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THE VALUATION OF FOREST CHARACTERISTICS

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THE VALUATION OF FOREST CHARACTERISTICS[1]

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Abstract

Most work on valuing the recreational benefits of public forests has concentrated on arriving at consumers surplus per visit figures, using either the travel cost method, or contingent valuation. We use both methods to try and explain the variation in consumers surplus across different forest types, by placing values on the physical characteristics of individual forests. These characteristics are also used to explain total visits to a given forest. Both maximum likelihood and ordinary least squares estimates are presented.

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1 We thank Rachel Bettis and Kim Taylor-Duncan for research assistance; and the Forestry Commission for funding the study on which this paper is based. Responsibility for the contents of the paper rests, however, entirely with the present authors.

1. Introduction.

Over a number of recent years, considerable research effort in the UK has been devoted to the valuation of the non-market aspects of forestry. This work ranges from travel cost and contingent valuation estimates of the value of a recreational day out in the forest (Willis and Benson, 1989; Hanley, 1989; Willis, 1991); values (both user and non-user) for welfare losses due to afforestation (Hanley and Craig, 1991); and estimates of carbon fixing benefits (Anderson, 1990). The research reported here extends this work to a consideration of the valuation of the physical characteristics of forests. If economic values (consumers' surplus) figures could be reliably attached to such characteristics, then this would greatly aid public agencies (in the UK, this principally means the Forestry Commission) in planning the provision of public forests, given a wish to promote public enjoyment of these forests. As Bowes and Krutilla (1989) put it:

> "Unfortunately,..multiple use management [of forests] has been hampered by the limited attention given to..estimating the economic value of changes in the condition of forest lands. Much..early demand analysis focussed on the total value of sites in their existing condition. In contrast, the forest manager is most concerned with management actions that effect changes in the physical attributes of forest sites" (Bowes and Krutilla p.177: our comments in brackets).

A similar point is made by Englin and Mendelsohn (1991):

"The non-market value of different site qualities has rarely been studied: As a result, we do not have measures of the non-market benefits of most decisions facing resource managers" (page 275).

A priori, the physical characteristics deemed important included the following:

* percentage of forest accounted for by broadleaved (deciduous) trees;
* diversity of conifer species;
* height diversity;
* mean height;
* presence/absence of water features;
* proportion of the forest as open space; and
* provision of trails and other visitor facilities.

These characteristics share the feature that they are at least partially under the control of forest managers.

Amongst the class of methods for valuing non-market goods, two seemed suitable for the valuation of such characteristics. These are the Contingent Valuation and the Hedonic Travel Cost model. Contingent Valuation (CV) was first used on UK Forestry Commission sites by Hanley and Common (1987), reported in Hanley (1989). The method is now widely accepted in the USA for use both by institutions (such as the Fish and Wildlife service) and in actions under the Comprehensive Environmental Response, Compensation and Liability Act. CV has also been taken up by the UK government, at least on a trial basis (Department of the

Environment, 1991). This paper does not assess the method; assessments are available elsewhere (eg Mitchell and Carson, 1989; Hanley, 1990; Kahneman and Knetsch, 1992).

Contingent Valuation is used here in two ways: first, by showing respondents pairs of photographs, depicting two forests which differ significantly with respect to one characteristic. Respondents are asked to state their preference ordering over each pair, and to express a maximum willingness to pay (WTP) to access the preferred forest in each pair. Secondly, we relate bids to preserve the option to visit the forest where respondents were questioned to the levels of the characteristics listed above; and to other variables thought relevant on which information was collected. This 'other information' includes socio-economic characteristics of respondents, and variables associated with their trip to the forest (such as length of journey). Our objective in both these contingent valuation approaches was to find out which characteristics were significantly related to recreational benefits. If significant relationships could be found in the second approach (which we term the bid curve approach); and if continuous measures of the forest characteristics variables could be found, then marginal WTP figures could be computed.

The Hedonic Travel Cost (HTC) method also seeks to obtain marginal valuations, or prices, for forest characteristics[2]. Previous applications have looked at the characteristics of fishing trips, water quality and visits to beaches [see, for example, Brown and Mendelsohn (1984), (Smith, Desvouges and McGivney (1983), Loomis, Sorg and Donnelly (1986) and Bell and Leeworthy (1990)]. Recently, two HTC applications to forestry have been reported, by Bowes and Krutilla (1989) and Englin and Mendelsohn (1991). Bowes and Krutilla report a study by Wilman in 1984 of the impact of forest characteristics on hunters' decisions about which forest sites to visit, in the Black Hills National Forest of South Dakota.

Willman analyses the effects of variations in two characteristics (one related to the suitability of forests for deer, and the other to the physical attractiveness of the forest) on the number of visits paid to a range of sites by hunters from each zone of origin sampled. These zones were small towns plus one small city within easy reach of the Black Hills. A two step procedure was followed: first, a marginal (travel) cost was estimated for each characteristic from each zone of origin; then a demand curve for the 'deer suitability' characteristic was estimated by regressing levels of suitability chosen by hunters

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2 We note that according to the typology of Bowes and Krutilla, what we report on here is a travel cost, as opposed to hedonic travel cost, study, since our focus is in using characteristics to predict visits.

against its marginal cost, and against demand shifters such as income and hunting experience. Thus a marginal value could be found for this characteristic.

Englin and Mendolsohn estimated implicit prices for forest characteristics for a large (n=2,997) sample of hikers with over-night camping permits in the Cascade Mountains, Washington.. They derive expressions for the values of marginal and non-marginal changes in characteristic levels from a quadratic utility function. Hikers were sampled at 92 trail entrances, and were split into 36 zones of origin. Trail characteristic data (on, for example, level of old-growth forest and presence/absence of clear-cut) was available from US Forest Service records. This was supplemented with census data to describe demand shifters for each zone. Again, a two stage method was followed. First, travel costs as a function of characteristic levels were estimated for each zone, yielding marginal costs for each characteristic. Some of these were negative, implying that either the characteristic was undesirable, or that hikers were over-satiated with it.[3] Demand curves for each characteristic were then estimated. This resulted in (expected) negative implicit prices in 10 out of 11 cases, out of which 6 were significantly different from zero at the 90% level.

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3 So that whilst total WTP was positive for that characteristic, marginal WTP was negative.

Despite recent criticisms of the HTC technique (see, for instance, Bockstael,McConnell and Strand, 1991; and Smith and Kaoru, 1987), it offers the potential for a methodological cross check (a "convergent validity" test) on both sets of contingent valuation data. This twin-methodology approach makes our paper unique in terms of forest characteristics.

The rest of this paper is structured as follows. Section 2 outlines the survey design and selection of sites to be sampled. Section 3 reports results from the hedonic travel cost study, whilst Section 4 details the outcome of the two contingent valuation experiments. Section 5 draws some conclusions, and offers suggestions for further research.

2. Survey Design and Data Collection

The survey was intended to collect data suitable for all three methods of analysis, namely the CV photo data analysis, the CV bid curve analysis, and the HTC exercise. With regard to the CV photo analysis, the two features of importance were (i) the total sample size (all respondents at every forest site sampled received the same set of photo questions); and (ii) the representativeness of this total sample relative to the population as a whole. With regard to criteria (i), larger sample sizes are clearly preferable to smaller sample sizes. As Mitchell and Carson (1989) have pointed out, desirable minimum sample sizes for open-ended CV studies are in excess of 300 respondents, given certain assumptions about reporting errors. With regard to criteria (ii), the population of interest is the total number of visitors to UK public forests (we seek to make no predictions for the general population). Clearly, we would want any sample drawn from the relevant population to be unbiased. At most forests, it turned out to be possible to sample *all* visitors on the days when sampling was carried out. This, however, gives a mis-representation of annual visits, since visits to forests have seasonal and weather-related determinants. Week-end visitors might be significantly different from week-day visitors. So long as the perception of forest characteristics, and visit-rates, varies according to measured characteristics, no bias will result, since these influences can be controlled for[4]. Surveyors were thus instructed to record weather, time of day, and week-end/week-day details for each respondent. However, some important variables may go un-measured, whilst others such as temperature will show insufficient variation in a summer-only survey. Given this possibility, the best strategy would be to have many interviewers surveying simultaneously at all chosen sites at random intervals throughout the year. Unfortunately, this was impossible due to resource constraints. A second-best alternative was thought to be to (i) record weather, time variables as above ; and to (ii) interview at each site on one

4 Although if measured variables are correlated, a loss of precision results.

week-day and one week-end. These visits were never more than two days apart. All interviews were conducted over the period June-August 1991.

With regard to the other two means of study (the bid curve CV approach, and the HTC study), the selection of sample *sites* was clearly very important, since both methods involve the estimation of equations in which the site characteristics appear. For a correct choice of model, reliability of coefficient estimates is achieved by minimizing the standard errors. Suppose that annual visits to a site Y_i (i=1..n) depend on a single characteristic of that site, X_{1i}. This implies:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \varepsilon_i \qquad \text{........(1)}$$

where the error term ε is normally distributed with expected value 0 and variance σ^2. The variance of the estimator β_1 is

$$\text{Var }(\beta_1) = \sigma^2/m \text{ Var}(X_j) \qquad \text{........(2)}$$

where there are m sites on which data is available. This implies two rules for site selection: (i) for a given sample size m, choose extreme values of X_i (see Englin and Mendelsohn, p.281); and (ii) for a given sample variance, choose the biggest sample size n. With more than one characteristic, the problem is more complex. If there are j=1...k characteristics, and the correct model is:

$$Y_i = \beta_0 + \sum_j \beta_j X_{ji} + \varepsilon_i \qquad \text{..........(3)}$$

then denoting deviations from sample means as x_{ji}, and writing these in matrix form as $X=\|x_{ji}\|$, the matrix of variances and co-variances is:

$$V = 1/m\ (X'X) \qquad \text{..........(4)}$$

and the variances of the estimators for $\beta_1 \ldots \beta_k$ are the diagonal elements of:

$$[\ \sigma^2/m]\ V^{-1} \qquad \text{.........(5)}$$

This implies that these variances will depend in a complex way on both the variances and co-variances of the characteristic variables X_j. If these variables are uncorrelated, then sample selection rules are to (i) choose sites to maximize the variance of each variable, and (ii) increase sample size.

However, an inspection of zero-order correlations between site characteristics revealed that the X_j terms are indeed correlated. Table 1 gives some information on the characteristics for which data was available from the Forestry Commission (FC)'s sub-compartment data base. In Table 2, zero-order correlations are presented.

Table 1

Characteristics Used[1]

Variable	Definition	Range
hm	mean height of all trees	3.5-20.9 m
hd	height diversity, all trees, as measured by Shannon index	0-1.57
pb	area of broadleaves as % of total forest area	0-95.2%
cd	Shannon index of diversity of conifer species	0-1.723
pw[2]	dummy variable for presence of water feature (loch, burn..) =0 if none, =1 if yes.	0-1
po	percentage of forest as open space (no trees)	0.1-100%

Notes: 1. As defined by sub-compartment data base: refers to all FC land within 3 km radius of each sub-compartment centre.
2. Not taken from the above data base, due to extreme inaccuracy. Measure used here constructed by us from site surveys.

Table 2

Zero order correlation matrix, forest characteristics

	hm	hd	pb	cd	pw	po
hm	1.0					
hd	-0.24	1.0				
pb	0.54	-0.39	1.0			
cd	0.40	-0.06	0.42	1.0		
pw	-0.19	0.11	-0.21	-0.26	1.0	
po	0.13	-0.09	0.24	-0.02	0.10	1.0

Notes: 484 sites; variables defined in Table 1.

Given that the X_j terms are correlated, simply choosing extremes of each variable could lead to a high degree of multicollinearity. Choice of sites should take account of covariances. In principle, this could be done by minimizing a suitable function of the elements of X. However, given the very large number of possible combinations of sites , this was too intensive in computing time. It was also necessary to recognize that the opportunity cost of having more sites was a reduction in the total sample size, given travelling time for the surveyors. We decided on a site sample size of 60 (n=60). The following compromise procedure was thus adopted: rank sites by each characteristic in ascending and descending order. Choose the top site on each characteristic list. Then choose the next site on each list which is in a separate geographic area to the first chosen. Continue in this manner until 60 sites have been selected. Avoiding pairs of sites in the same geographic area (defined as FC Forest Districts) avoids high covariances, since there are strong district similarities in UK forests.

Many sites qualified as 'extremes' , which values were defined in terms of the upper and lower 5% of the distributions for each characteristic[5]. Out of the 484 candidate sites, 43% (210) were 'extreme' on at least one count. Given the nature of forests in Britain, it is inevitable that the forests chosen to represent some extremes are not evenly distributed over the whole country, the most obviuos example being forests with a

[5] The obvious exception being the dummy variable, pw.

high proportion of broadleaved trees-which are concentated in Southern England- and those with high conifer species diversity, which are also concentrated in the South. As there are regional differences in e.g the range of substitute leisure activities and in topography, it is possible that these forest characteristics are correlated with variables omitted from our analysis owing to a lack of data. We shall discuss later the possibe effect of this on our results.

Study of the sub-compartment data base convinced us that in some respects, it was misleading. The need to specify our own 'water' variable has already been mentioned: this arose because the database confines itself to land owned by the FC, and most water bodies are not (leading to some very odd results!). A second problem was that whilst we had no reason to doubt the accuracy of the FC data as defined, it may not represent visitors' perceptions of a forest in a given sub-compartment. For example, a forest could be 95% sitka spruce, but the area immediately around the car park be birch and alder. If visitors do not stray far from their cars, then they will have a very different perception of the forest than is implied by the database. For this reason, two other sets of characteristics measures were obtained.

First, visitors own perceptions of forest characteristics. This includes all those terms listed in Table 1, with the difference that visitors ranked the following on five-point Likert scales:

*height diversity

*proportion of broadleaved trees

*proportion of forest as open space

Visitors were also asked to rank the following, on which no data was available from the database:

* quality of views

* quality of walking facilities (eg way-marked trails), and

* quality of other facilities provided (eg information boards)

Again, these rankings were on 5-point scales. Presence/absence of a significant water feature was also recorded, as perceived by visitors (we did not press a definition of "significant" on them). Respondents were typically questioned just before leaving a site. This process yielded a second, alternative set of characteristics information to that taken from the database. Finally, interviewers were also asked to rank forest characteristics at each site; the procedure followed was similar to that for respondents. This gave a third possible definition of the characteristics set.

The questionnaire was piloted over 2 days at Queen's View forest in Central Scotland. This aided the design of the CV parts of the survey, described in sections 4.1.1 and 4.2.1 below. With regard to the HTC analysis, visitors were asked as to the purpose of their visit; their point of origin that day; length and duration of trip; holidaymaker/daytripper status; expected stay time on site; whether their visit was the main purpose of their day out (and for those answering no, a rating of how important it was on a 1-5 scale);the number of times they had visited the site in the past 1 month and past 12 months; where they would have gone if they had not been able to visit the site that day (and what it would have cost them to make this substitute trip); their gross household income, age, and level of education; whether they were a member of a conservation group or not; and the composition of the party they came with that day. All respondents were also asked the CV questions (see section 4); and the characteristics questions listed above. A copy of the questionnaire is available from the authors.

General Results.[6]

Of the 60 sites selected for survey, 57 yielded responses, with a total of 1041 responses being obtained. This varied from a pre-determined maximum of 30 at each site, to a mere 1. Surveyors were instructed to spend at least two half days on any site (see above), but to move on once 30 responses had been gained at any site. Very few respondents were unable to answer the 'forest characteristics' questions, whilst respondents answers on this theme were closely correlated with the surveyors impressions of the same characteristics. The responses from surveyors and the public on height diversity, conifer diversity and open space were virtually uncorrelated with the FC's dat. Regression analysis rejected the hypothesis that this was

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6 For a full description of the survey and results, see Hanley and Ruffell, 1991.

explained by the fact that the FC data refers only to land in FC ownership, indicating that either the FC data is inaccurate; or (more likely) that it does not reflect peoples' perceptions of the forest. This is an important point: if we are interested in the value to individuals of different sorts of forest, using the FC data for these characteristics would give misleading answers. Responses from surveyors, respondents and the FC data base were significantly correlated for % of broadleaves and for mean height.

Of 1041 respondents, 42% were holiday makers and 58% day trippers. The demographic profile of the sample is very similar to 1989 Family Expenditure Survey data of the UK population, in terms of family composition and age. However, our sample had somewhat higher income and education levels than the general population (mean gross household income in the sample =£19,200, UK mean 1991 = £17,600; 12% of adults in sample with degree-level education versus 8% for UK population). Regarding visits to the site where respondents were questioned, the vast majority of holiday makers recorded only one visit per annum. Mean visits to a given site for day trippers was much higher at 26 visits per year. Average time on site for holiday makers was 2 hours, for day trippers 2.5 hours. We found no evidence to suggest that stay time should be treated as an endogenous variable, to be jointly determined with number of trips as in Smith, Desvouges and McGivney (op cit).

The mean distance travelled to visit the forest was 24 miles across the whole sample, with a standard deviation of 32 miles. There was a very close correlation (r=0.91) between stated and measured distance. Whilst holiday makers and day trippers differed insignificantly in terms of distance travelled, holiday makers travelled more slowly, and were less likely to have visited the forest as the main purpose of their day out. Over 90% of respondents said they enjoyed their time spent driving to the forest: this has implications for the treatment of travel costs in the HTC model, which is discussed in section 3. A visit to the forest was the main purpose of trip for over 75% of day trippers.

Respondents were also questioned as to their reasons for visiting the forest. These varied widely, and included motives such as walking, looking at nature, and picnicking. Seventeen categories of 'reason for visit' were distinguished. Finally, respondents had considerable difficulty stating where they would have gone that day if the forest had been closed. This question was designed to elicit information of the type and cost of substitutes. However, 15% of the sample could not answer this question, whilst 16% of holiday makers would merely have continued their journey. "Visiting another forest" was given as the substitute activity by 34% of respondents across the sample as a whole. Half of the sample was unable to cost the substitute good, whilst a further 25% gave the cost as zero. Mean substitute cost was £1.78 (σ=£2.65).The poor response to this question was perhaps inevitable, given the very wide range of motives people have in visiting a forest: a situation not encountered, for example, in considering recreational activities such as hunting or fishing.

3. Hedonic Travel Cost results.

In this section, we report the modelling of the influence of forest characteristics on consumers surplus, using the Hedonic Travel Cost (HTC) method. Alternative versions of the HTC methodology may be found in Brown and Mendelsohn (1984), Vaughan and Russell (1982) and Loomis, Sorg and Donnelly (1986). The methods differ principally in how they are applied. For example, the Brown and Mendolsohn approach requires individuals from a range of zones of origin to visit a large number of sites. Implicit prices are assumed to be identical for each individual in a given zone; but to vary across zones. This necessitates a large data set: 5,500 individuals spread over 63 zones, in their case. The method is most suited to situations where respondents can be sampled on the basis of zone of origin, rather than destination, to ensure an adequate number of observations from each zone. Vaughan and Russell's approach is also a two-stage method, where a visit-cost function is first estimated for each site in the sample, the independent variables being travel costs and socio-economic characteristics for each zone. These RHS coefficient estimates for each zone then become the dependent variables in the second stage, with site characteristics being the independent variables. Again, data requirements are high: a large number of zones in step one, and a large number of sites in step two.[7] Vaughan and Russell, however, noted that their approach could be simplified by pooling data across sites and estimating a single equation. This was also the route taken by Smith, Desvouges and McGivney (1983). However, due to the large number of interaction terms, this approach brings the possibility of a very large number of regressors if the number of site characteristics is large, and/or the number of socio-economic variables large. A simplified version of this approach may be found in Loomis et al (op cit); although this simplification leads to the violation of Smith *et al's* key result: that coefficients on socio-economic variables should depend on characteristic levels.

Our approach was a compromise between the theoretical attractions of the Smith, Desvouges and McGivney method, and the simplicity of Loomis, Sorg and Donnelly. Given that the number of characteristics to be modelled here is large, that a large number of reasons for visit seem likely to influence visit rates, and that the primary focus was on the impact of varying characteristics on consumers surplus, the decision taken initially was to include only one vector of interaction terms, namely between forest characteristics and travel costs. As will be seen shortly, it subsequently became desirable to add a further vector of interaction terms. Our basic model was:

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7 Although zonal visits could be replaced by individual visits in stage one.

$$\ln(VISA) = \beta_1 + \beta_2 tc + \beta_3 \ln(inc) + \beta_4 age + \beta_5 \ln(leng) + \sum_{j=1}^{6}\beta_j\ chars(j) + \sum_{j=1}^{17}\beta_{j+10} why(j) + \sum_{j=1}^{6}\beta_{j+27} chars(j).tc + \sum_{j=2}^{17}\beta_{j+32} why(j).tc + \varepsilon \quad \text{........(6)}$$

where:

VISA is the number of trips per time period to the site;

tc are round-trip travel costs;

income is household disposable income;

age is age of respondent;

leng is the number of days a year when the respondent was resident in the area where questioned;

chars are the forest characteristics; and

why are the reason-for-visit dummies; in the regression runs, there are initially 17 reasons for visit and so 16 dummies.

In the travel cost analysis we include the six main forest characteristics listed in Table 1 (*hm, hd, pb, cd, pw* and *po*). Supplementary characteristics on which we also collected data, which were also included in the CV bid curve analysis, were *views, walk,* and *visfasc*. These relate to the ranking by respondents of the characterstics listed on pages 9-10 (respectively, the quality of views, the quality of walking facilities (eg waymarked trails), and the quality of other visitor facilities (such as visitor facilities). We also had data collected from the surveyors on these characteristics (views excepted), termed *info* and *trails*. These five supplementary characteristic terms were tried in initial estimations of (6), but we found that they were all individually insignificant; that they were jointly insignificant; and that including them had a negligible impact on the other coefficients. The five supplementary characteristics were thus dropped from the analysis.

Functional form choice was dependent partly on the preference for a semi-log relationship between visits and travel costs to be found in earlier studies (such as Smith et al (1983), Loomis et al (1986), Benson and Willis (1989) and Hanley (1989)); and partly as a result of testing of alternatives. A constant income elasticity is specified.

We now comment briefly on how data were transformed for use in the regressions. Travel costs were evaluated per household, since no obvious way existed of dividing up travelling costs between members of a party (family or otherwise). Distances are converted into money by multiplying by the Automobile Association's average figure for running costs for petrol cars (13.567p/mile). With regard to travelling time, it is not clear that all visitors view time spent travelling as a cost (Chevas et al, 1989). Respondents were asked if the journey to the forest was part of the enjoyment of the day out. If the answer was "yes", then a zero value attaches to travel time. If the answer was "no", then travel time was valued at the Dept. of Transport's standard appraisal value for leisure time, adjusted for wage rates[8] . For a household with mean income, the figure is £2.68/hr (1991 £s). Travel costs (ie the *tc* term above) are the sum of distance and time costs. Due to the very poor response on the cost of substitutes, this measure was omitted . This *may* have the effect of biasing consumers surplus figures upwards (Smith and Kaoru, 1990). On- site time costs are valued at zero. This contrasts to Smith et al's treatment, but we would argue that forest visitors are in the most part seeking ways to fill up their leisure time: they are not, therefore, seeking the quickest means of generating a given value of service flow from the forest (unlike, say, a fisherman, who may want to catch up to his limit as quickly as possible).

Given the high proportion of holidaymakers in our sample, some means had to found of treating them analytically. The standard problem with holidaymakers in travel cost studies is that the existence of the site at which holidaymakers are sampled may be a significant determinant of their desire to visit the area on holiday. If this is so, some of their travel costs from their permanent residence to the holiday area should be counted , as using their travel cost that day underestimates the minimum value they place on a site. We considered two treatments. The first was to omit holiday makers from the analysis: this approach is not followed here. Alternatively, one can include some proxy to take account of the relatively few days in the

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8 This was done by taking the ratio of household income to the national average, and gave hourly rates varying from £0.49 to £8.37.

year that they were able to make a visit (by residing, on holiday, in the area around the site). This latter treatment is achieved by specifying the variable *leng* noted in equation 6: it takes the value 365 for all daytrippers, and a value determined by the number of vacation days for holidaymakers.

A further problem is the treatment of 'meanderers', individuals for whom a visit to the site was not the main purpose of their day out. In the HTC studies reported above, these individuals are not distinguished (perhaps because fishermen, for example, are very unlikely to have a purpose other than fishing). In our sample, the 32% of respondents who were classified as meanderers were asked to score the importance of the visit to their total enjoyment of their day out. This score (on a scale of 1 to 5) was then used to derive weights, which were used to adjust daily travel costs downwards. The trip generating function was estimated using both OLS and maximum likelihood. The latter approach takes account of the dependent variable (VISA) being truncated at 1 and 365.[9] After initial investigations, two modifications were introduced. These were:

1) To include a further vector of interaction terms. This attempts to capture the ways in which forest characteristics are inter-related. In particular, it seems plausible to suggest that

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9 In Hanley and Ruffell (op cit), we also report results using monthly visits as the dependent variable; and using a restricted data set excluding holidaymakers and meanderers.

height diversity, mean height and conifer diversity are more important in coniferous woods than in broadleaved woods. A stand of mature beech trees may have very low height diversity yet be considered attractive, whilst a monoculture of sitka spruce is only even remotely pleasurable to look at if the trees are of varying heights. Conifer diversity will be relatively unimportant in woods where there are few conifers. Again, in a conifer-only forest, subtle differences in needle colour (such as between Sitka and Norway Spruce) or cone shape may be important in relieving monotony. We therefore postulate that the coefficients on *cd*, *hd*, and *hm* should depend on *pb*. This gives three cross-product terms with an expectation of negative signs. We also include a squared term for *pb*, since the marginal value of broadleaves may decline at very high proportions (we thus expect a negative sign on this squared term). A squared term was also tried for percentage of forest as open space; here, over-satiation seems plausible (so that the maximum of the function $WTP=f(po^2)$ will lie within the range of observed values).

2) We suspect that our treatment of meanderers biased downwards the coefficient on the *tc* variable. If an individual *A* states that a visit to the site was "relatively unimportant" to their day out then only a small fraction of their travel costs are allocated to the visit. Call this amount £x. Say that another individual *B* from the same point of origin is not classified as a meanderer, and therefore is allocated all of her travel costs

to the visit, £y, where y>x. The travel cost model predicts that more visits will be taken, *cet. par.*, the lower are costs. Yet individual *A* may visit less than individual *B*, as she has rated her recorded visit as "unimportant" due, perhaps, to either different preferences or substitutes to *B*. This becomes a problem statistically if no data exists on preferences and substitutes. We have only very imperfect data on substitutes, which we have chosen to omit. However, including *import* as a preference-proxy categorical variable taking its value from the importance score above significantly improves results; plausibly so, we believe. Results for the trip generating equations with these alterations are presented for both OLS and ML as Table 3. As may be seen, both equations explain the variation in visits quite well. The OLS results are reported for comparability with earlier published work and to expose the extent of the difference from the ML results. As the mean of the dependent variable (annual visits) is close to the lower truncation point in terms of standard deviations, the OLS estimates suffer from severe truncation bias (Olsen, 1980). Our comments below, and Table 4, accordingly relate to the ML estimates. The coefficients on *tc, leng, import* and *age* are all significant. Purpose of visit dummies are aggregated into 5 categories, listed in the Table. *Whyb* (walking the dog) and *whye* ('other') are both significant. *Whyb* is also significant in its interaction with *tc*, as is *whyd*. Regarding forest characteristics (we use the surveyors' data set here) [10], *po* (percentage of forest as open space) is highly significant, with *hm* (mean height) being significant in its interaction with *tc*. The only other characteristic terms which approach significance are conifer diversity *cd* and mean height in interaction with *pb* and *tc*. These are disappointing results, and give little basis for deriving implicit prices.

We report, in Table 4, the effect of varying characteristics on consumers surplus per household per visit: however, these results should be treated with great caution. Across the sample as a whole at existing characteristic levels, mean consumers surplus per household per visit was £5.00, or £2.19/adult. This latter figure is similar to other UK studies (Hanley, 1989; Willis, 1990). We also computed consumers surplus by purpose of visit: this ranged from £5.66 for walkers and 'facility enthusiasts' to £2.22 for dog walkers.

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[10] See Hanley and Ruffell (op cit) for results using FC and respondents characteristic ratings.

Table 3

Travel Cost Results

	without truncation (OLS)		with truncation (ML)	
variable	coeff	|t|	coeff	|t|
constant	-1.10	1.27	-10.73	6.08
tc	-0.347	2.61	-0.438	1.98
lninc	0.0399	0.67	0.0130	0.14
age	0.00679	2.86	0.0122	3.07
lnleng	0.301	15.39	1.23	25.67
import	0.710	6.73	2.26	10.49
hm	-0.570	1.75	-0.282	0.41
hm*pb	0.228	1.90	0.0393	0.16
hd	-0.147	1.11	-0.0977	0.41
hd*pb	0.00218	0.05	-0.0920	1.32
pb	-0.329	1.36	0.526	1.16
pb*pb	0.0294	0.65	0.0461	0.56
cd	0.373	1.70	0.716	1.81
cd*pb	-0.0992	1.64	-0.185	1.57
pw	0.0440	0.39	0.0844	0.43
po	0.0852	2.10	0.320	4.31
whyb	2.00	14.64	3.14	14.40
whyc	0.142	1.15	0.175	0.66
whyd	-0.207	1.02	-0.547	1.58
whye	-0.469	2.73	-0.557	2.52
hm*tc	0.179	2.62	0.292	2.15
hm*pb*tc	-0.0592	2.75	-0.0861	1.90
hd*tc	0.0359	1.19	-0.00283	0.05
hd*pb*tc	-0.00405	0.49	0.0237	1.56
pb*tc	0.0451	1.17	-0.00129	0.01
pb*pb*tc	0.00781	0.85	0.00520	0.27

Table 3

	without truncation (OLS)		with truncation (ML)	
cd*tc	-0.0155	0.37	0.0360	0.40
cd*pb*tc	0.00619	0.60	-0.00666	0.29
pw*tc	-0.0167	0.98	-0.0669	1.42
po*tc	0.00175	0.23	-0.0201	1.16
whyb*tc	-0.146	4.01	-0.274	4.42
whyc*tc	-0.00503	0.26	0.00103	0.02
whyd*tc	0.0941	2.48	0.287	3.86
whye*tc	0.0300	1.66	0.0473	1.28
no. of obs.	974		974	
R^2	0.546		-	
$\bar{R}^2$	0.530		-	
$F(R^2)$	34.27		-	
s.e.r.	0.956		1.235	
rmse	45.89		47.11	

Dependent variable: ln(y) where y is annual number of visits.
Results in column 1 are OLS results ignoring truncation. Results in column 2 recognise that y is truncated at 1 and 365. ML estimation is used asssuming that the error is upper and lower truncated Normal.
The characteristic values are the surveyors' perceptions.
Reasons for visits are grouped as follows:

whya = reasons 1,2,4,9,10,13,14 (walkers and facility enthusiasts)
whyb = reason 3 (dog walkers)
whyc = reasons 5,6,8,11,15,16 (forest enthusiasts)
whyd = reasons 7,12 (break in journey)
whye = reason 17 (other)

s.e.r. = ML estimate of the standard error of the regression/ standard deviation of the disturbance
rmse = root mean squared error in y (not logy)

Consumers' surplus figures implied by ML coefficients (£ per household per visit)

Mean over whole sample	5.00
By reason for visit:	
walkers and facility enthusiasts	5.66
dog walkers	2.22
forest enthusiasts	5.70
break in journey	-9.09
other	7.74

Table 4

The effect of varying characteristic levels

	hm			hd			pb	cd			pw	po
pb	mean	1	4	mean	1	4	-	mean	1	4	-	-
0											6.04	
1	4.33	4.59	4.51	2.90	9.08	2.16	15.51	4.50	9.66	3.66	4.30	6.53
2	5.28	82.64	3.64	3.59	11.20	2.70	7.12	4.87	13.48	3.79		5.78
3	6.78	-5.17	3.06	4.71	14.61	3.59	4.86	5.30	22.30	3.93		5.18
4				6.83	21.02	5.36	3.83	5.81	64.51	4.08		4.69
5				12.41	37.46	10.58						4.29

The table shows the values of the surplus for differing values of the characteristics. Where there is an interaction term, pb is held at its mean (2.90), its minimum (1) and its maximum (4) to show how the variation depends on pb.

4. Contingent Valuation

As was mentioned in section one, two contingent valuation (CV) approaches were used in this study:

1. Using pairs of photographs to compare values; and
2. Using a bid curve approach.

We now detail each of these in turn.

4.1 CV using pairs of photographs.

During the pilot survey, respondents were shown several sets of photographs of forests. They were asked to indicate the principle characteristic that varied between each pair. In this way, we selected three pairs of photos for use in the main survey, each pair representing extremes of the following characteristics: proportion of broadleaves; height diversity; and presence/absence of a water feature. Unfortunately, suitable pairs with illustrated extremes of mean height, percentage of forest as open space and conifer diversity could not be found. This part of the study thus looks at a smaller set of characteristics than the HTC or bid curve sections.

For each pair of photos, respondents were asked to state their preference in terms of the question "Which forest do you find more attractive?". Respondents were then asked to imagine that this preferred forest was "..more expensive to visit than the other." They were then asked:

"How much extra would you be willing to pay to visit the forest you like best rather than the other?"

This bid represents the maximum value the respondent places on the increase in the characteristic level from the less-preferred extreme value to the most-preferred (as shown in the photo selected for each pair) *if* all other aspects of the two forests are perceived to be identical. Whilst every effort was made to make this the case, each pair did differ slightly in ways other than the characteristic of interest: for example, by being lighter or darker, or showing more or less sky. Bids (in terms of additional WTP) were collected by means of a payment card, with lower bound zero and an upper bound defined by respondents. Where a zero incremental WTP was tendered, a reason was sought. Protest bids were thus identified.

Results obtained were as follows:

Pair A: presence (photo 2) versus absence (photo 1) of water feature

918 usable (ie completed, non-protest) responses were collected. 831 respondents preferred photo 2 (water feature), 87 preferred photo 1. Those expressing a preference for photo 1 were treated as tendering a negative bid for photo 2. This gave a mean incremental WTP to access the water feature of £0.69, which is significantly different from zero. The 95% confidence interval was £0.61-£0.78. So on this evidence, water features significantly increase the average consumers surplus of a forest visit.

Pair B: mixed forest (photo 4) versus conifer only (photo 3).

Here 884 usable responses were obtained. 50 respondents preferred photo 3, but 834 preferred photo 4 (ie the mixed forest). If bids for forest 3 are treated as negative bids for forest 4, then incremental WTP to access the mixed forest was £0.49, which is significantly different from zero. The 95% confidence interval was £0.41-£0.56. So mixed forests result in significantly higher consumers surplus per visit than conifer-only forests, if this is the only characteristic that is allowed to vary. Interestingly, the percentage of all bids registered for the preferred characteristic in this set was the highest across all three sets, implying that on political vote grounds, species diversity is the characteristic to which people are least indifferent.

Pair C: uniform heights (photo 5) versus diverse heights (photo 6).

Here 899 usable responses were available. Of these, 221 expressed a preference for uniform heights and 678 for diverse heights. Again treating bids for forest 5 as negative bids for forest 6, mean incremental WTP to access forest 6 was £0.33, which is significantly different from zero. The 95% confidence interval is £0.26 to £0.41.

Whilst the CV data from the photo experiments is interesting, it suffers from two weaknesses: first, that as mentioned above, it was not possible to find pairs of photos which held constant all forest characteristics, and all photographic aspects, except the characteristic being studied; and second, that we have no way of measuring the 'amount' of characteristic in each photo. This means that although the mean incremental WTP for species diversity was significantly different from zero, we cannot say what incremental WTP would be for some further increase in diversity. For these reasons, and also as a methodological cross-check, we conducted a second CV experiment, which we now detail.

4.2 A bid curve approach

If significant relationships can be found between forest characteristics and WTP bids, then this offers a second means of using CV to investigate the value of such characteristics. Each respondent was asked the following question:

"This forest[11] is owned and managed by the Forestry Commission. Management of the area costs money. Suppose that, due to financial pressures, the Forestry Commission had to decide whether to charge an entrance fee (a day-ticket, perhaps) for this forest. If the only way of preserving the opportunity to visit the forest, was for such an entrance fee to be charged, what is the most you would be willing to pay, per adult per visit?"

This question, which was designed to give a reason for

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[11] That is, the forest where the respondent was sampled.

payment being required, seeks an estimate of user option price. Respondents were shown a payment card, again bounded at zero and a respondent-specified upper limit. Zero bids were recorded as either protests or genuine zeros, depending on the motive given. Reasons for protests are given in Table 5: total protests were 7.5% of all bids. Our conclusion from this is that respondents found the hypothetical market to be realistic, and/or that the market did not generate moral outrage for the majority of respondents. We report tests of question wording and bid revelation mechanism later.

Table 5

Protest Bids from option price responses

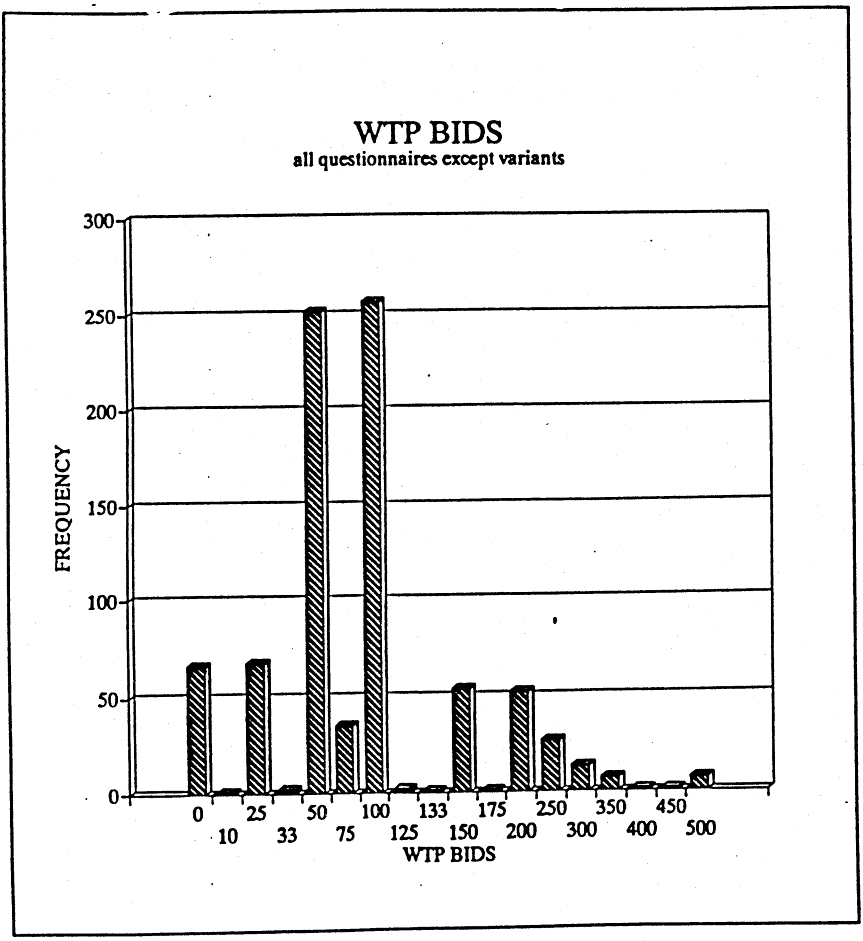
Reason	Number of cases
Impossibility of charging for access	16
Should be free: public have right to access	25
Object to specific payment mechanism	8
Unfair to poor people	11
Other	11
TOTAL	71

Once protest bids are excluded, then the following descriptive statistics on option price bids were obtained:

Mean	£0.93
95% confidence interval	£0.87-£0.98
Standard deviation	£0.79
Range	£0 to £5.00
Median	£0.75

Number of genuine zeros as % of all bids: 8.7%

A frequency distribution of bids is given as Figure 1:



WTP BIDS
all questionnaires except variants
300
250
200
150
100
50
0
FREQUENCY
0
10
25
33
50
75
100
125
133
150
175
200
250
300
350
400
450
500
WTP BIDS

WTP bids were hypothesized to depend on (i) socio-economic characteristics of respondents (age, income, education); (ii) preferences of respondents (proxied here by the variables *import* and *conserve* [membership of a conservation group]); (ii) the purpose of visit for respondents (given as the variables *why1* to *why17)*; and (iii) forest characteristics. These latter include the physical characteristics specified in the HTC model, namely *hm, hd, pb, cd, pw* and *po* (together with interaction terms as specified earlier); and surveyors rating of views *(views)*, walking facilities *(walks)*, visitor facilities (*visfacil)*, the provision of information boards at the site (*info*, =1 or 0), the presence of way marked trails (*trails,* =1 or 0), and whether any car parking fee was levied at the site where respondents were questioned (*price,* in pence: very few sites levied parking charges). Characteristic levels are from the surveyors' data, since this was the most complete set. Squared terms for all characteristics were also included to test for non-monotonic relationships between characteristics and WTP. Finally, we also specified dummy variables to control for the weather conditions when the WTP option price question was asked; how far *(dist)* respondents had travelled to the site, how long it had taken then (*travtime)* and how long they had stayed on site *(staytime)*.

In the initial bid curve estimations, many coefficients listed above had t statistics close to zero. We pursued a strategy of eliminating a variable iff (i) there was no strong prior argument for its inclusion; (ii) the absolute t statistic was less than one; *and* (iii) its removal did not significantly effect other coefficient values. As a result of this procedure, we obtained the results shown in Table 6. Again, both OLS and ML results are given for comparison: the ML results reflect truncation at zero, with the error lower truncated normal.

Table 6

Bid Curve Results

	OLS		with truncation (ML)	
variable	coeff	|t|	coeff	|t|
constant	-74.3	1.77	-458.2	3.61
rain1	9.94	1.22	28.2	1.26
temp1	-29.5	2.70	-69.4	2.18
temp2	-12.5	1.60	-30.2	1.55
day	15.1	2.76	34.5	2.37
holiday	-16.6	2.92	-32.0	2.28
dist	0.0553	0.53	0.120	0.46
travtime	0.0448	0.85	0.0761	0.77
staytime	0.0482	1.73	0.0822	1.29
why3	-21.5	2.61	-78.4	2.83
why4	23.9	2.18	34.2	1.52
why5	25.2	2.12	39.3	2.06
why9	-30.0	1.85	-71.5	1.15
why10	-17.4	1.09	-33.1	0.86
import	11.7	1.77	25.8	1.63
visa	-0.0912	1.62	-0.497	2.77
age	-0.421	2.33	-1.05	2.20
income	0.00123	4.02	0.00241	3.58
hm	38.3	1.99	122.7	2.30
hm*pb	-10.3	1.53	-31.3	1.74
hd	5.27	0.65	29.6	1.12
hd*pb	-0.414	0.17	-5.67	0.74
pb	12.6	0.83	36.2	0.80
pb*pb	0.756	0.28	3.79	0.48
cd	-7.13	0.54	-32.8	0.93

Table 6 - continued

	OLS		with truncation (ML)	
cd	-7.13	0.54	-32.8	0.93
cd*pb	0.944	0.25	7.71	0.71
pw	8.10	1.09	7.28	0.37
po	2.68	0.97	7.91	0.92
views	14.1	4.85	34.8	4.36
walks	-2.03	0.70	-4.61	0.57
visfacil	10.2	3.66	27.7	3.73
info	9.66	1.18	25.4	1.22
trails	-14.4	1.65	-38.3	1.85
price	0.334	3.12	0.667	2.78
no. of obs.	859		859	
R^2	0.269		-	
$\bar{R}^2$	0.240		-	
$F(R^2)$	9.20		-	
s.e.r.	68.1		101.8	
rmse	68.1		128.3	

Dependent variable: WTP in pence.
Results in column 1 are OLS results provided on handwritten sheet with report.
Results in column 2 assume that WTP is truncated at 0 and that error is lower truncated Normal. Note that this is not equivalent to Tobit which assumes that WTP is censored at 0)
rmse = root mean squared error in WTP
s.e.r. = ML estimate of the standard error of the regression/ standard deviation of the disturbance.

Taking the ML results as illustrative, weekend visitors bid higher than weekday visitors, whilst holiday makers bid more than daytrippers. WTP is strongly and positively related to income, and significantly but negatively related to respondents' age. Turning to forest characteristics, WTP rises with mean height of trees (*hm)* [the increase being dependent on the value taken by *pb* due to the interaction term, and ranging from +91p to +60p]; with respondents rating of views (*views)*; and with their rating of visitor facilities (*visfasc)*. Neither species diversity (*cd, pb)*, percentage of forest as open space (*po*) nor presence/absence of water features (*pw)* significantly effect option price bids in this pooled data; however, the signs on all these variables are in accordance with a priori expectations (so that, for example, WTP increases with height diversity, percentage of broadleaves, and presence of a water feature). Increasing conifer diversity has a negative effect on WTP: we comment on this in section 5. Reasons for visit are again significant in two cases, indicating that, for example, dog walkers are on average WTP 78p less than walkers. The adjusted R^2 value for the OLS equation is in excess of Mitchell and Carson's minimum recommended value of 15% for CV studies (Mitchell and Carson, 1989).

The linear functional form for the equations in Table 5 may, of course, be a poor choice. However, if a non-linear but monotonic form was appropriate between, for example, WTP and *pb*, the linear form would almost certainly perform better, whilst if a non-monotonic form were correct, the squared terms in the original equation (not reported here in full) would have performed better. It seems more likely that the disappointing results with regard to some forest characteristics are due more to inadequacies in the way characteristics were measured (see also the comments in Section 5).

CV results have been shown in several studies to be influenced both by the manner in which bids are collected (payment card, open-ended, referendum); and by the wording of CV questions (see Boyle, 1989; Bergstrom, Randall and Stoll, 1989 and 1990). We tested for such impacts in a limited fashion in this study in the following ways. First, by varying the bid collection mechanism. Two sub-samples were collected at the David Marshall Lodge, Achray Forest, whereby one sub-sample (variant A) replicated the main survey, using a payment card; whilst variant B contained an open-ended CV question, rather than the payment card. A third variant (C) used the open-ended mechanism, and also contained a change of wording in the CV question. Here, the sentence "..Suppose that due to financial pressure, the Forestry Commission had to decide whether to introduce an entrance fee" was replaced by .."Suppose the Forestry Commission decided it was appropriate to charge an entrance fee"..No other change in wording was made; the effect of this change was to remove the 'reason for payment' of variant A, and thus alters the information set of respondents. Finally, variant D has the reason for payment removed, but retains the payment card. Thirty responses were obtained for each variant. Calculating simple means showed that WTP increased relative to variant A (and thus the structure of the main survey) when payment card was replaced by open-ended; and when the 'reason for payment' was removed. This is potentially misleading, however, since these results may be due to other differences in the sample population of the four variants. This was confirmed using regression analysis, where the payment card/open-ended and reasons for payment/no reasons for payment treatments were specified as three dummy variables. None of these dummies were individually significant, nor were they jointly significant. We conclude that the change in wording and change in bid collection mechanisms have no significant impacts on option price estimates in this case.

5. Conclusions

This study sought to place economic values on the characteristics of public forests, and so aid both management of such forests, and explanation of consumers' surplus per visit estimates for UK forests. With regard to these characteristics, from the HTC study we were able to find significant relationships between visits per annum; and mean height and percent of forest as open space only. Notwithstanding this, we were able to calculate changes in consumers surplus as characteristics change for all characteristics (Table 4). Annual visits were found to depend strongly on travel cost, reason for visit, length of stay and importance of visit, all with 'correct' signs.

From the CV exercise, the use of photographs enabled us to say that higher levels of all three characteristics studied in this way were valuable, in that incremental WTP was significantly different from zero in each case. In the bid curve analysis, mean height, views and visitor facilities all significantly increase mean WTP. For example, a one-unit increase in the views rating (from, say, 3 to 4) increases mean WTP by 4.36 pence. Reasons for visit are again strongly significant, along with income, age and conditions under which the survey was performed. Neither CV study suffered unduly from protest bids. Our limited tests on question wording and bid revelation mechanism showed no significant effects, whilst bids were well-explained in terms of R^2.

Although height diversity,presence of water and % of broadleaves were significant in the CV photo study, none of these were significant in the bid curve analysis. One reason may be that people do not perceive on-the-ground differences in forest characteristics as well as they perceive them from photographs of extremes. Any such tendency might be explained by the importance of reasons for visit, in both the bid curve and HTC analyses: decisions on which forest to visit are more dependent on intended use rather than physical characteristics *for the sample as a whole*. However, specific groups of users might well discriminate more carefully in deciding which forest to visit according to reasons for visit: bird watchers might well have a greater preference for deciduous woods over a conifer monoculture, than would someone just walking their dog.

Some limited evidence is provided on this in Table 7, where mean option price bids are distinguished by classification of purpose of visit. In terms of the HTC and bid curve analysis, this would mean that either separate regressions should be done for each purpose of visit; or that purpose of visit should interact with characteristics. Regressions were performed on separate groups of users: however, no improvement over the whole-sample bid curve was noted in terms of increased significance levels for characteristics. Details are reported in Hanley and Ruffell (1991), Appendix 6.

Table 7

Option price WTP bids by purpose of visit

Purpose of visit category	%[1]	Mean WTP, £
1. Walking	28.5	0.98
2. Picnic/barbecue	16.9	0.94
3. Dog walking	14.0	0.58
4. Special feature (eg reptilliary)	6.0	1.33
5. Visit forest	5.6	1.28
6. Views/scenery	5.0	0.93
7. Break in journey	3.1	0.70
8. Visit area in general	2.4	1.17
9. Entertain children	2.3	0.82
10. Cycling	2.3	0.85
11. See water feature	1.8	1.39
12. Peace and quiet/fresh air	1.3	1.04
13. Boating, fishing	1.0	1.47
14. Visit forest centre	1.0	1.53
15. Watch wildlife	1.1	1.08
16. Photography	0.9	0.58
17. Other	6.9	1.11

Notes: 1. % of total respondents (=1041)

This wide spread of reasons for visit is in stark contrast to, for example, the cases studied by Englin and Mendelsohn (1991) and Loomis, Sorg and Donnelly (1986).

By and large, though, the results from both the HTC and bid curve analyses of the value of forest characteristics must be considered disappointing. In the bid curve analysis, marginal values for both conifer diversity and rating of walking are negative (although in both cases the coefficients are insignificant): however, all other characteristics have positive signs in accordance with a priori expectations.[12] For the HTC model, height and height diversity both have negative marginal values (although again insignificant, with all other signs being 'correct'). What explanations can be offered for this, and how might results be improved?

We have already commented at length on importance of reasons for visit. Other explanations for our results are:

1. Important characteristics are omitted from the FC data base from which the sample was drawn. These might include local topography, and forest variety within the 3km radius (only one figure is given for each characteristic within each 3km sub-compartment. If these missing characteristics are in addition correlated with included characteristics then our coefficients will be biased.

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[12] Except for the interactions with *pb*, which as we have said are expected to be negative.

2. Complex interactions between characteristics may exist which we have not specified. For example, tall trees may be valued when in an open forest setting and seen at a distance; but not so valued when they obscure views or darken the forest, as they may do in a forest with little open space. This lower value might also depend on the proportion of broadleaves (which let through more light); and even conifer diversity (larches shed their leaves in winter). All these characteristics have a role in determining one's subjective impression of a forest, which in turn determines the value one places on it.

In terms of how results could be improved, this will depend on the methodology. For HTC and the bid curve approach, further research should require:

(i) a database on forest characteristics measuring many more characteristics, both at surveyed sites and at substitute sites;

(ii) a much larger sample size, to allow this larger number of characteristics to be modelled, and a much greater number of interaction terms; and

(iii) a sample where the number of visitors from any one zone was sufficient to perform a Brown and Mendelsohn-type two stage analysis; and to permit disaggregation by purpose of visit given the large numbers of such purposes. This at no expense in terms of the number of sites sampled.

With regard to the CV photo analysis, the two principle weaknesses were that only three characteristics were thus studies, and that the photos did not hold all other features of the forest constant. It would therefore be sensible to repeat the exercise using artist's impressions for each characteristic under investigation, where the *only* aspect that varied between each pair was the relevant characteristic.

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