ECONOMIC VALUES, ETHICS, AND ECOSYSTEM HEALTH

Thomas P. Holmes and Randall A. Kramer

SCFER WORKING PAPER

No. 80

Holmes, Thomas P. and Randall A. Kramer. 1995. Economic values, ethics, and ecosystem health. Southeastern Center for Forest Economics Research, Research Triangle Park, NC. SCFER Working Paper No. 80, 25 pp.

About the Authors

Thomas P. Holmes is research forester, Southern Research Station, Research Triangle Park, NC 27709. Randall A. Kramer is associate professor, Duke University - School of the Environment, Box 90328, Durham, NC 27706.

Acknowledgments

This research was funded by the U.S.D.A. Forest Service.

About SCFER Working Papers

SCFER working papers are issued periodically by the Southeastern Center for Forest Economics Research for the purpose of sharing recent scientific findings of associates with other interested researchers. These papers are distributed in order to promote the timely release of new theories, data, and findings. Working papers represent preliminary research findings and readers are encouraged to contact the authors for more information. A complete list of SCFER working papers is available from the Center at P.O. Box 12254, Research Triangle Park, NC 27709. Selected papers are also available for download in Adobe Acrobat format at http://www.rtp.srs.fs.fed.us/econ/research/scfer/scferlst.htm.

ECONOMIC VALUES, ETHICS, AND ECOSYSTEM HEALTH

by

Thomas P. Holmes [1]

Southern Research Station

U.S. Forest Service

P.O. Box 12254

Research Triangle Park, North Carolina 27709

Randall A. Kramer

School of the Environment

Duke University

Durham, North Carolina 27708

1 Address all correspondence to this author.

Paper presented at the 1st International Symposium on Ecosystem Health & Medicine

Economic Values, Ethics, and Ecosystem Health

Thomas P. Holmes and Randall A. Kramer

Abstract - Economic valuations of changes in ecosystem health can provide quantitative information for social decisions. However, willingness to pay for ecosystem health may be motivated by an environmental ethic regarding the right thing to do. Counterpreferential choices based on an environmental ethic are inconsistent with the normative basis of welfare economics. In this paper, we examine some of the characteristics of willingness to pay values elicited using the contingent valuation method. Sequential contingent willingness to pay values for different levels of protection of high-elevation spruce-fir forests in the southern Appalachian Mountains were elicited from a random sample of households along with socio-economic and other information. An empirical analysis indicated that willingness to pay distributions and average willingness to pay did not vary with the level of protection. We discuss various factors that may explain our results including lexicographic preferences, low marginal values, lack of instrument sensitivity, or misrepresentation of the ecosystem services valued by the public. We conclude that

further theoretical development of the relation between ethical motivations and economic value is warranted.

I. Introduction

Public concern with sustainable economic development has helped bring prominence to ecosystem health as a broad social objective. As a normative concept, ecosystem health is an endpoint that captures an array of values related to moral, aesthetic, and instrumental concerns [Sagoff 1992]. The ability to articulate ecosystem health values in ways that are meaningful to policy formulation is a critical step in the design of improved programs of ecosystem management.

In this paper, we present a welfare economic approach to articulating values associated with forest health in the high-elevation spruce-fir ecosystem of the southern Appalachian Mountains. We recognize that economic paradigms are one of many potentially important methods for articulating ecosystem values. However, because welfare economic methods reflect the practical necessity of translating values into policy statements we argue that the economic method is particularly well suited for policy analysis.

Development of the contingent valuation method has allowed economic benefits to be estimated for environmental amenities that were previously non-quantifiable. However, significant concerns have been raised over the interpretability of suggested elements of amenity benefits including altuistic, intrinsic, and existence values. To the degree that willingness to pay values represent counterpreferential choices based on commitment to an ethical principle, they are not in accord with standard welfare economic theory.

II. Conceptual Issues

Economic values are derived from actual or intended behavior where the decision maker is faced with a trade-off. In making an economic decision, something of value must be sacrificed in order to gain the object of choice.

The welfare economic paradigm is concerned with the desirability of various policies that the government might undertake. The operational criterion that welfare economists utilize to evaluate a given policy is the *Pareto criterion*. This criterion states that a policy should be undertaken if it makes at least one person better off without making anyone worse off. Because there are very few, if any, policies that make no one worse off, this criterion is operationized by allowing the gainers from a policy change to potentially compensate the losers from that change. If the net gain of the potential transfers is positive, then the *potential-Pareto improvement* criterion says that the policy is socially desirable.

The value measure used in the implementation of the potential-Pareto improvement test is known as *Hicksian consumer surplus*. This measure is based on the principle of consumer sovereignty or the belief that the individual is the best judge of what provides her utility. Hicksian surplus is simply the area under the demand curve for a good or service that keeps the individual's utility constant at some reference level.

The reference level of utility for preventing an anticipated decline in ecosystem health is the utility associated with an unhealthy ecosystem. The *equivalent variation* form of the Hicksian surplus measure for

$$Total\ value \quad TV \quad [e(p_0,q_0,U_1) \quad Y_0] \quad [e(p_0,q_1,U_1) \quad Y_1] \quad Y_0 \quad Y_1 \qquad \textbf{(1)}$$

preventing anticipated ecosystem decline may be written as: where p is a vector of prices, q is a summary measure of ecosystem health, U is utility, and Y is the minimum amount of income required to maintain the reference utility level given prices and the level of ecosystem health. Because q_0 represents a higher level of ecosystem health than q_1, equation (1) represents an individual's *willingness to pay* (WTP) to prevent a decrease $q_0 - q_1$ in ecosystem health.

Environmental economists have developed a taxonomy of values related to natural areas. Although complete agreement on the definition of terms has not been reached, it is generally agreed that total economic value can be defined as the sum of *use value* and *passive-use value* (U.S. Department of Commerce 1993). *Use value* is the value experienced by individuals who actually use a natural resource. *Passive-use value* is the sum of *existence value*, or the value of simply knowing a natural resource exists even if active use is never intended, and values associated with potential future use either by oneself or others (Pearce and Turner 1990).

Our concern in this paper is that elicited willingness to pay values for amenities that contain substantial passive use components of value may reflect counterpreferential choices. A counterpreferential choice refers to choice based on commitment to an ethical principle (Brookshire, Eubanks, and Sorg 1986). Commitment may cause an individual to choose a less preferred item because it is the right thing to do: "One way to define commitment is in terms of a person choosing an act that he believes will yield a lower level of personal welfare to him than an alternative that is also available to him" (Sen 1977, p.327). Traditional welfare economic models are solely based on the concept of preferential choice - individuals make economic choices based on what they think will increase their personal welfare. Consequently, empirical evidence of counterpreferential choice will necessitate a rethinking of the standard economic models used for natural resource amenity valuation.

Within the economics profession it has been proposed that passive-use values may reflect lexicographic preferences (Edwards 1986, Edwards 1992, Stevens et al. 1991). The lexicographic decision rule uses a ranking criterion similar to that used for ordering words in a dictionary. The lexicographic rule always ranks one attribute of a decision problem above another. For example, a lexicographic decision maker that favors ecosystem health would always rank increments to ecosystem health as more important than any level of another attribute, such as cost. Because the lexicographic rule violates the continuity assumption, lexicographic preferences cannot be represented by a continuous utility function (Varian 1984).

Consider a minimum level of income Y^* below which more income is always preferred to ecosystem health and above which greater ecosystem health is alway preferred to income. Under this simple model, an individual with lexicographic preferences would be willing to pay the same amount to avoid any reduction in ecosystem health. Therefore, marginal ecosystem health values are zero (Edwards 1986).

We can evaluate the hypothesis that ecosystem health values represent lexicographic preferences by evaluating the the derivative of total economic value with respect to q:

$$MV \quad \frac{TV(p_0,Y;q)}{q} \tag{2}$$

If the marginal value MV > 0, then we can reject the hypothesis of lexicographic preferences.

Following Miller (1981), we represent passive-use by including resource stock in the individual's utility function. This representation is in keeping with other economic studies that use, for example, the number of animals protected as the existence good (Boyle et al. 1994). It is not clear that resource stock is the best measure of ecosystem health in terms of exactly what it is that people value. We return to this issue in the discussion of our results.

III. Procedures

Our experiment focuses on protection of the boreal montane forest ecosystem in the southern Appalachian Mountains. This ecosystem covers 26,610 hectares on the mountain tops and high ridges in Virginia, North Carolina, and Tennessee. The Great Smoky Mountains National Park contains about three-fourths of this ecosystem.

Since the 1950' there has been a dramatic increase in spruce-fir mortality occurring in this ecosystem. Using aerial photography, a recent inventory determined that in one-fourth of this area greater than seventy percent of the standing trees were dead (Dull et al. 1988). Decline of the spruce-fir forest is highly visible from roads and trails. The cause of the decline is generally attributed to the balsam wooly adelgid, an exotic forest pest accidently introduced from Europe. Also, there is professional concern that air pollution is a factor in the decline of these forests (Innes 1993).

A contingent valuation mail-out mail-back survey was used to gather information about household's willingness to pay for protection of the remaining healthy spruce-fir forests. The format of the survey and its implementation closely followed the Dillman (1978) method. The sampling frame was households living within a 500 mile radius (approximate one days drive) of Asheville, North Carolina. A sheet of color photographs representing three stages of forest decline and a map identifying the study area were included with the survey along with information about forest damage and forest protection programs.

We asked the following WTP questions:

(1) What is the most money you would pay each year in additional taxes to provide protection programs for spruce-fir forests along roads and trails in the southern Appalachian Mountains (which is about one-third of the remaining forest areas)? (circle one amount)

(2) What is the most money you would pay each year in additional taxes to provide protection programs for all of the remaining spruce-fir forests in the southern Appalachian Mountains? (circle one amount)

A comparison of responses to these questions forms the basis for our empirical analysis.

Two methods were used to elicit contingent values - payment card and dichotomous choice. In this study, we only reports results from the payment card observations. A comparison of results across value elicitation methods is presented elsewhere (Holmes and Kramer, forthcoming).

For the payment card method, respondents consider a list of values and circle a value that indicates their WTP for forest protection. Because payment card data presumably indicate the interval within which respondent's true valuation lies, a statistical method must be used to estimate the true underlying value. Simply choosing the midpoint of the interval and estimating a response surface with OLS regression leads to potentially biased parameter estimates and misleading inferences regarding average WTP (Cameron and Huppert 1991). To avoid these problems, we use the completely censored regression model.

This model assumes that the respondent's true but unobserved value (WTP_i) lies within the interval defined by lower and upper limits t_{li} and t_{ui} specified by adjacent payment card values. The probability that the respondent's true value falls within the interval reported by the payment card can be written as:

$$Pr(WTP_i\ (t_{li},t_{ui}))\quad Pr((t_{li}\quad x_i\text{â})/\text{ó} < z_i < (t_{ui}\quad x_i\text{â})/\text{ó}) \qquad \textbf{(3)}$$

where x_i is a vector of explanatory variables for individual ***i***, z_i is the standard normal random variable, â is a vector of behavioral parameters, and ó is the square root of the error variance. Because we assume that WTP is distributed lognormally, we use the log of the circled value as the dependent value in our analysis. Mean WTP_i is therefore estimated as exp(x_i'â)exp(ó^2/2).

IV. Empirical Results

The overall response rate was 52 percent of delivered surveys. Descriptive statistics for the variables used in the analysis are presented in Table 1. Circled WTP values ranged from $0 to $300. Thirty-four percent of the repondents gave a $0 WTP response to protect transportation and trail corridors while thirty-two percent of the respondents gave a $0 WTP response to protect all the remaining forests in this ecosystem.

For respondents who indicated that their WTP was $0 a follow-up question was asked to determine whether or not the response was a "protest response". Protests were identified if the respondent indicated either that they "should not have to pay" or that they "object to the question". Seventeen protest responses were identified and were deleted from subsequent analysis.

Table 2 shows the distribution of circled WTP values for protecting transportation/trail corridors and protecting all remaining forests. As can be seen, the distributions are quite similar. A likelihood-ratio test statistic for multinomial probabilities was computed (Kalbfleisch 1985, p.161). The results of this test provided no evidence that the WTP distributions were different.

Table 3 presents the completely censored regression models for protecting corridors and all reamining spruce-fir in the southern Appalachians. As can be seen, specific prior knowledge of the cause of forest decline, the number of days per year spent in outdoor recreation, and the log of income all have a positive effect on WTP while age has a negative effect. Because the dependent variable in these regressions is the logarithm of WTP, the values of the parameter estimates on the logarithm of income represent income elasticity of demand. Our results indicate that demand is relatively income inelastic and elasticity is somewhat higher for protecting all forested areas than for protecting corridors only.

Areas along transportation corridors and trails represent about one-third of the remaining extent of southern Appalachian spruce-fir forests. Estimates of average WTP indicate that the marginal value of protecting this area is about $30.20 per household per year. The marginal value of protecting all the remaining spruce-fir area in the southern Appalachians is $36.91 - $30.20 = $6.71 which represents an increase in value of about 22%. A t-test of the hypothesis that average WTP for corridor protection is not different than average WTP for protecting all remaining areas cannot be rejected at the 0.05 level. From a purely statistical standpoint, our results are consistent with a model of lexicographic preferences.

V. Discussion

Various explanations for our results can be suggested. We consider the following propositions:

1. Existence values dominate the set of individual values for protecting ecosystems, and expressions of existence value reflect lexicographic preferences.
2. Preferences for ecosystem values are relatively flat, but not lexicographic.
3. People hold non-zero marginal values for forest health but remaining stock of healthy forests is not an appropriate way to quantify forest health condition.
4. People hold non-zero marginal values for forest health but the payment card method is not sensitive to small marginal changes.

Mitchell and Carson (1989) describe four strategies for seperately estimating components of amenity value. Here we briefly review two strategies that can be used to estimate passive-use values. We are interested in evaluating whether passive-use values dominate valuations of forest health and whether estimated passive-use values are consistent with lexicographic preferences.

The first strategy we used to estimate value components is a decomposition strategy. Following our second WTP question (see above) we asked the following:

> Of the amount of money you circled above in question #13, what percentage of that amount would you assign to

each of the following reasons? (write a percent in each blank)

_____% USE OF FORESTS FOR MYSELF

_____% USE OF FORESTS FOR OTHERS (INCLUDING FUTURE GENERATIONS)

_____% PROTECTION OF THE FORESTS EVEN IF NO ONE USES THEM

_____% OTHER (please specify) ____________________

From the perspective of the individual, categories (2) and (3) represent passive-use values.

The average proportion of value, by category, was 10 percent for category (1), 33 percent for category (2), 53 percent for category (3), and 4 percent "other". Although this strategy is subject to the "fallacy of motivational precision" (Mitchell and Carson, 1989) it is clear that passive-use value dominates use value. These proportions are also quite similar to values reported by Peterson et al. (1987) for protecting forests from ozone damage in southern California.

Another strategy for evaluating passive-use value is available that is not subject to the fallacy of motivational precision. Based on self reports, we created a subset of the data representing respondents who had never used the resource in the past and never intended to use the resource in the future. Then we estimated the WTP models as before. The WTP values estimated for this group can be viewed as an expression of passive-use value.

Using this strategy, we estimated the average WTP to protect corridors and all remaining spruce-fir areas are $23.49 and $31.09 per household per year, respectively. These values represent 78 percent and 84 percent of WTP estimated using the entire sample. These proportions are quite similar to the proportions revealed by the decomposition strategy and tend to confirm that passive-use values dominate use values for this amenity. However, we note that marginal existence value using the second strategy increases by $7.60 (or 32 percent), although this amount is not significantly different than zero.

Regarding the second proposition, is it possible that marginal ecosystem health values are low but non-zero? Although we do not have all the information required to fully evaluate this issue, we consider a simple statistical reason for rejecting the hypothesis of no significant difference in average WTP values based on statistical power. It is well known that the power of a statistical test increases with with the sample size given the standard error and the difference in value being tested for. Using the sample size tables presented by Mitchell and Carson (1989, p.365), we estimated that we would need about 800 observations to conclude that our marginal WTP values are non-zero at the 0.05 significance level using a two-tailed test. About 600 observations would be required to detect significance using a one-tailed test. Therefore, if our data set were two to three times larger, we would likely reject the hypothesis that marginal ecosystem health values are zero (and that preferences are lexicographic).

The third proposition concerns whether our representation of forest health using measures of aerial extent were meaningful to respondents. The focus groups and pre-tests we conducted indicated that the approach using aerial extent was readily understandable by respondents and portrayed a realistic approach to management. Whether changes in the experimental design would have yielded different responses is difficult to judge. For example, we might describe changes in ecosystem health using ecosystem stress concepts described by Rapport et al. (1985). Using this approach, changes in ecosystem health status might be described as impacts resulting from particular stressors (eg., pollutant discharges or extreme natural events) or by loss of specific ecosystem functions (eg., loss of primary productivity or system retrogression). Incorporation of ecosystem stress concepts in future ecosystem valuation research is recommended.

Finally, our fourth proposition concerns the sensitivity of the payment card responses to incremental valuations. Our listed payment card values were based on the distribution of responses to an open-ended WTP question conducted during a pre-test. The values from our pre-test suggested a log-normal distribution of WTP values. Discrete payment card values were chosen to represent and subsequently model the underlying continuous WTP distribution. Conseqently, circled values were considered to indicate the interval within which the true but unobserved WTP value would occur. True increments in value would not be observed, therefore, if the increment to value was less than the width of the appropriate payment card interval. Because the number of intervals can have a significant effect on the estimation of WTP values (Cameron and Huppert 1989), further research investigating the use of this value elicitation method for estimating marginal ecosystem values is warranted.

VI. Conclusions

Given our experimental evidence, it is not possible to make an unambiguous conclusion about whether contingent values for forest ecosystem health represent lexicographic preferences. Although marginal value estimates were not significantly different than zero the power of the tests were moderately weak. About 80 percent of the respondents circled the same payment card value for protecting part and all of the ecosystem. However, true positive marginal values may have been hidden by the payment card intervals used.

Our data strongly suggest that passive-use values are very important in the valuation of ecosystem health. A fuller understanding of the nature of these values is required to interpret their economic content. Economists need to explore models of ethical behavior beyond the lexicographic model to improve the distinction between economic and non-economic value. If economic reasoning is to be applied to improved management for protecting ecosystem health, logically consistent models are prerequisite.

Literature Cited

Boyle, K. J.; Desvousges, W. H.; Johnson, F. R.; Dunford, R. W.; Hudson, S. P. An investigation of part-whole biases in contingent valuation studies. *Journal of Environmental Economics and Management* 27:64-83;1994.

Brookshire, D. S.; Eubanks, L. S.; Sorg, C. F. Existence values and normative economics: implications for valuing water resources. *Water Resources Research* 22:1509-1518;1986.

Cameron, T. A.; Huppert, D. D. OLS versus ML estimation of non-market resource values with payment card interval data. *Journal of Environmental Economics and Management* 17:230-246;1989.

Dillman, D. *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley and Sons, Inc.;1978.

Dull, C.; Ward, J.; Brown, H.; Ryan, G.; Clerke, W.; Uhler, R. *Evaluation of Spruce and Fir Mortality in the Southern Appalachian Mountains* Atlanta: USDA Forest Service Protection Report R8-PR13;1988.

Edwards, S. F. Ethical preferences and the assessment of existence values: does the neoclassical model fit? *Northeastern Journal of Agricultural and Resource Economics* 15:145-150;1986.

Edwards, S. F. Rethinking existence values. *Land Economics* 68:120-122;1992.

Holmes, T. P.; Kramer, R. A. An independent sample test of yea-saying and starting point bias in dichotomous-choice contingent valuation. *Journal of Environmental Economics and Management* 28:(forthcoming);1995.

Innes, J. L. *Forest Health: Its Assessment and Status*. Wallingford UK:CAB International;1993.

Kalbfleisch, J. G. *Probability and Statistical Inference*. New York: Springer-Verlag;1979.

Miller, J. R. Irreversible land use and the preservation of endangered species. *Journal of Environmental Economics and Management* 8:19-26;1981.

Mitchell, R. C.; Carson, R. T. *Using Surveys to Value Public Goods - The Contingent Valuation Method*. Washington, D. C.: Resources for the Future;1989.

Pearce, D. W.; Turner, R. K. *Economics of Natural Resources and the Environment*. Baltimore:Johns Hopkins University Press; 1990.

Peterson, D. C.; Rowe, R. D.; Schulze, W. D.; Russell, G. W.; Boyce, R. R.; Elliott, S. R.; Hurd, B. *Valuation of visual forest damages from ozone*. Washington, D. C.: U.S. Environmental Protection Agency Cooperative Agreement #CR812054-02;1987.

Rapport, D. J.; Regier, H. A.; Hutchison, T. C. Ecosystem behavior under stress. *The American Naturalist* 125:617-640;1985.

Sagoff, M. Has nature a good of its own? In: R. Costanza, B. G. Norton, and B. D. Haskell, eds. *Ecosystem Health: New Goals for Environmental Management*. Washington, D.C.: Island Press; 1992:57-71.

Sen, A. Rational fools: A critique of the behavioral foundations of economic theory. *Philosophy and Public Affairs* 6:317-344;1973.

Stevens, T. H.; Echeverria, J.; Glass, R. J.; Hager, T.; More, T. A. Measuring the existence value of wildlife: what do CVM estimates really show? *Land Economics* 67:390-400;1991.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Natural resource damage assessments under the oil pollution act of 1990, *Federal Register* 58:4601-4614;1993.

Varian, H. *Microeconomic Analysis*. New York: W. W. Norton & Company; 1984 (second edition).

Table 1. Descriptive statistics for explanatory variables

Variable acronym	Description	Mean (standard deviation)
KNOW	= 1 if have previous knowledge of insect damage, = 0 otherwise	0.232
DAYS	Number of days recreate more than 10 miles from home per year	22.96 days (36.884)
AGE	Respondent age	46.99 years (15.288)
ln(INCOME)	Logarithm of household income	$10.376 (0.774)

Table 2. Maximum likelihood test for multinomial probabilities comparing WTP responses for two levels of forest protection.

Payment card amount	Observed frequency of WTP for protecting corridors	Observed frequency of WTP for protecting all remaining forests
$0	77	71
2	23	21
4	16	13
6	4	6
8	1	2
10	35	38
15	6	4
20	19	19
25	11	13
30	5	4
40	0	0
50	14	15
75	2	1
100	9	14
125	1	1
150	0	2
175	0	0
200	1	0
250	0	0
300	1	1
500	0	0
Number of observations	225	225

Note: the likelihood ratio statistic, D, is 13.1 indicating that we cannot reject the null hypothesis of no significant difference in the distribution of values.

Table 3. Completely censored regression models estimated for two levels of forest protection.

Variable	Protection along transportation corridors and trails	Protection of all remaining forests
Constant	-0.737 (-0.400)	-1.6452 (-0.899)
KNOW	0.792 (2.727)	0.627 (2.160)
DAYS	0.009 (2.509)	0.008 (2.212)
AGE	-0.029 (-3.425)	-0.029 (-3.392)
ln(INCOME)	0.352 (2.138)	0.460 (2.809)
ó	1.555 (14.814)	1.577 (15.274)
Number of observations	170	174
mean WTP	$30.20 (26.99)	$36.91 (28.40)

Note: t-statistics are in parentheses.