributes and marginal valuations of attributes can be derived directly from the estimated indirect utility function. In general, where the indirect utility function v[Q,Y-WTP] is obtained in the decomposed form $v[q_1,...,q_N,Y\text{-WTP}]$, the marginal rate of substitution between any two attributes i and j is $-v_i/v_j$, the negative of the partial derivative of v with respect to q_i divided by the partial derivative of v with respect to q_j (Freeman). Equivalently, the marginal willingness-to-pay for any attribute q_i is $-v_i/v_{(Y\text{-WTP})}$. If the indirect utility function has a linear form

$$v = a + b_1 q_1 + ... + b_N q_N + b_{WTP}\text{WTP}$$

with income Y and the rating interval dummies subsumed in a, the marginal rate of substitution between attributes i and j is simply $-b_i/b_j$, and the marginal WTP for attribute i is simply $-b_i/b_{WTP}$.

The process of choosing among alternative bundles with specified prices matches decision processes which consumers know well. While economists are trained to view prices and quantities as mathematically dual (and open-ended CVM studies make that duality explicit), consumers' perceptions are unencumbered by this theoretical framework: they tend to view price as simply another attribute of the good in question, and questions structured in accordance with such perceptions should avoid many of the protest and strategic biases that so often afflict CVM studies.

DATA

Delaware's new Land Protection Act of 1990 established the "Greenspaces for Delaware's Future" Program, and will divert up to $70 million of the State's realty transfer tax revenues from the state's general fund to finance the purchase of conservation easements or full fee interests in environmentally important parcels of land. A newly-created citizen advisory group, the Delaware Open Space Council, is charged with overseeing the selection of parcels for the Program. Given Delaware's small size and population, the Program is one of the most ambitious of its kind. Its budget represents approximately $100 per Delaware resident, and, if costs averaged $1,000 per acre (for fee purchases, easement purchases and gifts combined), could include almost six percent of the Delaware's total land area in the Program.

In cooperation with the Delaware Division of Fish and Wildlife, the author conducted a mail survey of Delawareans' preferences for open space preservation under the Greenspaces Program. The questionnaire form summarized the objectives and design of the Program, explained the Program budget and the Open Space Council, and distinguished fee purchases by the State, purchases of conservation easements, and land donations. Each respondent was asked to rate seven hypothetical parcels as candidates for the Greenspaces Program, using a 0-to-10 Likert scale. The parcel descriptions were constructed from a 49-card orthogonal conjoint design based on six attributes with seven levels for each attribute. The six attributes were: parcel size in acres; land cover and habitat; groundwater quality; surface water quality; terms of acquisition and projected public use; and cost per acre. A seven-level blocking attribute was included in the design to identify seven equivalent blocks of cards, so that each respondent would only have to rate seven cards within one block.

The survey was executed between October and December, 1990. It targeted 1,961 Delaware households drawn from a list of recipients of the Delaware Conservationist, a free quarterly magazine published by the Delaware Department of Natural Resources and Environmental Control, and followed standard mail survey procedures (Dillman; Lansing and Morgan). Of the 1,961 addresses targeted, 41 were invalid, and 1,109 yielded responses, including 103 returned largely unanswered and 1,006 valid responses. Of these, 855 responses included usable ratings of the cards in the conjoint question. Most of the remaining 151 respondents gave ratings of "10" to all seven cards, expressing enthusiasm for the Greenspaces Program but implying total indifference between parcels. In evaluating the scale of the Program in a subsequent question, most respondents indicated the current budget was "about right;" only 5.3 percent indicated the budget was too large, while 21.1 percent indicated it was too small.

Excluding nonrespondents and respondents who provided ratings with no variation, the sample of 855 respondents yielded a total of 5,891 ratings (some respondents failed to rate all seven cards). These ratings were regressed against the parcel attribute variables via ordinal probit, with the utility difference function specified:

$$D = a_0 + a_2I_2 + ... + a_{10}I_{10} + b_1\text{ACRES} + b_2\text{PCTCROPL} + b_3\text{PCTWETLD} + b_4\text{PCTBEACH}$$
$$+ b_5\text{TESTED} + b_6\text{ATRAZINE} + b_7\text{NITRATE} + b_8\text{CLEAR} + b_9\text{DRINK} + b_{10}\text{SWIM} + b_{11}\text{FISH}$$
$$+ b_{12}\text{BUY} + b_{13}\text{PUBACCES} + b_{14}\text{HUNT} + b_{15}\text{COSTACRE} + c_1\text{BLOCKA} + ... + c_6\text{BLOCKF}.$$

The nine dummies $I_2,...,I_{10}$ account for nine rating intervals; the tenth interval is subsumed in the intercept. ACRES represents the number of acres in the parcel. PCTCROPL, PCTWETLD and PCTBEACH represent percents of the parcel in cropland, wetland or saltwater beach, respectively; the default land cover is forest. The variable TESTED takes a value of one if the groundwater has been tested, and a value of zero otherwise. The variables ATRAZINE and NITRATE represent concentrations of these chemicals in the groundwater, expressed as percents of the EPA's maximum safe standards (0.1 ppm for atrazine; 10 ppm for nitrates). The variables CLEAR, DRINK, SWIM and FISH are surface water quality indices: CLEAR equals two where the water is "clear" (three levels), equals one where the surface water is "too shallow for swimming" (two levels), and equals zero where the water is "murky" (two levels). DRINK equals one where the water is potable (one level), and equals zero otherwise. SWIM equals one where the water is both deep enough and pure enough to be swimmable (two levels), and equals zero otherwise. FISH equals four where there is good diversity of fish (four levels), and equals three, two and one as fish diversity declines in the other three descriptions. BUY equals one for parcels the state would purchase outright, and equals zero for parcels on which the state would buy a conservation easement. PUBACCES equals zero if no public access is permitted (one level), equals one if there will be limited recreational access (three levels), and equals two if the site will be open for general recreation (three levels). HUNT equals one if hunting will be permitted (two levels), and equals zero otherwise. COSTACRE is the stated dollar cost per acre of the easement or fee purchase. The six dummy variables BLOCKA ... BLOCKF are included to account for any differences in the average ratings of the seven blocks of cards not attributable to differences in the attribute levels. BLOCKG is the omitted default.

Since the ratings provided by more conscientious respondents tended vary across the full 0-to-10 range, while the more perfunctory ratings had comparatively little variation, the variance of each respondent's ratings was used to weight the observations. The coefficient estimates from the weighted probit model were very close to those of the unweighted model, and were generally more efficient.

Estimation results are presented in Table 1. All attribute coefficients have signs as hypothesized, and all are significant at the 99 percent level, except for those on PCTCROPL and SWIM which are not significant at any acceptable level. Since the specification of this indirect utility difference function is linear, marginal WTP's for site attributes are obtained by dividing each attribute's coefficient (equivalent to its marginal utility) by the negative of the coefficient on COSTACRE (equivalent to the marginal utility of money). This effectively converts the model from a utility metric to a dollar metric.

The assumed normality of residuals from the probit model supports calculation of confidence intervals for these WTP estimates using Fieller's method. Expressing the valuation estimate

$$\mathrm{WTP}_i = -b_i/b_{\mathrm{COSTACRE}}$$

as the hypothesis

$$b_i + b_{\mathrm{COSTACRE}}\mathrm{WTP}_i = 0,$$

the confidence limits for each WTP_i are the quadratic roots of the inequality

$$[b_i + b_{\mathrm{COSTACRE}}\mathrm{WTP}_i]/[S_i^2 - 2S_iS_{\mathrm{COSTACRE}}\mathrm{WTP}_i + S_{\mathrm{COSTACRE}}^2\mathrm{WTP}_i^2]^{0.5} > t,$$

where S_i^2, $S_{COSTACRE}^2$ and $S_iS_{COSTACRE}$ represent the coefficient variances and covariance respectively, for the t-value corresponding to any desired confidence level (Finney). The 95 percent confidence intervals (t = 1.96) for each estimate are included in Table 2.

Table 1: Probit Estimation Results
(observations weighted by variance of ratings)

VARIABLE	COEFFICIENT	STD. ERROR	MARG. VALUE ($b_i/b_{COSTACRE}$)
INTERCEPT	0.642753	0.030277	$1,766.14
I2	-0.208677	0.004852	
I3	-0.449833	0.006484	
I4	-0.651606	0.007290	
I5	-0.818596	0.007779	
I6	-1.189157	0.008571	
I7	-1.332099	0.008817	
I8	-1.492869	0.009072	
I9	-1.841668	0.009607	
I10	-2.033180	0.009910	
ACRES	9.8300×10^{-5}	9.050×10^{-6}	$0.27
PCTCROPL	8.6600×10^{-5}	0.000229	$0.24
PCTWETLD	0.002758	0.000142	$7.58
PCTBEACH	0.006217	0.00041	$17.08
TESTED	0.179459	0.01516	$493.11
NITRATE	-0.080436	0.030585	($221.02)
ATRAZINE	-0.259946	0.010836	($714.27)
CLEAR	0.044628	0.015952	$122.63
DRINK	0.062834	0.018743	$172.65
SWIM	0.012434	0.01778	$34.16
FISH	0.113290	0.010264	$311.30
BUY	0.401172	0.01021	$1,102.33
ACCESS	0.158799	0.007262	$436.35
HUNT	0.057830	0.011316	$158.90
COSTACRE	-0.0003639	6.0120×10^{-7}	($1.00)
BLOCKA	0.096343	0.019467	
BLOCKB	0.034809	0.018357	
BLOCKC	0.008154	0.018616	
BLOCKD	-0.049769	0.019221	
BLOCKE	0.002240	0.019128	
BLOCKF	0.047410	0.019113	

Log Likelihood = -95059.0

Table 2: 95 Percent Confidence Intervals
for Marginal WTP Estimates from Conjoint Model

VARIABLE	COVARIANCE WITH $b_{COSTACRE}$	WTP_I ESTIMATE	LOWER BOUND	UPPER BOUND
INTERCEPT	-2.7355E-08	$1,766.14	$1,595.00	$1,938.50
ACRES	1.1084E-12	$0.27	$0.22	$0.32
PCTCROPL	-3.8323E-11	$0.24	($1.00)	$1.47
PCTWETLD	-1.5398E-11	$7.58	$6.81	$8.35
PCTBEACH	5.6077E-12	$17.08	$14.88	$19.29
TESTED	-4.1534E-09	$493.11	$410.85	$575.65
NITRATE	5.2867E-09	($221.02)	($56.25)	($386.11)
ATRAZINE	2.5933E-09	($714.27)	($655.03)	($773.68)
CLEAR	1.0162E-09	$122.63	$36.72	$208.47
DRINK	3.7366E-10	$172.65	$71.71	$273.57
SWIM	-2.9396E-09	$34.16	($61.57)	$130.04
FISH	-1.5806E-09	$311.30	$255.79	$366.89
BUY	-8.4263E-10	$1,102.33	$1,046.78	$1,157.96
ACCESS	6.7967E-10	$436.35	$397.41	$475.25
HUNT	-3.3031E-10	$158.90	$97.94	$219.89

The model yields a base WTP estimate of $1,766 per acre for protection of a default parcel (few acres; entirely forested; presumably pure groundwater but not tested; murky, non-swimmable surface water supporting few fish; no public access; protected via conservation easement). Each additional acre in the parcel increases per-acre WTP by an estimated 27 cents. WTP for protection of cropland is not significantly different from WTP for protection of forest. WTP for protection of wetland parcels is estimated to be $2,524 per acre, or $758 per acre more (i.e. 100 percent wetland times $7.58 per percentage point of parcel in wetland) than WTP for protection of forest. WTP for protection of ocean shore parcels is estimated to be $3,734 per acre, or $1,708 per acre more than WTP for protection of forest.

WTP estimates for groundwater quality are quite high, and, given the nature of the Greenspaces Program, reflect significant existence value. Mere certainty about the purity of the groundwater (via testing), as opposed to uncertainty (with some contamination implied, given the groundwater quality levels respondents referred to in the other cards), increases WTP by an estimated $493 per acre. Nitrate contamination is viewed as much less serious than atrazine contamination, despite the stronger toxicological evidence against nitrates. Nitrate contamination at the EPA's maximum safe standard (10 ppm) reduces WTP by an estimated $221 per acre; atrazine contamination at the EPA's maximum safe standard (0.1 ppm) reduces WTP by an estimated $714 per acre. The difference may reflect respondent perceptions that nitrates are more "natural" than atrazine.

A parcel's surface water quality also enhances WTP for its protection. WTP for water clarity, as opposed to severe murkiness (a two point difference in the visual quality index), is estimated to be $245 per acre. WTP for potability is estimated to be $172 per acre; again, this is mostly existence value rather than use value. Swimmability *per se* does not augment WTP. WTP for high fish diversity vis-a-vis few or no fish at all (a three point difference on the fish quality index) is estimated to be $934 per acre.

The model indicates an estimated WTP increment of $1,102 per acre for parcels purchased outright and managed by the state, as opposed to parcels protected under conservation easement and remaining in private ownership. Part of this increment may be due to respondent unfamiliarity with conservation easements, or lack of confidence in their effectiveness. Estimated WTP is increased by $873 per acre for parcels which will support general public recreation, as opposed to parcels where no public access will be allowed (a two point difference in the public access index). The model indicates an overall marginal WTP estimate of $159 per acre for land on which hunting will be permitted. Respondents whose ratings reflected opposition to hunting were effectively out-voted by hunters and others viewing hunting as an appropriate wildlife management tool.

LIMITATIONS AND CONCLUSIONS

This study has several weaknesses. Most seriously, since the target sample was drawn from the mailing list of the Delaware Conservationist magazine, the study results obviously cannot be assumed to represent Delawareans generally. A second criticism is that the WTP estimates derived in this study are not well defined according to the usual taxonomy of environmental amenity values: i.e. current use values, preservation values, option values, and pure existence values. These are probably commingled in the different WTP estimates. Third, the design of the survey involved some difficult decisions about the amount of information that should be provided to respondents. The explanation of the Greenspaces Program in the conjoint question was clearly essential, but possibly biased the responses by its wording or style. Indeed, the degree to which a researcher should "inform" a respondent in order to obtain an "appropriate" response is a fundamental point of controversy in social science research. Various studies (e.g. Desvousges and Smith; Samples, Dixon and Gowan), have shown that the provision of such factual information can influence WTP estimates quite dramatically.

Overall, these results indicate that public WTP for open space and its constituent amenities, as expressed in the public choice framework of the Greenspaces Program, exceeds current market prices for most types of land except beach frontage. The derived WTP estimates are well defined with respect to ex ante utility, and the confidence intervals on these WTP estimates compare favorably with confidence intervals from most conventional CVM valuations of such amenities. The analysis explicitly accounts for the composite nature of the environmental quality that open space provides. Indeed, its results suggest that valuation models focusing on single aspects of environmental quality may yield comparatively inefficient WTP estimates to the extent that they are underspecified. Greenspaces Program officials might use this kind of model for appraising the environmental attributes of actual parcels, and for making benefit-cost comparisons between parcels.

While open space protection programs such as the Delaware's Greenspaces Program are clear articulations of public demand for environmental quality, the public valuations of environmental amenities implied in those programs reflect significant information deficiencies and risk aversion, and may be less "rational" than valuations determined by experts. The underlying issue in this research is whether a partially-informed public can obtain appropriate levels of environmental protection through market-oriented processes such as the Greenspaces Program. Ideally, such processes reveal the true public costs of environmental protection and augment the information base, so that these valuations will become more rational through time.

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Appendix A: Orthogonal Conjoint Design
7 blocks; 6 attributes; 7 levels per attribute

block/ card#	A	B	C	D	E	F
A1	1	1	1	1	1	1
A2	2	3	4	6	7	5
A3	3	5	7	4	6	2
A4	4	7	3	2	5	6
A5	5	2	6	7	4	3
A6	6	4	2	5	3	7
A7	7	6	5	3	2	4
B1	1	7	6	4	3	5
B2	2	2	2	2	2	2
B3	3	4	5	7	1	6
B4	4	6	1	5	7	3
B5	5	1	4	3	6	7
B6	6	3	7	1	5	4
B7	7	5	3	6	4	1
C1	1	6	4	7	5	2
C2	2	1	7	5	4	6
C3	3	3	3	3	3	3
C4	4	5	6	1	2	7
C5	5	7	2	6	1	4
C6	6	2	5	4	7	1
C7	7	4	1	2	6	5
D1	1	5	2	3	7	6
D2	2	7	5	1	6	3
D3	3	2	1	6	5	7
D4	4	4	4	4	4	4
D5	5	6	7	2	3	1
D6	6	1	3	7	2	5
D7	7	3	6	5	1	2

block/ card#	A	B	C	D	E	F
E1	1	4	7	6	2	3
E2	2	6	3	4	1	7
E3	3	1	6	2	7	4
E4	4	3	2	7	6	1
E5	5	5	5	5	5	5
E6	6	7	1	3	4	2
E7	7	2	4	1	3	6
F1	1	3	5	2	4	7
F2	2	5	1	7	3	4
F3	3	7	4	5	2	1
F4	4	2	7	3	1	5
F5	5	4	3	1	7	2
F6	6	6	6	6	6	6
F7	7	1	2	4	5	3
G1	1	2	3	5	6	4
G2	2	4	6	3	5	1
G3	3	6	2	1	4	5
G4	4	1	5	6	3	2
G5	5	3	1	4	2	6
G6	6	5	4	2	1	3
G7	7	7	7	7	7	7

Appendix B: Attributes and Attribute Levels
Conjoint Analysis, 1990 Delaware Wildlife Survey

Attribute A: Size of Parcel

1. 50 acres
2. 100 acres
3. 200 acres
4. 400 acres
5. 800 acres
6. 1,200 acres
7. 2,000 acres

Attribute B: Land Cover and Habitat Description

1. 70% prime cropland under cultivation, 30% brush and forest with stream.
   Habitat supports songbirds, hawks, upland game birds, deer and other upland mammals.
2. 30% old field, 70% mixed hardwood/softwood forest with stream.
   Habitat supports songbirds, owls, hawks, deer and other upland mammals.
3. 100% mixed hardwood/softwood forest with small pond.
   Habitat supports Delmarva fox squirrel and other mammals, owls, songbirds.
4. 80% mixed hardwood/softwood forest with streams, 20% large pond.
   Habitat supports songbirds, owls, hawks, reptiles, amphibians, muskrat.
5. 100% freshwater wetland, mostly under forest cover.
   Habitat supports reptiles, amphibians, muskrat, otter, beaver, songbirds, owls, hawks.
6. 80% open coastal wetland, 20% cropland under cultivation.
   Habitat supports bald eagles and other raptors, migratory waterfowl, reptiles, amphibians, muskrat, otter, beaver.
7. 40% saltwater beach and dunes, 60% brush and forest.
   Habitat supports piping plover, shore birds.

Attribute C: Groundwater Quality

1. Groundwater is pure.
2. Groundwater has not been tested.
3. Groundwater contains nitrate runoff from neighboring cropland at one-half the EPA's maximum safe standard.
4. Groundwater has trace pesticide runoff from neighboring cropland (atrazine) at one-tenth of the EPA's maximum safe standard.
5. Groundwater has pesticide runoff from neighboring cropland (atrazine) at one-fifth of the EPA's maximum safe standard.
6. Groundwater has pesticide runoff from neighboring cropland (atrazine) at one-half of the EPA's maximum safe standard.
7. Groundwater has pesticide runoff from neighboring cropland (atrazine) at one and one-half times the EPA's maximum safe standard.

Attribute D: Surface Water Quality

1. Surface water is clear, drinkable; diverse fish.
2. Surface water is clear, suitable for swimming but too shallow; diverse fish.
3. Surface water is clear, swimmable, not recommended for drinking; diverse fish.
4. Surface water suitable for swimming but too shallow, slight runoff from neighboring cropland; diverse fish.
5. Surface water too shallow for swimming, slightly brackish; moderate fish diversity.
6. Surface water is very shallow, murky, low in dissolved oxygen; low fish diversity.
7. Surface water is murky, suitable for canoeing, very low in dissolved oxygen; very few fish.

Attribute E: Terms of Acquisition and Public Access

1. State buys conservation easement only; no public access allowed.
2. State buys conservation easement only; walking on trails only.
3. State buys conservation easement only; owner permits camping, no hunting.
4. State buys conservation easement only; owner permits both camping and hunting.
5. State buys parcel for State Wildlife Management Area; hunting permitted.
6. State buys parcel for State Wildlife Management Area; no hunting.
7. State buys parcel for State Park; will be developed for general recreation.

Attribute F: Acquisition Cost

1. Acquisition cost $1 (gift).
2. Acquisition cost $100/acre.
3. Acquisition cost $250/acre.
4. Acquisition cost $500/acre.
5. Acquisition cost $1,000/acre.
6. Acquisition cost $1,500/acre.
7. Acquisition cost $2,500/acre.

Appendix C: Conjoint Questions (Block A)
1990 Delaware Wildlife Survey

9. Under Delaware's new "Greenspaces for Delaware's Future" Program, the State of Delaware will spend up to $70 million for the preservation of environmentally important parcels of land. The newly-created Delaware Open Space Council will oversee the administration of the Program, and will have to consider many environmental objectives, including wildlife conservation, in deciding which particular parcels the State should protect.

Suppose you were appointed to the Delaware Open Space Council. What types of habitat would you be most concerned to protect? Using a **rating scale of 0 to 10** (ranging from 0="no importance" up to 10="extremely important"), please rate how important you think it is to protect habitat for each of the following wildlife categories:

endangered species (such as the Delmarva fox squirrel, bald eagle and piping plover). RATING _______
raptors (hawks, owls, osprey and other birds of prey). RATING _______
migratory waterfowl and **shore birds.** RATING _______
songbirds. RATING _______
upland game birds (such as quail, pheasant, mourning dove). RATING _______
reptiles and **amphibians** (such as snakes, frogs, salamanders). RATING _______
wetland-dependent mammals (such as muskrat, otter, beaver). RATING _______
upland mammals (such as deer, fox, rabbits, field mice). RATING _______

10. Under the Greenspaces Program, the State has several ways it can protect natural areas. These include:
(a) **buying the land** from the owner outright. The State assumes the responsibility for maintaining the parcel.
(b) **buying a conservation easement** from the owner, so that the owner keeps the parcel but may never clear or build on it. The owner generally continues to be responsible for maintaining the parcel. The parcel can be bought or sold later subject to the use restrictions laid out in the easement. Conservation easements do not necessarily provide for public access to the site.
(c) **accepting gifts** of land. The State assumes responsibility for maintaining the parcel.

Landowner sales and gifts must be voluntary. The Program does not permit the State to seize or take any land via condemnation.

On the back of this page seven parcels of land are described according to the following characteristics:

* parcel **size** (in acres)
* type of **land cover** (percent in forest, wetland, beach, cropland or open water)
* quality of **wildlife habitat** (what species will the parcel support?)
* **groundwater** quality (contaminated? drinkable?)
* **surface water** quality (drinkable? swimmable? fishable?)
* type of **public access** to be permitted (none? hiking? camping? hunting?)
* **type of protection** (outright purchase? easement purchase? gift?)
* the **cost** of protecting the parcel.

Please look over all seven parcel descriptions on the back of this page. If these parcels were candidates for protection under the Greenspaces Program under the stated terms, how would you **rate each** of them on a **rating scale of 0 to 10** (ranging from 0="reject absolutely" up to 10="absolute top priority").

PARCEL A1: 50 acres: 70% prime cropland under cultivation, 30% brush and forest with stream.
Habitat supports songbirds, hawks, upland game birds, deer and other upland mammals.
Groundwater is pure.
Surface water is clear, drinkable; diverse fish.
State buys conservation easement only; no public access allowed.
Acquisition cost: $1 (gift). RATING ______

PARCEL A2: 100 acres: 100% mixed hardwood/softwood forest with small pond.
Habitat supports Delmarva fox squirrel and other mammals, owls, songbirds.
Groundwater has trace pesticide runoff from neighboring cropland (atrazine) at one-tenth of the EPA's maximum safe standard.
Surface water is very shallow, murky, low in dissolved oxygen; low fish diversity.
State buys parcel for State Park; will be developed for general recreation.
Acquisition cost: $1,000/acre. RATING ______

PARCEL A3: 200 acres: 100% freshwater wetland, mostly under forest cover.
Habitat supports reptiles, amphibians, muskrat, otter, beaver, songbirds, owls, hawks.
Groundwater has pesticide runoff from neighboring cropland (atrazine) at one and one-half times the EPA's maximum safe standard.
Surface water suitable for swimming but too shallow, slight runoff from neighboring cropland; diverse fish.
State buys parcel for State Wildlife Management Area; no hunting.
Acquisition cost: $100/acre. RATING ______

PARCEL A4: 400 acres: 40% saltwater beach and dunes, 60% brush and forest.
Habitat supports piping plover, shore birds.
Groundwater contains nitrate runoff from neighboring cropland at one-half the EPA's maximum safe standard.
Surface water is clear, suitable for swimming but too shallow; diverse fish.
State buys parcel for State Wildlife Management Area; hunting permitted.
Acquisition cost: $1,500/acre. RATING ______

PARCEL A5: 800 acres: 30% old field, 70% mixed hardwood/softwood forest with stream.
Habitat supports songbirds, owls, hawks, deer and other upland mammals.
Groundwater has pesticide runoff from neighboring cropland (atrazine) at one-half of the EPA's maximum safe standard.
Surface water is murky, suitable for canoeing, very low in dissolved oxygen; very few fish.
State buys conservation easement only; owner permits both camping and hunting.
Acquisition cost: $250/acre. RATING ______

PARCEL A6: 1,200 acres: 80% mixed hardwood/softwood forest with streams, 20% large pond.
Habitat supports songbirds, owls, hawks, reptiles, amphibians, muskrat.
Groundwater has not been tested.
Surface water too shallow for swimming, slightly brackish; moderate fish diversity.
State buys conservation easement only; owner permits camping, no hunting.
Acquisition cost: $2,500/acre. RATING ______

PARCEL A7: 2,000 acres: 80% open coastal wetland, 20% cropland under cultivation.
Habitat supports bald eagles and other raptors, migratory waterfowl, reptiles, amphibians, muskrat, otter, beaver.
Groundwater has pesticide runoff from neighboring cropland (atrazine) at one-fifth of the EPA's maximum safe standard.
Surface water is clear, swimmable, not recommended for drinking; diverse fish.
State buys conservation easement only; walking on trails only.
Acquisition cost: $500/acre. RATING ______

Appendix D: Summary of Conjoint Ratings

	RATING											
CARD	0	1	2	3	4	5	6	7	8	9	10	TOTAL
A1	4	3	4	2	3	10	4	7	6	10	74	127
A2	3	0	5	3	8	23	10	10	24	16	20	122
A3	3	1	5	5	3	12	13	16	20	15	32	125
A4	1	0	2	9	3	13	10	17	22	13	35	125
A5	3	2	7	8	9	18	16	12	19	5	26	125
A6	17	4	7	6	15	23	10	8	23	4	5	122
A7	0	2	1	1	5	8	11	12	19	16	48	123
B1	9	5	7	8	4	17	8	16	17	9	32	132
B2	4	0	6	3	3	16	10	18	21	12	37	130
B3	19	10	12	15	16	17	7	9	13	5	6	129
B4	2	0	1	0	2	6	5	8	21	19	67	131
B5	7	5	3	10	14	22	8	14	25	11	10	129
B6	5	0	3	5	4	14	8	11	27	21	34	132
B7	3	1	3	2	3	6	4	4	8	11	87	132
C1	6	2	4	5	5	14	7	9	26	9	40	127
C2	12	5	2	13	10	37	11	7	17	3	9	126
C3	1	2	1	6	5	20	14	14	27	11	27	128
C4	7	3	8	10	16	16	9	9	18	8	22	126
C5	14	6	6	10	12	18	6	13	12	9	20	126
C6	0	1	4	2	2	4	4	2	11	10	88	128
C7	4	3	7	2	4	15	11	13	17	11	39	126
D1	3	1	4	2	2	12	12	9	21	8	37	111
D2	2	3	2	2	4	6	7	5	19	14	45	109
D3	6	4	3	13	11	18	5	8	15	6	21	110
D4	3	2	5	7	5	18	10	12	19	6	22	109
D5	3	3	2	5	1	5	2	6	11	5	68	111
D6	10	3	8	14	9	31	10	6	7	6	5	109
D7	10	6	4	3	7	24	4	6	12	12	23	111
E1	13	8	12	9	9	21	11	6	14	5	5	113
E2	10	8	8	9	5	22	6	6	10	6	23	113
E3	2	2	4	5	2	15	6	12	25	13	27	113
E4	2	1	4	5	3	5	6	5	12	14	56	113
E5	3	1	3	6	6	15	13	12	20	6	26	111
E6	0	4	2	3	1	5	6	12	16	17	45	111
E7	4	5	8	5	6	10	8	12	15	9	30	112
F1	12	2	5	7	10	22	8	9	22	2	17	116
F2	6	0	7	4	6	19	11	11	23	7	23	117
F3	1	0	1	2	3	8	8	1	18	7	66	115
F4	15	2	10	12	9	21	8	13	11	6	8	115
F5	1	1	2	0	3	13	6	7	14	17	52	116
F6	3	1	2	5	5	20	6	6	20	13	34	115
F7	1	1	6	6	3	14	9	11	26	7	32	116
G1	2	1	7	5	7	22	16	13	23	7	22	125
G2	2	2	2	1	3	6	5	8	14	6	77	126
G3	5	3	5	1	6	18	7	3	31	16	32	127
G4	6	7	2	10	9	15	10	17	22	10	16	124
G5	5	3	7	5	8	24	4	9	25	11	24	125
G6	3	5	8	8	7	19	7	8	23	4	35	127
G7	10	2	10	7	7	10	7	5	12	5	25	100
TOTAL	267	136	241	286	303	767	404	467	893	473	1654	5891