Ex Ante Valuation of Atmospheric Visibility

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ABSTRACT

In a world of incomplete markets for environmental goods, ex ante planned expenditures rather than ex post realized outcomes explain the values individuals attach to these goods. We use the distance function to develop restrictions from a model of ex ante consumer behavior involving these goods. A contingent valuation approach is then employed to estimate policy-relevant components of the ex ante economic values that recreationists attach to differing subjective probabilities of alternative atmospheric visibility levels at a wilderness location and at an urban location in Oregon. Marginal valuations of probability changes are similar at the two sites. Marginal rates of time preference for resolving uncertainties vary between 10 and 50 percent and are inversely related to education. Existence value averages 10 percent of total value, and evidence is mixed that site-specific values act as surrogates for general environmental preferences.

I. INTRODUCTION

> "Landscape perception and the impulse to preservation of place is, perhaps, no more or less an authentic existential act, free of deterministic rationalism, undertaken as a way to dignify a man and to make his surroundings more humane... In these technologically parlous times, the impulse born of aesthetic perception and the fruitless search for Eden is, surely, absurd. But it is authentically affirmative of life. What further argument for landscape preservation is needed?" (Little, 1975, p. 50)

A search for an Eden in which nothing disturbs aesthetic and moral visions of nature may well be absurd. Nevertheless, in the United States, the 1977 Clean Air Act Amendments (PL95-95, 91 Stat. 731) and other environmental laws demand a public conscience which strives for something less than Eden and which insists that the nothing less be rationalized. The Amendments demand justifications for landscape preservation or restoration that offer more information than can entreaties about existential acts authentically affirmative of life.

If consumer sovereignty commands respect, public environmental control authorities must incorporate into policy decisions individuals' preference revelations for alternative environmental states. These revelations and their consumer welfare implications can be measured either ex ante or ex post. The ex ante measure, the option price, is the compensation paid or received to restore expected utility given a change in the expected environment. Expected consumer's surplus, the ex post measure, is the Marshallian or Hicksian surplus evaluated after the true state of nature is revealed. Buchanan (1969) and Helms (1985) demonstrate that the ex ante measure is the less restrictive of the two since it captures risk attitudes -- the precise factor of interest when the exact environmental consequences of a policy choice are uncertain. Therefore, in a world of incomplete markets for environmental goods, ex ante planned expenditures rather than ex post realized outcomes explain choice and welfare.

An ex ante approach is especially appropriate when estimating the value of atmospheric visibility in landscapes. Prospective visibility levels are inherently uncertain, implying that individuals and policymakers must allocate resources based on the perceived probability that a particular visibility state will occur at a particular time and place. Studies about the value of visibility have appeared for at least fifteen years.[1] The sequence of studies perhaps represents the most complete example of the evolution of nonmarketed environmental good valuation techniques. Nevertheless, they examine rather restrictive problem dimensions relative to the choices individuals and policymakers actually confront. The stochastic and the intertemporal features of visibility changes have been totally neglected, and the physical and spatial features of the individual's decision problem have sometimes not been fully defined. Similar inattentions to important dimensions of policy choices are found throughout the nonmarketed goods valuation literature. In this paper, we show that the contingent valuation method (CVM) is easily made to fit the dimensions of policy choices, dimensions that form nearly every environmental good. In addition, we provide empirical insights into the roles that each of these dimensions play in individuals' atmospheric visibility valuations.

We use CVM to construct four contingent claims markets in which the physical, stochastic, spatial, and intertemporal properties of access to visibility states are varied. Our study builds upon previous ex ante valuation studies (see for example Brookshire et al., 1983, and Desvousges et al., 1987) of environmental goods in four key ways. First, we elicit the individual's subjective probabilities of alternative visibility states, thereby allowing his personal risk perceptions to influence his valuations of differing access contingencies. Previous studies provided each respondent with a uniform "objective" probability selected by the researchers and then elicited valuations based on changes in this probability. These earlier approaches did not recognize that different people may have different perceptions of the probability of an event.

Second, we provide the first test of Kahneman's (1986) conjecture that site-specific values in CVM merely act as surrogate measures for general environmental preferences. If Kahneman is correct, then site-specific nonmarket valuation studies using CVM will not provide useful information for the specific amenity in question.

Third, we estimate marginal rates of time preference for improved visibility. Finally, we supply estimates of the existence value of improved visibility.

The paper proceeds as follows. In the next section, we develop a model of ex ante visibility valuation. Section 3 describes a CVM design consistent with the ex ante valuation model. Empirical results are presented and examined in Section 4. The last section summarizes the paper and discusses its broader implications and limitations.

II. A MODEL

Below we use an explicit model of consumer behavior to develop restrictions that subsequently guide the interpretation of our empirical results. Specifically, we identify the parameters of four key dimensions of value relevant to atmospheric visibility and other environmental policy *decisions: option price, marginal rates of time preference, existence value, and location value.*

Definitions and Assumptions. Consider an individual who practices a two-stage budget allocation process. In stage one, he allocates his money income and leisure time in a weakly separable fashion between recreational activities and all other commodities. In stage two, he allocates his recreational budget, M, given a fixed, twice-differentiable, and quasi-concave von Neumann-Morgenstern subutility function, U. Assume this individual expects to derive utility from a vector of site-specific recreation activities, x, a site-specific level of atmospheric visibility, Q, and, following Smith (1987), a set of contingent claims, Z, defining the nonprice terms under which access to a site will be available. Hiking, camping, and travel to a site are examples of x-vector elements. The contingent claims are defined over the physical, stochastic, spatial, and intertemporal properties of access. Let p represent the vector of exogenous money and time prices for x, where the elements of x are measured in terms of annual site-specific participation or visit frequencies.

Further assume that the individual's total visits to all sites and that the sequencing and allocation of his total visits among sites are invariant. Suppose that there exists a finite, nonzero equilibrium price at which a fixed length specific site visit, $\bar{x}_k$, $k = 1,\ldots,n$, would be made when x_k is a choice variable.

Let Q be uncertain. Suppose that Q_i, $i = 1,\ldots,n$, represents alternative visibility states. Because his total site visits and their allocation and sequence are invariant, Q_i is exogenous to the individual.

Let $\pi_i(A)$ *be his subjective probability of state i occurring at site* $\bar{x}_k$ *conditional on the ambient air pollution concentrations, A.*

Finally, Z_{ijk} *is a freely and fully enforceable access claim or contract to a visibility state,* Q_i*, at a time j, j = 1,...,t, at a site* $\bar{x}_k$*. Let* β_{ijk} *be the normalized price for this access claim.*

<u>The Distance Function</u>. With the planned expenditure function of Helms (1985) and Smith (1987), the individual chooses an expenditure-minimizing quantity of a contingent claim for a visibility state subject to a fixed ex ante level of expected utility, $\bar{V}$*:*

$$\bar{c}(\beta_{ijk};\ \bar{x};\ p;\ \bar{V};\ \pi_1(A),\ldots,\ \pi_n(A);\ Q_1,\ldots,Q_n)$$

$$= \min_{Z_{ijk}} \sum_i \sum_j \sum_k \beta_{ijk} Z_{ijk} + p\bar{x} \tag{1}$$

$$\text{subject to } \bar{V} = \sum_i \pi_i U_i(\bar{x},\ Q_i,\ Z_{ijk}),$$

where, given the invariance of visits, $\bar{c}(\bullet)$ *is the restricted cost of utility or expenditure function for a given level of expected utility. This expenditure function is consistent with the dichotomous choice (yes/no) approach used in some recent CVM studies, e.g., Hanemann (1984). The individual is presented with a price,* β_{ijk}*, for a posited contingent claim, and is then asked if he would purchase a particular quantity of the claim.*

The expenditure function in (1) is not immediately translatable, however, into the traditional CVM elicitation process, e.g., Brookshire <u>et al</u>. (1983), where a quantity of an investigator-supplied contingent claim is described to the respondent and he is then asked to state the price he would pay to secure it. A distance function, which Deaton (1979) shows to be the dual of the expenditure function, accurately describes this version of the *decision problem. Given that visits are not a choice variable, we follow Deaton (1979) and Pauwels (1988) and define the restricted distance function, $\bar{d}(\bullet)$ as*

$$\bar{d}(Z_{ijk}; \bar{x}; p; \bar{V}; \pi_1(A), \cdots, \pi_n(A); Q_1, \cdots, Q_n)$$

$$= \min_{\beta_{ijk}} \sum_i \sum_j \sum_k \beta_{ijk} Z_{ijk} + p\bar{x} \tag{2}$$

$$\text{subject to } \sum_i \sum_j \sum_k \bar{c}(\beta_{ijk}; \bar{x}; p; \bar{V}; \pi_i(A); Q_i) = 1.$$

Pauwels (1988) shows that differentiation of the restricted distance function with respect to a Z_{ijk} yields the restricted compensated inverse demand function with marginal willingness to pay as a function of utility and the Z_{ijk}.[2/]

Given (2), we now examine the ex ante compensating surplus measures of value, the β_{ijk}, for four contingent claims defining conditions of access to Q_i: (a) the value (option price) of changing the probability of securing an access claim to Q_i; (b) the value (time preference) when an already secured access claim to Q_i is delayed until the t^{th} time period; (c) the value that remains (existence value) after removing an already secured access claim from the choice set; and (d) the value added (locational value) when an already secured access claim is extended from one site to a set of k sites.

<u>Option Price</u>. For a specific site and time the individual's restricted option price, $\overline{OP}_i$, for a change from π_i^0 to π_i^1 in the probability of securing an access claim to the ith visibility state (level) is

$$\overline{OP}_i = \bar{d}(Z_{ijk}; \bar{x}; p; \bar{V}; \pi_i^0; Q_i) - \bar{d}(Z_{ijk}; \bar{x}; p; \bar{V}; \pi_i^1; Q_i). \tag{3}$$

$\overline{OP}_i$ is thus the change in planned expenditures on Z_{ijk} to be allowed the

individual if he is to be indifferent between π_i^0 and π_i^1. When there are n states, $\overline{OP}$ is the average of the changes in planned expenditures that must be allowed him if he is to recover his initial expected utility level.[3] If the individual's expected utility function is concave in the Q_i, Jensen's inequality implies that $\overline{OP}_i$ will be greater than the income change required to recover the individual's expected utility level after the realization of what was the average of the visibility states. The difference represents a risk premium which incorporates risk attitudes and risk beliefs or perceptions. The premium changes as the subjective probability density function changes (Helms, 1985).

Time Preference. The outcomes of programs to alter environmental amenities are not instantaneously realized and abandoned, nor are the alterations necessarily permanent. At a specific site, the individual values a delay from t = 1 to t = n, n > 1, in securing an access claim to a particular subjective probability, π_i^0, of the i^{th} visibility level as

$$\overline{DV}_i = \bar{d}(Z_{i1k};\ \bar{x};\ p;\ \bar{V};\ \pi_i^0;\ Q_i) - \bar{d}(Z_{ink};\ \bar{x};\ p;\ \bar{V};\ \pi_i^0;\ Q_i). \qquad (4)$$

Estimation of $\overline{DV}_i$ allows the individual's marginal rate of time preference to be directly inferred using the appropriate present value and discounting formulae.

Existence Value. Starting with Krutilla (1967), economists have repeatedly argued that an individual can value an amenity without ever using it or planning to use it. Within our framework, this implies that the individual would value some particular probability of provision of Q_i at a specific site and time even though any claim of access to this Q_i is completely removed from his choice set. Thus existence value, $\overline{XV}_i$, is

$$\overline{XV}_i = \bar{d}(Z_{1jk}, Z_{2jk}, \ldots, Z_{njk}; \bar{x}; p; \bar{V}; \pi_i^0; Q_i) - \bar{d}(Z_{2jk}, \ldots, Z_{njk}; \bar{x}; p; \bar{V}; \pi_i^0; Q_i). \tag{5}$$

Location Value. Finally, we examine how ex ante valuations of an access claim to Q_i vary with the spatial coverage of the claim. Thus location value, $\overline{LV}_i$, is

$$\overline{LV}_i = \bar{d}(Z_{i1\tau}; \bar{x}; p; \bar{V}; \pi_i^0; Q_i) - \bar{d}(Z_{ijk}; \bar{x}; p; \bar{V}; \pi_i^0; Q_i), \tag{6}$$

where τ is the union of locations, $k = 1, \ldots, m$. A small or zero magnitude for $\overline{LV}_i$ would be consistent with Kahneman's (1986, pp. 190-193) conjecture that site-specific value statements in contingent valuation experiments are really surrogates for attitudes about environmental quality, broadly conceived.

III. THE CONTINGENT VALUATION EXPERIMENT

The Design. The CVM questionnaire was built around computer-generated haze levels superimposed upon an 8 x 10 inch color photograph of a vista from a Central Oregon Cascades wilderness site and an 8 x 10 inch color photograph of a vista from a Portland, Oregon, urban park site. The Cascades images depicted a hilltop view toward heavily forested lesser hills, while the Portland images represented the view of Mount Hood obtained looking east from the hills lying immediately to the west of the city's downtown area. Visual ranges for the Cascades simulations were 309, 121, 88, and 53 kilometers; the Portland simulations portrayed ranges of 82, 43, 30, and 20 kilometers. For each site, these distances corresponded respectively to the 90th, 50th, 20th, *and 2.5th percentiles of the visual range cumulative distributions (Core, 1985). For concreteness, all interviews were conducted outdoors in late summer 1985, in the immediate vicinities of the photograph sites.*

The questionnaire at each site proceeded in three steps. First, the respondent was asked to rank-order the four depicted vistas from his most to his least preferred. Second, he was asked to state the percentage chances during his visit (Cascades) or his summertime presence in the city (Portland) that his most and his least preferred vistas would occur. Finally, in accordance with (2), he was asked to estimate his marginal willingness to pay for each of a series of contingent claims defining changes in access conditions for the four vistas. This three-stage structure allowed the respondent first to frame and then to solve his decision problem. Separation of the ordering and the value estimation processes reduces the complexity of the respondent's task and conforms to the Slovic and Lichtenstein (1968) view of decision making in which the framing phase precedes the evaluation phase.

In the third step, each respondent initially estimated (3), his option price for an access claim supplied by a special fund that would guarantee provision of each of the appropriate four vistas during his current visit (Cascades) or during the current summer (Portland). The respondent was __*not*__ *allowed to adjust visit or activity patterns during this third step.*[4] *Cascades respondents estimated their option prices in terms of a daily access fee over and above any entrance fee that they had already paid. In Portland the respondent was asked to estimate his one-time option price.*[5]

The starting bid point for a claim guaranteeing provision of a Cascades respondent's most preferred vista was \$3.00, with intervals varying between \$0.50 and \$4.00 according to the interviewer's perception of the respondent's impatience; the Portland starting point was $40.00, with intervals spread from $1.00 to $20.00.[6] This iterative value estimation procedure applied only to the respondent's most preferred vista. Once he had settled upon his maximum payment for this vista, he presumably had enough information about his preferences to allow him to state without further prodding his option prices for the three remaining vistas. Finally, the respondent estimated the time preference, existence, and location values in (4), (5), and (6) by adjusting his option price statement for his most preferred vista.

IV. EMPIRICAL RESULTS

Data Properties. Data were obtained from 99 Cascades and 67 Portland interviews.[7] The Cascades sample retains all completed interviews; the Portland sample excises a single completed interview with a 13-year-old female. Both samples had very similar demographic features. Twenty-three Cascades respondents were engaged in multiplepurpose trips. The median round trip mileage for the Cascades sample was substantially less than the arithmetic mean. Respondents' visits to the Portland site were nearly always an interlude in a round of daily activities.

The expected visual ranges of 134 km in the Cascades and 47 km in Portland were calculated by weighting the visual ranges in each respondent's most and least preferred vistas by the respective subjective probabilities that he had assigned, splitting the residual probability equally between the two remaining visual ranges, and then summing over the four probability-weighted visual ranges. The resulting arithmetic means taken over all respondents exceed by 10 percent the actual visual range medians of 121 km in the Cascades and 43 km in Portland. However, respondents' perceived *probabilities of their most and their least preferred vistas exceeded the true probabilities by a factor of two or more, thus supporting findings of Lichtenstein et al. (1978) and Machina (1982) that people tend to over-assess low probability events.*

<u>Preference Expressions</u>. No outright preference reversals occurred between any respondent's initial rank-ordering of vistas and his marginal value estimates, although equal estimates were frequently provided for vistas which the respondent had earlier strongly rank-ordered. Every respondent's rank-orderings and technical rank-orderings of vistas with the two greatest visual ranges were identical at each site. Tables 1a and 1b present statistics for respondent estimates of the option price, $\overline{OP}_i$. *Given independence of respondent subjective probability estimates and value estimates of vistas, the tables report the average respondent's marginal willingness to pay for a claim securing a change from the probability he had earlier assigned the occurrence of each vista to the guaranteed provision of the vista. For example, the $4.04 figure in the 309 km column of Table 1a says that the average respondent was willing to pay this amount in order to secure a claim that would increase the chance of this vista being realized from 35 percent to 100 percent, where 35 percent is the arithmetic mean of Cascades respondents' perceived chance of their most preferred vista. This respondent's expected compensating surplus was calculated by weighting the option prices he estimated for claims securing his most and least preferred vistas by their respective subjective probabilities of occurrence, splitting the residual probability equally between his option prices for claims securing the two remaining vistas, and then summing arithmetically across the four vistas. A Wilcoxon signed rank test for matched samples did not accept at the*

95 percent confidence level the null hypothesis of equality of option prices for the elements in the six possible pairs of vistas for each sample in Tables 1a and 1b. The entitlement which the willingness to pay measure implies does not allow a respondent value estimate to be less than zero in Portland, or less than the access fee he had already paid in the Cascades.

Tables 2a and 2b present the statistics for the second, third, and fourth contingent claims markets; that is, the representative respondent's value estimates for guaranteed provision of his most preferred vista given a claim to a change in the posited time horizon, $\overline{DV_i}$, the choice set, $\overline{XV_i}$, and the spatial extent, $\overline{LV_i}$. When the data for DV_i is used to estimate marginal rates of time preference for resolving visibility uncertainties, the Cascades sample produces arithmetic mean rates of 10.0 percent for a 2-year delayed resolution and 49.7 percent for a permanent resolution. For the Portland sample the implied mean marginal rates are 17.8 percent for a 2-year delayed resolution and 45.1 percent for a 10-year resolution.[8] These estimates lie considerably above the 1.0 to 3.5 percent rates that the respondents in Brookshire et al. (1983) estimated for Wyoming game animal habitat. They correspond rather well, however, to the 20-50 percent subjective discount rates that Hausman (1979), Houston (1983), and Hartman and Doane (1986) found for energy using household durables and that Friedman (1962) and Fuchs (1982) found for human health and capital.

For $\overline{XV_i}$, arithmetic mean respondent value estimates when there was no access claim to a permanent (Cascades) or to a 10-year guaranteed resolution (Portland) of the most preferred vista were about 10 percent of the value estimates for the identical resolutions when the claim was available. Although 10 percent is not a negligible portion of total ex ante value, it is *far short of the greater than 50 percent estimate that Schulze et al. (1983) produced for the existence value of visibility in the Grand Canyon.*

The fourth contingent claims market estimated marginal willingness to pay when the claim to the visual range in each respondent's most preferred vista was extended throughout the State of Oregon. Use of the Wilcoxon signed rank test to evaluate the null hypothesis of the equality of the mean total payments for this extension, $\overline{LV}_i$*, and the mean payments for the most preferred vistas,* $\overline{OP}_i$*, resulted in the hypothesis not being rejected at the 90 percent confidence level for the Portland sample. It could not be rejected at the 60 percent level for the Cascades sample. Thus, especially for the Portland sample, it is plausible that many respondents treated the local visual range as a surrogate for visual range throughout Oregon. Alternatively, they may have been indifferent to conditions elsewhere. These results provide mixed support for Kahneman's (1986) conjecture that option payments act as surrogate measures of general preference for environmental amenities.*

<u>*Explaining Respondent Willingness to Pay Estimates*</u>*. The restricted inverse Hicksian demand function in (3) has the access claim terms, the prices of recreation activities, the utility level, predetermined visits, and the probabilities of visibility states as its arguments. Access claim terms are identical for each respondent in each sample. Price measures employed are the simple sum of respondent travel costs at 30 cents per mile and on-site costs for the current visit, as well as respondent-estimated expenditures for a single incident of the respondent-selected substitute activity. For the Cascades sample, travel costs were weighted by the respondent's interview site visit days as a fraction of total trip days. The opportunity cost of time is represented in the Cascades sample by a dummy variable indicating whether the*

individual was foregoing current income during his site visit.[9] *In the Portland sample the respondent's estimate of the costs of his visit included lost wages. Variables representing respondent education, length of residency, annual visits, and frequency of outdoor activities mirror differences among respondents in tastes and in prior beliefs. Note again that neither our model formulation nor our respondents treat annual visits and activity frequencies as choice variables. Expected visual range is the visibility level that must be exceeded if the respondent is to make a positive willingness to pay estimate. Other than the depicted visual ranges, we treat all variables as linear. In accordance with Fechner's law, the depicted visual ranges are entered in their natural logarithms.*[10]

Out of their 396 estimates of the willingness to pay for access claims, $\overline{OP_i}$, *Cascades respondents made 181 estimates of zero, where each respondent value estimate-visual range combination is treated as a distinct observation.*[11] *The 268 Portland respondent willingness to pay estimates contained 123 zeroes. There was no upper bound to the willingness to pay that a respondent could estimate; he was not required to choose among discrete willingness to pay categories; and the exogenous variables in (3) were observed irrespective of whether he had a zero or a positive willingness to pay. These facts justify application of the Tobit transformation to (3), given that the error term is independently and identically distributed with mean zero and constant variance [McDonald and Moffitt (1980)]. Tables 3a and 3b display the resulting parameter estimates for each sample. The Portland specification in Table 3b presumes that the factors influencing the respondent's willingness to pay for visibility improvements at any site in the* *urban area are identical to those influencing his willingness to pay at the interview site.*

With the exception of the statistically insignificant "cost of visit" variable in Table 3a, all price coefficients in both tables have the expected signs: as the cost of the respondent's visit and his foregone income increases, the value he acquires at the interview site declines; as the price of a substitute increases, the value at the site increases. The positive signs attached to the education coefficients are consistent with heightened sensitivities to differences among claims to the "qualities" of natural environments, whatever the sources of these differences. The educated individual may be a more efficient producer of environmental services (Michael, 1973). The statistical performances of the other taste and prior belief variables differ drastically between the two samples. Only in the Cascades sample do they exert a fairly significant influence.

Expected visual range, because it could be lower or higher than the particular range that the respondent was asked to value, could have a coefficient of either sign. The positive coefficients attached to ln (visual range) imply that willingness to pay increases at a decreasing rate as visual range increases. The percentage rates of decrease in each sample are similar.

<u>Implicit Discount Rates</u>. If different groups of individuals use disparate implicit discount rates in evaluating the own-effects of a project, attempts by policymakers to override these time preferences may cause unintended and possibly undesired results. Scholastic searches for a unique market rate are irrelevant if intertemporal opportunities to trade are seriously impaired and if these opportunities vary widely among groups. Therefore, even if the mechanism of the individual's discount rate choice is

not derived from first principles, the ad hoc association of the results of this choice with various individual attributes is of interest.

Only years of education displayed a statistically significant (one-percent level, one-tailed test) coefficient in ordinary-least-squares regressions to predict the discount rates that respondents applied to a claim to permanent attainment (Cascades) and to 10-year attainment (Portland) of their most preferred vistas.[12/] *Cascades respondents, on average, reduced the discount rates they applied by 7.2 percent with each additional year of education; Portland respondents reduced theirs by 6.6 percent. Variables representing Portland residency, annual outdoor recreation days, and age exerted no statistically significant influence upon the discount rates that Portland respondents applied. Similarly, Oregon residency, annual visits to the interview site, and age had no statistical influence upon Cascades respondents' implicit discount rate choices.*

V. CONCLUDING COMMENTS

This paper provides estimates in an explicitly ex ante, stochastic, and intertemporal setting of the site-specific values of claims to urban and to wilderness atmospheric visibility improvements. These estimates provide upper bound measures of value since respondents were unable to vary visit numbers in response to visibility changes. The main empirical findings are that: option price payments for claims guaranteeing access to improved visual ranges increase at a decreasing rate; the percentage rates of decrease at a wilderness site and at an urban site are similar; marginal rates of time preference for resolving uncertainties about visual ranges vary between 10 and 50 percent and are inversely related to education; existence value averages 10 *percent of total value; and evidence is mixed of site-specific values acting as surrogate measures for general environmental preferences.*

We close by discussing the broader implications of our work on the nonmarket valuation of environmental phenomena. First, individual decisions are inherently ex ante, implying that planned expenditures rather than realized costs explain individual choice. As shown by Helms (1985), the relevant measure of ex ante value refers to changes in the level of uncertainty for provision of a given level of a resource rather than a change in the resource level itself. By allowing respondents to rank order preferred resource levels, state their perceived likelihood of future provision of each level, and finally reveal their willingnesses to pay for an increase in likelihood of provision, our approach captures the correct definition of ex ante value. The empirical results reported herein demonstrate that this definition of ex ante value can be measured in a straightforward manner.

Second, our approach allows us to expand the dimensions of past CVM exercises involving atmospheric visibility and other environmental goods to match heretofore disregarded dimensions of policy choices. By focusing respondent attention on policy-relevant dimensions of choice, we are able to inform policymakers of the absolute and the relative weights individuals attach to these dimensions.

Lastly, we acknowledge a significant limitation that the employment of respondent degrees of belief rather than technical "objective" probabilities imposes upon the usefulness of these results. Each respondent's degrees of belief were employed to calculate his expected visual range. Consequently, as the Tobit estimates demonstrate, the value (compensating surplus) he attached to a claim for a change in the probability of a visibility level was sensitive *to whether this level was greater than or less than his expected level. The respondent was in essence asked to treat his expected level as a prior entitlement. These entitlements differed across respondents. The differing entitlements resulting from discrepancies across respondents' degrees of belief about identical objective visibility levels inhibited any effort to develop equivalent surplus and compensation-demanded measures of value. Valuations across respondents would then have been noncomparable because different value measures would have been applied to identical objective visibility levels.*

TABLE 1a

Cascades: Willingness to pay per Day of Current Visit

Visual Range (km)	309	121	88	53
Median payment	$2.50	$2.00	$ 0	$ 0
Arithmetic mean payment	4.04	3.00	0.89	0.42
Standard deviation	5.49	4.18	1.65	1.27

Expected visual range = 133.56 km

Expected surplus = $1.96

TABLE 1b

Portland: Willingness to pay During 1985 Summer

Visual Range (km)	82	43	30	20
Median payment	$ 60.00	$40.00	$ 0	$ 0
Arithmetic mean payment	93.36	57.00	16.95	3.38
Standard deviation	172.41	94.45	38.45	5.13

Expected visual range = 47.02 km

Expected surplus = $44.10

TABLE 2a

Cascades: Willingness to pay per Day of Current 1985 Visit for Contingencies Attached to Most Preferred Vista

Contingency	Median Payment	Arithmetic Mean Payment	Standard Deviation
Delay resolution until Summer 1987	$2.00	$ 3.76	$ 5.52
Permanent resolution	8.00	11.48	37.67
No access claim, permanent resolution	0	1.12	2.70
Resolution throughout Oregon	3.00	6.64	14.73

TABLE 2b

Portland: Willingness to pay in Summer 1985 for Contingencies Attached to Most Preferred Vista

Contingency	Median Payment	Arithmetic Mean Payment	Standard Deviation
Delay resolution until Summer 1987	$ 42.00	$ 61.64	$ 83.76
Permanent resolution	200.00	262.48	372.71
No access claim, permanent resolution	0	23.51	38.92
Resolution throughout Oregon	70.00	117.57	217.32

TABLE 3a

Cascades: Tobit Estimates of Willingness to pay
$ Per Day of Current Visit

Variable	Normalized Coefficient	Asymptotic t-Value
Constant ($)	-7.508	-11.014
Cost of visit ($)	$.760 \times 10^{-3}$	.867
Substitute expenditures ($)	$.119 \times 10^{-2}$	2.612
Foregone income (1=yes; 0=no)	- .253	2.437
Education (years)	.161	6.433
First visit (1=yes; 0=no)	- .417	- 2.340
Length of visit (days)	$- .535 \times 10^{-1}$	- 1.139
Expected visual range (km)	$.498 \times 10^{-2}$	2.997
ln Visual range (km)	.943	10.122

Log-likelihood function	-734.164
Observations at limit	181
Observations not at limit	215
Standard error of estimate	4.827
$\bar{R}^2$	.271

TABLE 3b

Portland: Tobit Estimates of Willingness to pay
$ Per Year

Variable	Normalized Coefficient	Asymptotic t-Value
Constant ($)	-5.626	- 6.949
Cost of visit ($)	$-.230 \times 10^{-2}$	- 2.723
Substitute expenditures ($)	$.246 \times 10^{-2}$	1.218
Education (years)	.100	3.318
Annual outdoor recreation (days)	$.438 \times 10^{-3}$	.502
Portland area residency (years)	$-.712 \times 10^{-3}$	- .149
Expected visual range (km)	$-.164 \times 10^{-1}$	- 1.755
ln Visual range (km)	1.290	8.796

Log-likelihood function	-972.415
Observations at limit	123
Observations not at limit	145
Standard error of estimate	136.520
$\bar{R}^2$	.182

FOOTNOTES

1/ See Randall et al. (1974), Rowe et al. (1980), Schulze et al. (1983), and Hanley (1988), for example.

2/ Anderson (1980) uses a distance function to show the inverse demand analogs to the well-known empirical restrictions (adding up etc.) on direct demand systems.

3/ This is a generalization of the Diamond and Stiglitz (1974) mean utility preserving spread. While working within a state-independent framework, they defined the spread as a change in the distribution of states that maintains utility but shifts the probability mass toward the tails of the distribution. A state dependent utility treatment allows utility to increase in some states and decrease in others if average utility taken across states is unchanged.

4/ At first glance it may appear overly restrictive to assume visits are fixed, since efficient responses to changes in nonmarket goods include changing the number of visits. An effective CVM approach, however, must control n-1 parameters, only allowing one parameter (environmental quality) to vary. In many previous CVM studies, one cannot determine if respondents were allowed to vary more than one parameter, thereby creating a confounding problem. To avoid this, we explicitly control for substitution by not allowing it to occur. According to the Le Chatelier principle, relaxing this assumption would simply imply a decreased value for the good in question. Therefore, one can view our restricted measure of value as an upper bound.

5/ Mitchell and Carson (1988) favor discrete choice referendum methods, e.g., Hanemann (1984), rather than direct willingness to pay methods in CVM. Discrete choice methods ask the respondent to rank alternatives from most to least preferred, given their associated prices. They argue that referendum methods accord much more closely to individuals' normal market experiences than do the direct inquiries into willingness to pay that we adopt here. They may be correct. However, Mitchell and Carson (1988) disregard numerous analytical and practical difficulties of the referendum method. They do not make it clear why having respondents express less information about preferences is desirable. Moreover, they fail to note that the discrete choice method when applied to risk problems requires independence of alternatives. Finally, empirical results obtained with referendum methods for environmental goods have not been especially robust. Incorrect signs have appeared on price and income terms and the explanatory power of key parameters has often been weak.

6/ For a review of the controversy on "starting point bias," see Boyle et al. (1985), and Samples (1985). Those who express concern about this bias appear to attach no credence to abundant economic, e.g. Markowitz (1952), and psychological, e.g. Tversky and Kahneman (1981), arguments and evidence that the individual's decision problem is solved conditional upon a reference point or set rather than with respect to final wealth. If the individual chooses the reference point in addition to the value estimate, values estimates become noncomparable across individuals when they choose different, unobservable reference points. A finding of "starting point bias" fails to contradict the reference point view of decision-making.

7/ The final questionnaires resulted from a sequence of two pretest questionnaires given to 15 respondents at each site. Pretest and final questionnaire interviewers went though two one-hour training sessions conducted by an area survey consulting firm. Final questionnaires were administered by 4 employees of the Oregon Department of Environmental Quality.

8/ For the summer 1987 resolution the relevant formula is $\bar{W} = \bar{S}/(1+r)^2$, where W is the 1987 income equivalent, S is the 1985 income equivalent, and r is the discount rate the respondent used to estimate $\bar{W}$. For the permanent or the 10-year resolution the formula is $\bar{W} = \bar{S}[(1+r)^t - 1]/r(1+r)^t$, where t is respectively infinity or 10. Since $\bar{W}$, $\bar{S}$, and t are known, these expressions are solved for r. As the time horizon increases over which discounting occurs, the estimated rate will converge upon a maximum.

9/ This disregards the Chavas et al. (1989) finding that the commodity value of travel time is positive but only a small fraction of the wage rate.

10/ Fechner's law [Baird and Noma (1978)] of psychophysics states that the perceived strength of a just noticeable increment in a sensation (willingness to pay) is proportional to the logarithm of the stimulus (visual range).

11/ Each respondent made 4 value statements for $\overline{OP_i}$. Thus the individual's disturbance terms among his 4 statements could be correlated, implying a loss in estimation efficiency. If interest focuses on the visual range term, Tables 3a and 3b make it clear that little statistical efficiency would be gained by resorting to a seemingly unrelated regression technique.

12/ The value statements of 6 percent of the Cascades respondents and 10 percent of the Portland respondents implied zero rates of discount. An ordinary-least-squares regression intended to explain the 2-year attainment discount rates explained nothing. A majority of these rates were zero in each sample.

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TABLE A1

Cascades: Sample Attributes

Attribute	Number	Mean	Standard Deviation
Sample Size	99		
Oregon residents	87		
Visit length (nights)		1.56	1.70
First visit	13		
Trip length (days)		4.90	10.66
Trip expenditures		$ 81.53	$130.14
Trip mileage		390.08	559.11
Substitute trip expenditures		$101.39	$142.09
Could have worked	53		
Education (years)		15.40	2.43
Age (years)		38.67	12.30
Expected visual range (km)		133.56	33.39
Perceived chance of most preferred vista (percent)		35.30	16.60
Perceived chance of least preferred vista (percent)		23.30	12.90

TABLE A2

Portland: Sample Attributes

Attributes	Number	Mean	Standard Deviation
Sample size	67		
Portland area residency (years)		16.90	17.51
Annual site visits		9.24	31.41
Annual outdoor recreation (days)		74.80	69.34
Cost of visit		$ 31.99	$104.24
Cost of substitute		$ 15.74	$ 44.46
Education (years)		15.01	2.51
Age (years)		39.99	15.39
Expected visual range (km)		47.02	8.41
Perceived chance of most preferred vista (percent)		29.90	16.40
Perceived chance of least preferred vista (percent)		18.60	15.90