LOG OR PRESERVE? AN EXTENSION OF THE CHARACTERISTICS MODEL OF CONSUMER CHOICE TO VALUE BENEFITS OF PRESERVING NATIVE FOREST

J. A. SINDEN

Department of Agricultural Economics

and Business Management

University of New England

Contributed paper presented at the Annual Conference of the

Australian Agricultural Economics Society

Brisbane, February 1990

Log or preserve? An extension of the characteristics model of consumer choice to value benefits of preserving native forest.

J.A. Sinden

ABSTRACT

Environmental groups confront the use of native forests with the argument that forest area A must be preserved because of its unique characteristics X, Y, and Z. If forests were bought for preservation purposes, and if their characteristics were separable, this argument would be susceptible to analysis with the standard techniques of demand analysis. Relative necessity of characteristics can be assessed by relative price-elasticities of demand for the different characteristics. "Relative uniqueness', in terms of consumer preferences, can be assessed in the same way. In the absence of actual market transactions to observe and analyse, the purchase of forest habitats of different characteristics is simulated in a questionnaire, the questionnaire is applied to two groups of subjects, and own and cross price elasticities for several forest characteristics are calculated. Characteristics of rare species, high trees and diverse species had low elasticities whereas forest type with characteristic of providing jobs had higher elasticity.

1. INTRODUCTION

The current debates over the use of forest land seem to be polarised into a choice between logging all of a given area or preserving all of it. The debates are exacerbated by the effects of contrasting markets for the different kinds of output. Wood products are exchanged in quasi-competitive markets whereas there are no markets at all for the unpriced services of protection of the environment, aesthetics, or water production. These services are not intrinsically unmarketable -- their external-effect, public-goods nature precludes the formation of markets for them.

The objectives of this paper are (a) to simulate a market for the purchase of native forest, (b) to derive elasticities for different characteristics of the forest, and (c) to interpret the results in terms of the current debates over land use.

2. METHOD

2.1 Requirements

Environmentalists typically argue that it is necessary to preserve a given forest because its characteristics are unique. Economists could assess this argument by observation of the price-elasticities of demand for separate characteristics -- if they had those elasticities. In terms of consumption theory, a good with a relatively low elasticity is more of a necessity because quantity consumed falls off less rapidly for a given rise in price. A good with a higher elasticity is more of a luxury -- quantity consumed falls off more rapidly for a given rise in price.

The "relative uniqueness" to consumers of characteristics of the forest can also be assessed through price elasticities of demand for characteristics. A relatively low elasticity indicates a "relatively unique" characteristic and a relatively high elasticity indicates the opposite.

Thus the implications of the typical environmental argument seem to be assessable through price-elasticities of demand for characteristics of the forest. This assessment obviously requires a method to calculate elasticities for characteristics. Actual purchases of forests by individuals are rather rare, so the method must lend itself to simulation of purchases and application through questionnaire surveys.

2.2 A model of consumer choice

The characteristics model of consumer choice makes the reasonable assumptions that (a) goods are purchased for the utilities they provide and that (b) utilities are derived from the characteristics of the goods. The total utility from a bundle of goods depends therefore on the total amounts of characteristics purchased. The consumer's utility function is therefore

$$U = U(Xol, ..., Xom) \qquad (1)$$

where Xoj is the total amount of the jth characteristic from the consumption of all goods and services. There are m characteristics in all.

But each Xoj is a function of the quantities of each good consumed (qi) and the quantity of each characteristic provided by each good (Xij). Let there be a total of n goods and m characteristics.

Thus the utility function can be re-expressed as

$$U = U(q_1,...q_n,X_{11}, ..., X_{nm}). \qquad (2)$$

This model assumes that individuals choose goods to provide the combination of characteristics which maximises utility. It rests on Lancaster's (1966) theory of characteristics which developed equation (2) by recognising that the consumer can vary only the quantities of goods purchased. The magnitudes of ijs are determined by the producers (or by composition of the forests in this case). The consumer therefore seeks to choose that combination of goods which maximises

$$U = U(X_{11}, ..., X_{nm})$$

subject to the budget constraint

$$\sum_{i=1}^{n} p_i q_i \leq B$$

and a technology constraint

$$\sum_{i=1}^{n} bijqj = Xoi$$

where pi is the price of good iB is the individuals budget, bij is the input output coefficient by which characteristics are produced from goods.

2.3 Application

If the consumer chooses quantities of each of n goods, and if the quantities depend on their own prices and the prices of all other goods and on the available budget, the choices are modelled by the following system of demand equations.

$$Q_1 = f_1 (P_1, \ldots P_n, I)$$

$$Q_n = f_n (P_1, \ldots, P_n, I)$$

All prices and budget B are exogenous. A priori, the sign on the own-price coefficient should be negative while that on the budget should be positive. There are no a priori expectations on the significance or the signs of the cross-price coefficients.

This system of equations allows price elasticities for characteristics to be determined and relationships between characteristics to be examined. Cross-price elasticities will indicate complementary or substitute relationships between them. A positive elasticity indicates substitutability while a negative elasticity indicates complementarity.

Any mis-specification of exogenous variables and any under-specification of these variables is likely to be common to all equations. Further, the disturbance terms are likely to be correlated. The possible gain in estimation efficiency by jointly estimating all the equations led Zellner (1962) to call this system "a set of seemingly unrelated regressions". Zellner's method for estimating the system yields estimators that are more efficient than those from applying ordinary least squares to each equation, and so it will be used.

3. DATA COLLECTION

3.1 Choice of Characteristics

The selected characteristics must be relevant to policy choices, and must be readily be understood by those who are surveyed. Height of trees dominated a recent Tasmanian land-use choice and rarity of species seems always to be a focus of environmentalist arguments. Both were included, as was a jobs lost category. To test the understanding of these characteristics, and to explore the importance of others, 120 persons in Armidale were surveyed. They included groups of students, townspeople, Australians, overseas students, and members of environmental groups. The major results are shown in Tables 1, 2 and 3, and these indicate that diversity of species and recreation potential were important further characteristics. This "pre-survey" also indicated that subjects could readily understand the idea of characteristics of the forest, and perceive of them as separable. The final list of six characteristics was as follows: rarity of tree species, height of trees, number of jobs lost per hectare preserved, diversity of species, type of recreation permitted, and location .

3.2 The simulation game

The choice of forest habitats to preserve was simulated in a simple budget-allocation game, following Sinden and Worrell (1979). The importance of individual preferences to social choices was first explained to subjects who were then shown a table which described each of six forest habitats. The table presented the game and nominated a price per hectare to purchase for preservation, and nominated a total budget.

The habitats were defined in terms of the six characteristics, and each habitat varied from the others in one characteristic. For example, habitat one had diverser species than the other five habitats but it had common levels for the other five characteristics. Habitat two had higher trees than the other five habitats, but had common levels for the other five characteristics. The table appeared as follows.

	Habitat Description of characteristics 1 to 6	Price per ha.	No. of ha purchased	Total cost
1.				
2.				
3.				
4.				
5.				
6.				
			Total	

The context of the choice was defined as follows. Each individual was expressing his own preferences for government purchase of forests to preserve. The budget had to be spent and the quantity of each habitat purchased had to follow individual preferences. Prices and budgets were varied to obtain sufficient variation for the analysis within bounds of realism.

4. RESULTS

After initial tests, the method was applied to two large groups of subjects.

4.1 Students of Ag Econ 303-1 Benefit-Cost Analysis

While one's own students can be a captive sample, they can sometimes represent a particular sector of the population. Not least, they should be highly oriented to job search and so perhaps favouring logging to provide general levels of employment. In any event, the 60 students of 1989 class of Ag Econ 303-1 Benefit Cost Analysis, at the University of New England, were surveyed during normal class time. Six habitats were included in the simulation game to cover diverser species (Q_1), higher trees (Q_2), different location (Q_3), rarer species (Q_4), more intense recreation (Q_5) and fewer jobs lost (Q_6).

Three levels of budget ($0.3m $0.6m and $1.0) were used with each of six sets of prices -- to give a total of 18 price/budget sets to be organised in the questionnaire. The price of each kind of habitat averaged $400 per hectare, and varied between $100 and $900 per hectare. Each questionnaire included three price sets, each with a given budget -- so the basic budget game had to be repeated six times to cover the 18 price budget sets.

To obtain 20 questionnaires for each of the 18 price/budget sets, the students were surveyed twice (one week apart). Two surveys x 3 price/budget sets per questionnaire x 3 different questionnaires in a given class meeting allows the necessary 18 price budget sets to be used for 20 students.

The average quantities of each habitat purchased, at each price and budget combination, were calculated and the estimated system of equations was as follows.

System $R^2 = 0.999$

$$Q_1 = 1963.7 - \underset{(3.7)}{2.02\,P_1} - \underset{(0.3)}{0.06\,P_2} + \underset{(1.7)}{0.82\,P_3} - \underset{(2.4)}{0.32\,P_4} - \underset{(1.4)}{1.26\,P_5} - \underset{(1.4)}{0.179\,P_6} + \underset{(3.0)}{0.40B}$$

$(R^2 = 0.678)$

$$Q_2 = 554.16 - 0.06\ P_1 - 0.69\ P_2 + 0.30\ P_3 + 0.11\ P_4 - 0.38\ P_5 - 0.55\ P_6 + 0.35\ B$$

(0.2) (5.7) (1.4) (1.2) (1.1) (1.2) (3.7)

($R^2 = 0.775$)

$$Q_3 = -948.08 + 0.82\ P_1 - 0.30\ P_2 - 1.47\ P_3 - 0.31\ P_4 + 1.20\ P_5 + 1.74\ P_6 + 0.45\ B$$

(1.70) (1.42) (2.6) (1.6) (1.2) (1.3) (2.0)

($R^2 = 0.507$)

$Q_4 = 1414.4 - 0.32\ P_1 + 0.11\ P_2 - 0.31\ P_3 - 2.05\ P_4 - 0.14\ P_5 - 0.24\ P_6 -$ [illegible]2 B

(2.4) (1.2) (1.6) (7.4) (1.6) (1.8) (4.2)

($R^2 = 0.832$)

$$Q_5 = 2699.8 - 1.26\ P_1 - 0.38\ P_2 + 1.20\ P_3 - 0.14\ P_4 - 2.87\ P_5 - 3.43\ P_6 + 0.33\ B$$

(1.4) (1.1) (1.2) (1.4) (1.5) (1.3) (6.0)

($R^2 = 0.788$)

$$Q_6 = 3860.3 - 1.79\ P_1 - 0.55\ P_2 + 1.74\ P_3 - 0.24\ P_4 - 3.43\ P_5 - 3.77\ P_6 + 0.7\ B$$

(1.4) (1.2) (1.3) (1.8) (1.3) (1.5) (10.0)

($R^2 = 0.904$)

Budgets were coded in \$000, and prices directly in \$ their dollar values.

The own price elasticities, tested in increasing order, were as follows.

Rarer species (Q_4)	- 0.785
Higher trees (Q_2)	- 0.996
Diverser species (Q_1)	- 2.204
Different location (Q_3)	- 2.371
Intense Recreation (Q_5)	- 7.285
Preserve jobs (Q_6)	- 7.870

4.2 Residents of a Country Town

The second survey involved a random sample of 180 households in Armidale, stratified to cover all residential areas of the city. Five goods, or kinds of forest were used in the simulation game. There were again six prices and three budgets for each good to give a total of 18 individual games. There were two price sets and one budget in each questionnaire so a total of nine different questionnaires were required. The total of 180 households permitted each of the nine questionnaires to be administered to 20 households.

In this application, the average price of each kind of habitat was \$40 and the budgets were \$30,000, \$60,000, and \$100,000.

This context of the game was changed slightly for this group. Forests could now be purchased near Armidale and so local recreation opportunities could be expanded and/or more local jobs could be preserved and/or more local habitats could be preserved.

As usual, the average quantities of each habitat purchased for each price/budget combination were calculated and used as the quantities in the data set. The estimated system of equations was as follows, where budget B is coded in dollars.

System $R^2 = 0.997$

$$Q_1 = 677.65 - 14.56\,P_1 - 0.21\,P_2 - 1.46\,P_3 + 0.56\,P_4 - 1.37\,P_5 + 0.84\,B$$

(3.4) (0.1) (0.9) (0.2) (0.7) (4.7)

($R^2 = 0.812$)

$$Q_2 = 112.86 + 0.21\,P_1 - 4.52\,P_2 + 0.97\,P_3 - 0.15\,P_4 - 0.30\,P_5 + 0.42\,B$$

(0.1) (4.0) (1.0) (0.1) (0.3) (4.2)

($R^2 = 0.788$)

$$Q_3 = -901.24 - 1.46\,P_1 + 0.97\,P_2 - 22.82\,P_3 - 0.49\,P_4 - 0.59\,P_5 + 2.00\,B$$

(0.9) (1.0) (4.7) (0.5) (0.7) (3.6)

($R^2 = 0.701$)

$$Q_4 = 359.04 + 0.56\,P_1 - 0.15\,P_2 - 0.49\,P_3 - 7.97\,P_4 - 0.88\,P_5 + 2.89\,B$$

(0.2) (0.1) (0.5) (1.7) (0.3) (2.7)

($R^2 = 0.532$)

$$Q_5 = 428.08 - 1.37\,P_1 - 0.30\,P_2 - 0.59\,P_3 - 0.87\,P_4 - 6.73\,P_5 + 2.63\,B$$

(0.7) (0.3) (0.6) (0.3) (2.2) (3.0)

($R^2 = 0.42$)

The own price elasticities, listed in increasing size, are as follows.

Characteristic	Elasticity
Rarer species (Q3)	- 0.776
Height of trees (Q2)	- 0.778
Diverser species (Q1)	- 1.06
Less jobs displaced (Q5)	- 1.34
4 More intense recreation (Q4)	- 1.72

4.3 Substitutes and Complements

The existence of substitutes and complements amongst the habitats can be tested by observing cross-price elasticities. Posiuve elasticities indicate substitutes and negative ones indicate complements. As the t values on the coefficients in the previous system of equations show, there were no significant cross-price elasticities for the residents of Armidale. The significant elasticities for the students were as follows.

Characteristics which are substitutes

height/location	+ 0.433
diversity/location	+ 0.895

Characteristics which are complements

rarity/use	- 0.052
rarity/jobs	- 0.092
rarity/diversity	- 0.353
rarity/location	- 0.513
diversity/use	- 1.372
diversity/jobs	- 1.951

This group of s[illegible]ects appears to regard location as a readily - substitutable characteristic and so the location in which forests are preserved is perhaps realtively unimportant to them. Rarity, and to some extent diversity, are regarded as complements in a package with other characteristics.

5. DISCUSSION

The research needs to be pursued in several directions including investigations for the effects of actual of rarity or jobs lost on elasticities and the clarification of appropriate prices and budgets. Hopefully however, the tests reported here indicate the potential of the method to reveal the elasticities of different characteristics.

A major economic determinant of the decision to log or preserve is the value that would be lost if an area is logged. In simplest terms, this value is the loss in surplus if one hectare of forest of given characteristics is logged. The method, and the results so far, allow these values to be calculated for forests with particular bundle of characteristics.

The value of a loss of one per cent of each kind of habitat can be calculated from the elasticities and the base price, a loss in consumers surplus (Figure 1). For the student group, the base price per hectare was $400 and for the town residents it was $40.

A one per cent loss in area for the habitat with less-elastic demand will lead to a surplus loss of (a + b), whereas the loss for the habitat with more-elastic demand will be (a) alone. The loss in surplus values are more meaningful in relative terms, and are as follows.

Students

	$	Relative terms
Intensive recreation	0.5	0.10
Less jobs lost	0.5	0.10
Location	1.7	0.33
Diverser species	1.8	0.35
Higher trees	4.0	0.78
Rarer species	5.1	1.00

Residents of Armidale

	$	Relative terms
Intensive recreation	0.23	0.44
Diverser species	0.25	0.48
Less jobs lost	0.30	0.56
Height of trees	0.52	1.00
Rarer species	0.52	1.00

For the residents of the country town, surplus benefits from forests of higher trees equal the benefits from preserving rarer forest species, ceteris paribus. Provision of more forests for intensive recreation has least benefit.

References

Lancaster, K.J. 1966 "A New Approach to Consumer Theory", Journal of Political Economy, 74(2), 132-157.

Ladd, George W. and Veraphol Suvannunt 1976, "A Model of Consumer Goods Characteristics", American Journal of Agricultural Economics, 58(3), 504-510.

Sinden, John A. and Albert C. Worrell, 1979 Unpriced Values: Decisions without Market Prices, Wiley-Interscience, New York.

Zellner, A. 1962 "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", Journal of the American Statistical Association, 57, 348-368.

Table 1

Preferences for forest characteristics:
21 members of local Environmental Groups

Characteristic	Number of votes	Per Cent
Diversity of tree and animal species	20	19.05
Rarity of tree and animal species	18	17.14
Environmental stability	18	17.14
Naturalness of vegetation and landscape	13	12.38
Size of area*	11	10.50
Opportunity for wildnerness-type recreation	6	5.71
Scenic/landscape value	6	5.71
Contribution to nature study and education	6	5.71
Cultural and historic values	4	3.81
Height of trees	2	1.90
Ease of access	1	0.95
Opportunity for picnic-type recreation	0	0.00
Totals	105	100.00

* Interpreted as a management factor.

Table 2

Preferences for forest characteristics:
24 members of a local tree planting group

Characteristic	Number* of votes	Per Cent
Animal life	20	20.83
Bird life	15	15.63
Diversity of tree species	14	14.58
Size of area	12	12.50
Rarity of tree species	11	11.46
Wilderness recreation	7	7.29
Diversity of non-tree plant species	7	7.29
Rarity of non-tree plant species	5	5.21
Location	3	3.13
Tree height	1	1.04
Picnic recreation	1	1.04
Totals	96	100.00

* Each person had four votes.

Table 3

Preferences for forest characteristics:
25 Australian Students

Characteristic	Number of votes	Per Cent
Rarity of habitat as a whole	14	18.67
Diversity of trees species	10	13.33
Reservation as wilderness	9	12.00
Rarity of plant species	8	10.67
Rarity of animal species	6	8.00
Age of trees	6	8.00
Animal life	5	6.67
Bird life	4	5.33
Rarity of bird species	4	5.33
Size of area	3	4.00
Availability of water	2	2.67
Location	2	2.67
Availability of picnic type recreation	1	1.33
Rugged topography	1	1.33
Totals	75	100.00

* Interpreted as a management factor.

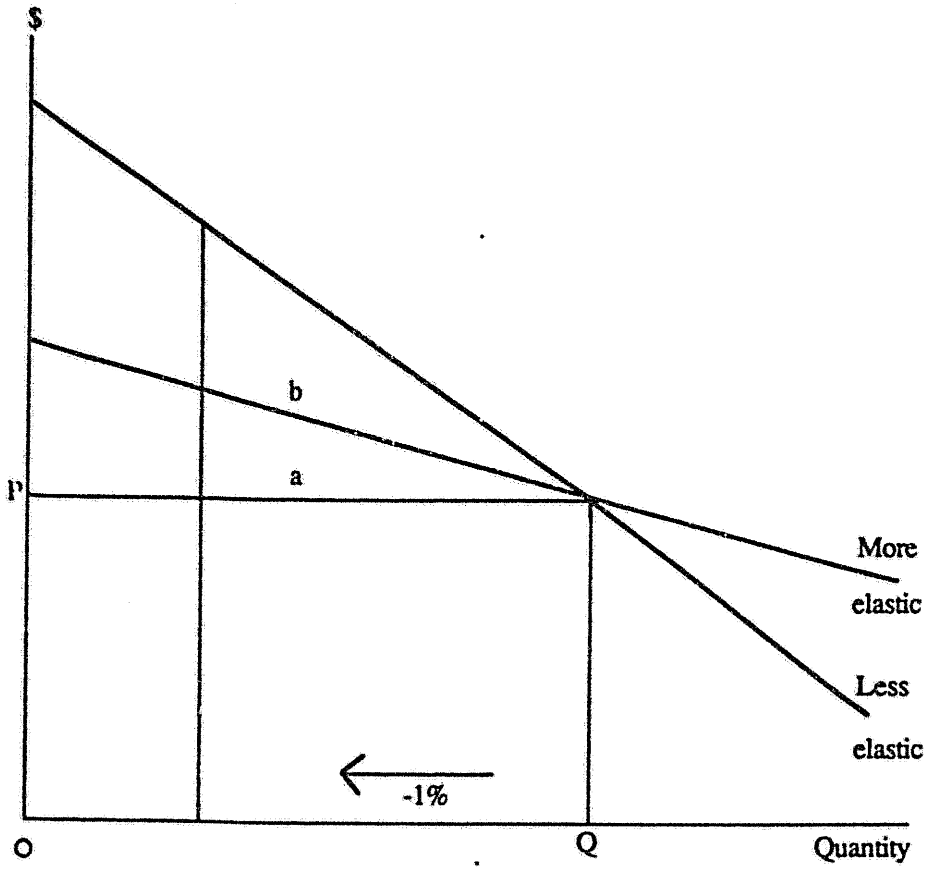

Figure 1. Changes in consumers surplus from loss of 1 per cent of area of twc kinds of forest.