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ANALYSIS

Valuing the recreational benefits from the creation of nature reserves in Irish forests

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Abstract

Data from a large-scale contingent valuation study are used to investigate the effects of forest attributes on willingness to pay for forest recreation in Ireland. In particular, the presence of a nature reserve in the forest is found to significantly increase the visitors' willingness to pay. A random utility model is used to estimate the welfare change associated with the creation of nature reserves in all the Irish forests currently without one. The yearly impact on visitors' economic welfare of new nature reserves approaches half a million pounds per annum, exclusive of non-recreational values.

Keywords: Non-market valuation; Contingent valuation; Forest attributes analysis; Nature reserves

1. Introduction

Creating nature reserves (henceforth NRs) in public forests is one important way of preserving biological diversity and providing ecological goods to the public. Yet the economic benefits of the creation of NRs are not well known. Managers of public forests must often provide timber revenues as well as biodiversity protection and a natural setting for outdoor recreation. In much public woodland the managerial task is therefore that of providing both market and non-market goods. Although the creation of NRs in forests is sometimes in conflict with the use of woodland

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for outdoor recreation, a nature conservation site within the forest adds to most visitors' recreational experience. Some studies indicate that social benefits for non-market goods of forests are sizeable and may exceed those provided by traditional forest market products (i.e. Lockwood et al., 1992).

The costs of creating a NR in a public forest may have an easy definition in terms of foregone timber revenue or shadow prices arising from the constraints imposed on the process of timber production. In contrast, defining and measuring the full social benefits produced by creating a NR is a challenge. The full value, economic or otherwise, of a NR is unlikely to fully represent the complexity, and often uniqueness, of functions supported by the ecosystem that the NR is designed to preserve. Differing ethical beliefs about the adequacy of monetary measures to represent ecological values add to the challenge. Yet, forest managers need to deal with these hard decisions and they are often required by policy makers to document the expected public benefits of conservation initiatives. Although total conservation values are very controversial, some aspects of conservation seem more amenable to economic analysis. This study explores the effect of creating NRs on the recreational value of woodlands.

NRs within public forests are areas of conservation land use, mostly covering sites $\not> 10$–20 hectares. They conform to two major types, unmanaged deciduous woodland including scrub woodland, and bog and wetland areas. Such conservation areas can support rare varieties of flora such as sphagnum and bryophyte communities while providing habitats for rare as well as common forms of wildlife (McCurdy, 1989). The conservation value of most forests can be enhanced by co-operation between foresters and ecologists. A conservation plan can be drawn up highlighting wildlife habitats, identifying fragile or unusual flora and integrating conservation practices in the forest management plan. If appropriate, a NR area can be designated to protect and conserve existing valuable ecosystems or to encourage their re-establishment. Within a NR area created in this way, conservation management will take precedence over commercial forestry (Forest Service, 1991). Designation of a forested area as a NR is therefore equivalent to a shift in forest management from the previous regime to a more conservation-oriented regime. This occurs regardless of whether the NR is designated to protect existing natural features or to promote their re-establishment.

The use of non-market valuation methods is well established in the estimation of various economic values associated with environmental functions of forests and forest ecosystems. In particular, several authors have attempted to quantify benefits from individual forest attributes with non-timber valuation methods (Englin and Mendelsohn, 1991; Mattson and Li, 1995; Boxall et al., 1996). Of the multitude of functions performed by NRs, we focus exclusively on forest recreation. This is, we believe, one of the first attempts to estimate the effect of the creation of NRs on stated willingness to pay (henceforth WTP) for recreational visits to public woodland. To do so, following McFadden (1973) and Hanemann (1984, 1989), we develop a probabilistic model to link discrete choice contingent valuation (henceforth CV) responses to forest attributes and the socio-economic characteristics of visitors. Using a random utility difference interpretation of the observed responses, we define the distribution of WTP for visiting forests. A particular strength of the forest-attribute random utility function developed in this study is that it is based on broad CV data obtained from 26 Irish forests, involving nearly ten thousand visitors. We should like to point out at the outset that the aim of the paper is to estimate the sensitivity of stated WTP for access charges to forest attributes 'at the forest gate', including the presence of a NR. This amounts to identifying the probability of the Hicksian variation conditional on forest site attributes at the forest gate, and after forest site selection. As such, our chosen approach — CV — is quite appropriate. Substitutability issues are better explored via revealed preference methods, such as the travel-cost method. For a travel-cost analysis of forest recreation from the same set of forests (see Scarpa, 1999).

We find that WTP for visiting forests depends significantly on forest attributes, the presence of

NRs being a prominent one. We use the empirical model to illustrate how to derive the distributions of WTP for the visitors to each forest, which are equivalent to a forest's access charge schedules. We then estimate forest-specific welfare changes that would result from establishing NRs in those forests currently without one. The estimated benefits of new NRs, from recreation alone, are substantial.

2. Estimation of WTP probabilities conditional on forests' recreational attributes from CV responses

CV has become one of the most widely used tools to estimate non-market public benefits from changes in environmental quality. Since its inception (Bishop and Heberlein, 1979) the referendum format, asking a specific amount for the WTP, has gradually grown in popularity. Because the respondents are only required to provide a Yes–No answer to a given WTP amount, this format relies on a smaller cognitive effort than the earlier open-ended format where the respondent was required to state a maximum WTP value. For this and other properties (Hoehn and Randall, 1987) the referendum format is now considered the best approach to elicit value responses in CV studies, and its use was advised by the Blue Ribbon Panel for studies aiming at compensatory litigation for environmental damage assessment (NOAA, 1990). Thus, this was the format employed in the CV surveys conducted in the 26 recreational forests of this Irish study. A strong limitation of this format, however, is its relative sample inefficiency. Many observations are needed to obtain precise benefit estimates, especially when conditional estimation is the objective. The approach used in the present study relates the probability of positive response to a given bid amount to the levels of forest attributes experienced during the course of the forest visit. The typical dichotomous-choice CV design splits the random sample in K subsamples each of which is probed by assigning a given bid amount t_k. The probability of a yes response at each bid amount is then estimated on the basis of the frequency of observed 'Yes' responses at each bid amount.

In this study, the object of interest is a structural relationship for $\mathrm{WTP}|t$. The objective of estimation includes a parameter vector θ and the distribution of $\mathrm{WTP}|t,\mathbf{x},\theta$, where $\mathbf{x}$ is a vector of relevant covariates. The most common way to estimate parametrically the measures of welfare change from dichotomous responses is to fit a linear index to a parametric cumulative distribution function (henceforth cdf). This linear index consists of the bid amount (or a transformation thereof) and a constant. To obtain conditional probabilities of Yes–No responses other socio-economic covariates can also be included in the model. The coefficient of the linear index can be linked to economic theory and interpreted as a random utility-difference function (Hanemann, 1984, 1989) or, via a simple reparametrization, as a valuation function (Cameron and James, 1987; Cameron, 1988; McConnell, 1990). In either case, θ is most commonly estimated by maximizing the sample log-likelihood function and the statistical properties of the model are identical. An often-used specification that seems to fit most data sets well and has appealing computational (concave sample likelihood function) and theoretical (non negativity of WTP) qualities is the probit or logit specification of a linear index with a natural log transformation of the bid amount. Other, less frequently employed distributions are the Weibull and Gamma, which are asymmetric and limited to the non-negative orthant. Often, though, a simple natural logarithm transformation of the bid amount provides both a good fit of the observed responses and the often required non-negativity and asymmetry of the WTP distribution. The natural log transform was the original specification employed by Bishop and Heberlein in their seminal paper in 1979. After 20 years of CV applications it probably remains one of the most frequently adopted specifications and fits most data sets well (Sellar et al., 1986; Ready and Hu, 1995; Downing and Ozuna, 1996; Langford et al., 1998, amongst others).

With a random utility theory interpretation of this specification (Hanemann and Kanninen, 1999) the probability of observing a Yes response can be linked to the respondent's WTP for the proposed change, as follows. The visitor regards the enjoyment of the outdoor experience in the forest as a deterministic event, while for the analyst the determinants of utility derived from the visit are assumed to be observable only in part. These observable components constitute the deterministic part of the model. What determines the remainder of the utility level is unobservable to the analyst who assumes it to be stochastically distributed according to some given properties, which are typically summarised into a specific functional form.

2.1. Improving estimate efficiency and model specification

To improve on the well-known problem of sample inefficiency from CV referendum data, the WTP question is sometimes reiterated at a lower or a higher bid amount, depending on the outcome of the first response (the so-called 'follow-up', Hanemann et al., 1991). This additional response is often assumed to be generated by the same underlying WTP distribution as the first one, allowing interval data estimation of the probability model. Yet, the second response is clearly not independent from the first one, and this may justify the use of bivariate estimation, where the first and second response are treated as being generated by two correlated, but distinct WTP distributions (Cameron and Quiggin, 1994). However, estimation of interval data models in Monte Carlo experiments run on responses generated by bivariate processes have shown that, within given parameter values, this assumption causes only a small bias in welfare estimates, while increasing efficiency significantly (Alberini, 1995). For this reason we assumed that both responses were generated by the same underlying WTP distribution and use interval-data analysis.

When the respondent is not aware that there will be a follow-up question, this format allows estimation of a probability model on the basis of the first response alone. This allows the researcher to fall back on the single bound estimates if the data actually provide evidence of strategic behavior in the follow-up responses.

To improve estimation efficiency in the Ireland forest recreation study, each initial response was followed by a question with a bid amount (t^h) higher than the first one (t) when the first response was 'Yes', and lower (t^l) when it was 'No'.

We therefore have two responses from which to estimate the distribution of Δv and the associated WTP. Under the assumption that the first and second response have the same underlying distribution of WTP, the interval data probabilities of the four possible responses are along with sample log-likelihood function reported in Appendix A.

We propose that the increase in utility Δv derived from a visitor to a forest site depends on a vector of forest attributes $\mathbf{q}$ relevant to the outdoor experience as well as on one of individual characteristics $\mathbf{z}$, and that this relation is linear with a given set of parameters $\{\alpha, \gamma, \beta\}$ to be estimated. Thus, Δv is specified as a linear index. So, assuming a linear index for $\Delta v = \alpha + \beta \ln(t) + \gamma'\mathbf{x}$, where $\mathbf{x}$ collects the effects of $\mathbf{q}$ and $\mathbf{z}$, and given that η is distributed logistically, one can re-write Eq. (5) as:

$$Pr(\text{Yes}|\mathbf{x},t;\alpha,\gamma,\beta) = 1 - Pr(\eta < \Delta v) = 1 - \Lambda(\Delta v) = \Lambda(-\Delta v) \quad (1)$$

and since $\Delta v = \alpha + \beta \ln(t) + \gamma'\mathbf{x}$ we get:

$$Pr(\text{Yes}|\mathbf{x},t;\alpha,\gamma,\beta) = [1 + \exp(-\alpha - \beta \ln(t) - \gamma'\mathbf{x})]^{-1} \quad (2)$$

This is the log–logistic model in the presence of covariates $\mathbf{x}$. In this specification the bid parameter β is the marginal utility of the natural log transform of money, γ is the vector of utility difference shifters associated with the covariates $\mathbf{x}$, while α captures all the other effects in a constant. After estimating α, β and γ by maximum likelihood, the various features of the WTP distribution (expectation, median and other percentiles) can be computed from the parameter estimates. Under the correct specification, thanks to the invariance properties of maximum likelihood estimates (Goldberger, 1993), they will be unbiased and minimum variance estimates of the population parameters.

By definition, median WTP [M(WTP)] is the value of t at which $Pr(\text{Yes}|\text{Bid amount}) = 0.5$. The logistic density is symmetric around zero, so M(WTP) is the value of t such that $\alpha + \gamma'\mathbf{x} + \beta \ln(t) = 0$, which leads to:

$$M(\mathrm{WTP}|\mathbf{x},t;\alpha,\gamma,\beta) = \exp[-(\alpha+\gamma'\mathbf{x})/\beta] \quad (3)$$

It is also possible to obtain estimates of all the other percentiles as functions of the estimated parameters by using the equation:

$$\mathrm{WTP}(p) = \exp[-(\alpha+\gamma'\mathbf{x})/\beta + I_p] \quad (4)$$

Where I_p is the logistic variate corresponding to the chosen percentile p:

$$I_p = -\ln(1/p - 1) \quad (5)$$

Computing p and WTP(p) with and without a NR in a specific forest site, it is possible to infer the changes in the WTP associated with NR creation. The close-form formula for the conditional expectation of WTP are reported in Appendix A.

3. Survey administration and data

In 1992, the Queen's University of Belfast conducted a recreation benefit study by administering on-site, face-to-face CV interviews in 13 sites in Northern Ireland and 13 in the Republic of Ireland. Over 9400 visitors were interviewed by trained interviewers who completed the task in a period of a few weeks, which is probably short enough to ensure preference stability. All the CV surveys shared an identical design across forest sites and the visitor refusal rate was $<10\%$. The question asked of all respondents in all sites was:

> 'If it were necessary to raise funds through an entry charge to ensure this forest or woodland remained open to the public and with no charge being made for parking, would you pay an entry charge of £t for each person in your party (including young people under 18) rather than go without the experience?'

We are therefore comparing two states, the first in the presence of the outdoor visit to site j and the payment of the admission charge t which defines the state $u(m-\mathrm{WTP}, f(\mathbf{q});\mathbf{z})$; the second, in the absence of the outdoor visit to site j and intact income level m, which defines the state $u(m;\mathbf{z})$. This money measure is an Hicksian compensating measure as it includes an income effect.

This payment vehicle was chosen in a series of pilot studies during which other access charges payment vehicles were considered, such as parking fees and annual permits.

The inital (first bound) bid amounts t used were: {50, 100, 150, 250, 400} (in pence). They were uniformly and randomly distributed across visitors. Respondents who answered 'yes' were presented with a follow-up question that reiterated the WTP question with a higher bid amount t^h, respectively: {100, 150, 250, 400, 700}. Instead, respondents who answered 'no' were asked the same question again, with a lower bid amount t^l, respectively: {30, 60, 80, 150, 250}. Bid amounts were chosen on the basis of initial parameter estimates of the WTP distribution obtained from extensive pilot studies.

During the interview, other information was also obtained concerning the socio–economic profile of visitors, such as age, sex, household income, personal income, dominant reason for the visit, means of transport to the forest and other information characterizing the profile of the visitor. All of these were included in the **z** vector. However, only household income had a statistically significant effect and was stable for different functional forms. This was hence combined with data on the site attributes deemed relevant for outdoor recreation, which made up the **q** vector. The forest attributes relevant for this paper are in Table 1.

The presence of a NR is a site-specific attribute and disentangling this effect from those of other attributes requires CV surveys be conducted across a number of sites, with and without a NR. There must be enough different sites to allow sufficient variation in site attributes to measure their effects on observed responses. Given the importance of bid design for welfare estimates the different sites should also share the same bid design. The Irish CV study has those desirable characteristics.

4. Estimating probability of response conditional on site attributes.

The Irish forest sites surveyed differed in many of the attributes that could affect a visitor's recre-

Table 1
Site attributes for Irish forests

Forest site	Total area (100 of hectares)	Congestion (100 visits per car park space)	Natural reserve	Trees before 1940 (% of total)	Tree coverage (% of total forest area)			Median Household income bracket[a]
					Conifers	Broadleaves	Larch	
Northern Ireland forests								
Tollymore	6.29	2.68	No	26	57	5	21	5
Castlewellan	6.41	1.38	No	12	44	7	17	5
Hillsborough	1.99	40.00	No	6	57	12	17	5
Belvoir	0.95	44.00	Yes	0	24	6	27	5
Gosford	2.51	1.39	No	2	40	21	0	4
Drum Manor	0.94	1.40	No	11	20	9	0	4
Gortin glen	14.60	1.17	No	3	70	2	3	4
Glenariff	11.82	1.75	Yes	2	67	1	7	5
Ballypatrick	14.61	0.85	No	0	81	0	3	4
Somerset	1.38	2.00	No	3	59	14	6	3
Florencecourt	13.93	0.50	Yes	1	32	5	0	5
Lough Navar	26.09	0.77	Yes	0	68	1	1	5
Castlearchdale	4.99	4.75	Yes	1	54	3	4	4
Republic of Ireland forests								
Lough Key	3.4	3.00	No	7.3	22	78	0	5
Hazelwood	0.7	20.00	No	0	7	93	0	6
Dun a Dee	2.4	5.00	No	2.6	51	48	1	6
John F. Kennedy	2.52	1.70	No	0.4	35	60	5	5
Dun a Ree	2.29	3.00	No	2.2	64	36	0	6
Currachase	2	3.30	No	0.3	20	68	12	5
Cratloe	0.65	3.80	No	2.1	56	3	41	6
Douneraile	1.6	4.00	No	8.1	4	96	0	4
Farran	0.75	1.70	No	0.9	83	7	10	6
Guaghan Barra	1.4	5.00	No	4.2	46	12	42	6
Avondale	2.86	1.80	Yes	2.4	30	10	4	5
Killykeen	2.4	2.00	No	2.7	90	8	2	5
Glendalough	3.26	2.00	Yes	4.3	42	7	27	6

[a] Income bracket was: 1, under £3999; 2, 4000–£7999; 3, 8000–£11 999; 4, 12 000–£15 999; 5, 16 000–£19 999; 6, 20 000–£29 999; 7, 30 000–£39 999; 8, higher than £40 000.

ational experience. This study concentrates on a few that were measured, and that could be important for forest managers. The vector of site attributes **q** included total area (TOTAREA in 100 hectare units), under the hypothesis that the sheer extent of a forest could affect the experience of its visitors. It also included a dummy variable (NATRES = 1 or 0) to reflect the presence or absence of a NR in the forest, a major policy issue being the desirability of such reserves. To assess the impact of large old trees, which are such a salient feature of forest landscapes, the percent of total trees planted before the year 1940 was used (PRE1940). Another descriptor of the forest landscape included in **q**, was the percentage of land covered with conifers (CONIFS) broadleaves (BDLEAF) and larch (LARCH) (measured in ten percentage points to decrease numerical errors). A measure of site congestion (CONGEST expressed as 100 visits/car park space/year) was used to control for the negative effect of inadequate facilities and crowding on the utility of a visit. Congestion effects can be measured in many ways. We adopted this particular measure because car park congestion is often taken as a strong signal of site congestion at the forest gate, when it is likely to strongly affect the actual WTP for access charges.

Table 2
Parameters of probability of willingness to pay function

Parameter	Single bounded		Double bounded	
	$\ln L = -0.4799$[a]		$\ln L = -1.1267$	
Constant	9.752	0.276***	10.633	0.221***
Forest area	0.018	0.007**	0.016	0.005***
Congestion[b]	–0.358	0.029***	−0.358	0.023***
Natural reserve	0.581	0.067***	0.465	0.065***
Old trees	0.0007	0.0015	0.0025	0.001**
Coverage				
Conifers	0.054	0.019***	0.057	0.017***
Broadleaves	0.129	0.017***	0.113	0.014***
Larches	0.205	0.034***	0.130	0.028***
Income bracket	0.082	0.016***	0.101	0.013***
Bid	−2.217	0.048***	−2.416	0.038***

[a] $\ln L$, log likelihood function.
[b] Congestion values in Table 1 were scaled by 1/10.
***,
**, Significant at 1 and 5% level, respectively, for 8371 observations.

The vector **z** consisted of only one variable: the visitor's household income bracket (HHINCOME) with expected positive sign, reflecting higher probability of a Yes response at a given bid t at higher income brackets. Other functional forms were investigated, but gave inferior log likelihood values.

Single bound (henceforth SB) and double bound (henceforth DB) parameter estimates were obtained by maximimizing the log-likelihood functions in the appendix. Maximization was carried out with the Newton–Raphson algorithm and the standard convergence setting of the Gauss Maximum Likelihood package (Aptech Systems, 1997), using analytical gradient and Hessian. The results for the interviews conducted in the 26 forest sites are in Table 2. Despite missing data on household income there were still 8371 usable observations. All the coefficient estimates have the expected sign in both SB and DB models. The values of the two likelihood functions at a maximum are not directly comparable as the DB includes a second set of responses, nor would be other conventional measures of fit based on likelihood values (such as the various pseudo R squares). The mean likelihood value $[\exp(\ln L/N) \times k]$, where $k = 1$ for SB and 2 for DB, is similar and quite high for both models, 0.62 for the SB model and 0.65 for the DB, indicating a good fit for both models, and a small improvement in fit by the latter.

In the SB model all but one parameter were significantly different from zero at the 1 or 5% level. The exception was the coefficient of the old trees (PRE1940), which was not significantly different from zero at conventional significance levels, but which was significant, with the expected positive sign, once the follow-up question was used in the DB estimation. Interestingly, given the purpose of this study, in both models the presence of a NR had a significant effect on the visitors' WTP for the recreational experience. The magnitudes of the coefficients of the tree coverage variables are in accord with expectations. Decreasing marginal utility implies that a marginal increase of the most common tree type cover produces the lowest increase in utility. So conifers, which are widely represented across Irish forests, have the lowest marginal effect, followed by broadleaves which are the second most common and then by larch — the rarest species in Irish forests — but quite colorful in autumn landscapes. As expected, income has a low but significantly positive effect on the probability of a positive response to any given bid amount. The total area of the forest site has a low positive effect.

5. Model applications

The models in Table 2 allow for a range of inferences useful for forest managers. Here, because of its higher precision, inference is carried out with the DB model, under the hypothesis that the assumptions invoked in model estimation are in fact true. Yet, any model is only a simplification of the economic reality and this needs to be born in mind in the interpretation of the inference results.

The estimated model defines a mapping between per visit WTP and forest attributes. The percentiles of the WTP distribution in the population of visitors, rather than its expectation or median, may be more useful for forest managers. It can show the effect of varying the access charge on the number of visits, and thus on congestion. The same can be achieved by varying the level of an attribute, such as broadleaf coverage in favour of conifers, for example.

Given the public nature of forest management in Ireland and the quasi-public good nature of forest recreation, the M(WTP) and other percentiles are an informative welfare measure in this context. Because of its relationship with the median user attitude towards a management policy, several policy decisions may be judged by their effect on estimated M(WTP).

The logit pdf is symmetric around zero, so the M(WTP) is obtained when the value of the linear index is equal to zero (see Eq. (5) above). For example, suppose there is an interest in establishing a new NR in one forest. Table 1 (Northern Ireland forests) contains the attributes $\mathbf{q}$ for the candidate site, from which one can build the index I^0 for the ex-ante condition with no NR:

$$I^0 = \alpha + \beta \ln(\mathrm{WTP}) + \gamma'\mathbf{x}^0 \quad (6)$$

For example, the median $P = 0.5$ and by symmetry of the logit pdf $I^0 = 0$, so:

$$I^0 = \alpha + \beta \ln(\mathrm{WTP}_{P=0.5}) + \gamma'\mathbf{x}^0 = 0 \quad (7)$$

$$\rightarrow M(\mathrm{WTP}^0) = \exp[-(\alpha + \gamma'\mathbf{x}^0)/\beta] \quad (8)$$

After the introduction of a NR, the vector of forest site attributes would change into the ex-post vector $\mathbf{x}^1$, hence:

$$M(\mathrm{WTP}^1) = \exp[\text{-}(\alpha + \gamma'\mathbf{x}^1)/\beta] \quad (9)$$

and the estimated change in M(WTP) for a single visit, due to the presence of a NR is:

$$\Delta M(\mathrm{WTP}) = \exp[-(\alpha + \gamma'\mathbf{x}^0)/\beta] - \exp[-(\alpha + \gamma'\mathbf{x}^1)/\beta] \quad (10)$$

If all the other forest attributes $\mathbf{q}$ and socio–economic variables $\mathbf{z}$ are unchanged, the ex-post attribute vector $\mathbf{x}^1$ will change by one element of $\mathbf{q}$ only: the dummy for the presence of the NR changing from 0 to 1.

Similarly for the expected value:

$$\Delta E(\mathrm{WTP}) = \{\exp[-(\alpha + \gamma'\mathbf{x}^0)/\beta] - \exp[-(\alpha + \gamma'\mathbf{x}^1)/\beta]\} [\pi/\beta]/\sin[\pi/\beta] \quad (11)$$

Because all the WTP parameters of interest in this study are closed-form expressions of the ML parameter estimates, their confidence intervals were generated by sampling randomly 10 000 times from the multivariate normal distribution of the parameter estimates. This distribution is centered at the point estimates of $\{\alpha, \gamma, \beta\}$ and has a variance–covariance matrix Ω approximated here by the inverse of the computed Hessian at the likelihood function maximum (Krinsky and Robb, 1986).

6. Effects of creating NRs

There are no a-priori reasons for excluding any

Table 3
Predicted WTP for a single visit in forests without a nature reserve

Northern Ireland forests							
Tollymore		Castlewellan		Hillsborough		Gosford	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
183 (175 – 192)[a]	136 (90–201)	175 (168–182)	129 (125–135)	102 (95–108)	75 (71–80)	160 (154–168)	119 (114–124)
Drum Manor		Gortin glen		Ballypatrick		Somerset	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
144 (135–154)	107 (100–114)	174 (166–184)	129 (123–136)	175 (166–186)	130 (123–137)	169 (162–176)	125 (121–130)
Republic of Ireland forests							
Lough Key		Hazelwood		Dun a Dee		John F. Kennedy	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
240 (204–282)	178 (151–209)	214 (178–260)	159 (132–192)	191 (175–209)	142 (130–155)	221 (195–249)	163 (145–184)
Dun a Ree		Currachase		Cratloe		Douneraile	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
180 (168–194)	133 (124–143)	237 (205–274)	176 (152–203)	164 (154–174)	121 (114–129)	262 (212–326)	194 (157–241)
Farran		Guaghan Barra		Killykeen			
Mean	Median	Mean	Median	Mean	Median		
150 (140–162)	111 (103–120)	172 (164–181)	128 (122–134)	144 (133–157)	107 (99–116)		

[a] 90% confidence interval.

of the investigated forests currently without a NR as a candidate for having at least part of their territory designated as NR. This would imply the designated area to be shifted under a more conservation-oriented management plan. One can derive the expected recreational benefits from such a policy by using the model estimates. The models for the WTP distribution for recreation in Irish forests developed above are used here to estimate the distribution of WTP for each forest j, conditional on the site characteristics of that forest, $\mathbf{q}_j$, and on the median income bracket of visitors at that site, $\mathbf{z}_j$. We compute these for all the forests currently without a NR. The estimates of expected and median WTP for a visit at each site, in the status quo conditions, are in Table 3. These estimates are obtained exclusively on the basis of the forest's attributes. They will obviously differ from those based on models estimated only on responses provided by those visitors intercepted at each single forest site. On the other hand, the latter models would not be of use to conduct inferences based on forest site attributes, which is the main thrust of this study. The predictions for Hillsborough and Douneraile forests show, respectively, the lowest and the largest WTP values. The median WTP ranges from 75 (71–80) pence per visit at Hillsborough under the status quo, to 194 (157–241) pence at Dourneraile, while mean WTP ranges from 102 (95–108) at the first site to a maximum of 262 (212–326) at the second. These values are similar to those reported in other British woodland studies (Willis and Benson, 1989; Willis, 1991; Garrod and Willis, 1992).

The model is also employed to infer changes in WTP per visit associated with the creation of a NR at sites that did not have one. As mentioned above, Fig. 1 reports the full probability distribution of WTP before and after the introduction of a NR on Tollymore forest. Although, the accuracy of estimated percentiles decreases when moving away from the median, there is a clear separation of the distributions with and without a NR.

Table 4 shows the predicted change in WTP with creation of NRs in each of the forests currently without one. Again, Hillsborough and Douneraile show, respectively, the lowest and the largest welfare changes. The median WTP would increase by as little as 16 (11–21) pence at Hillsborough, and as much as 41 (27–59) pence at Douneraile, while mean WTP would increase from a minimum of 22 (15–28) pence at the first site to a maximum of 56 (36–80) pence at the second.

If respondents had followed the rule in Eq. (3) when answering the CV question, then changes in WTP measure welfare changes and, under the usual caveat (Boadway and Bruce, 1984), the estimates obtained can be aggregated and used in benefit–cost analysis. As an illustration we computed the yearly aggregate impact on visitors' welfare from the introduction of NRs. This was done by multiplying the estimated per visit changes in WTP by the yearly number of visits to each forest. The results are in Table 5 and show that amongst Northern Irish forests, creating NRs at Tollymore and Hillsborough would increase welfare the most. NRs at Lough Key and Hazelwood would make the largest welfare contribution in the Republic of Ireland. The total yearly welfare increase due to creating NRs is estimated at £251 628 (226 277–£278 718) in Northern Ireland and £318 042 (265 103–£382 036) in the Republic of Ireland. However, these are probably lower bound estimates of the true changes in social welfare. In fact, respondents have revealed their WTP an access charge to visit the forest rather than going without the experience. So, other values associated with NR creation, such as increased property values in the forests' surroundings or existence value for habitat protection or creation are excluded from these estimates.

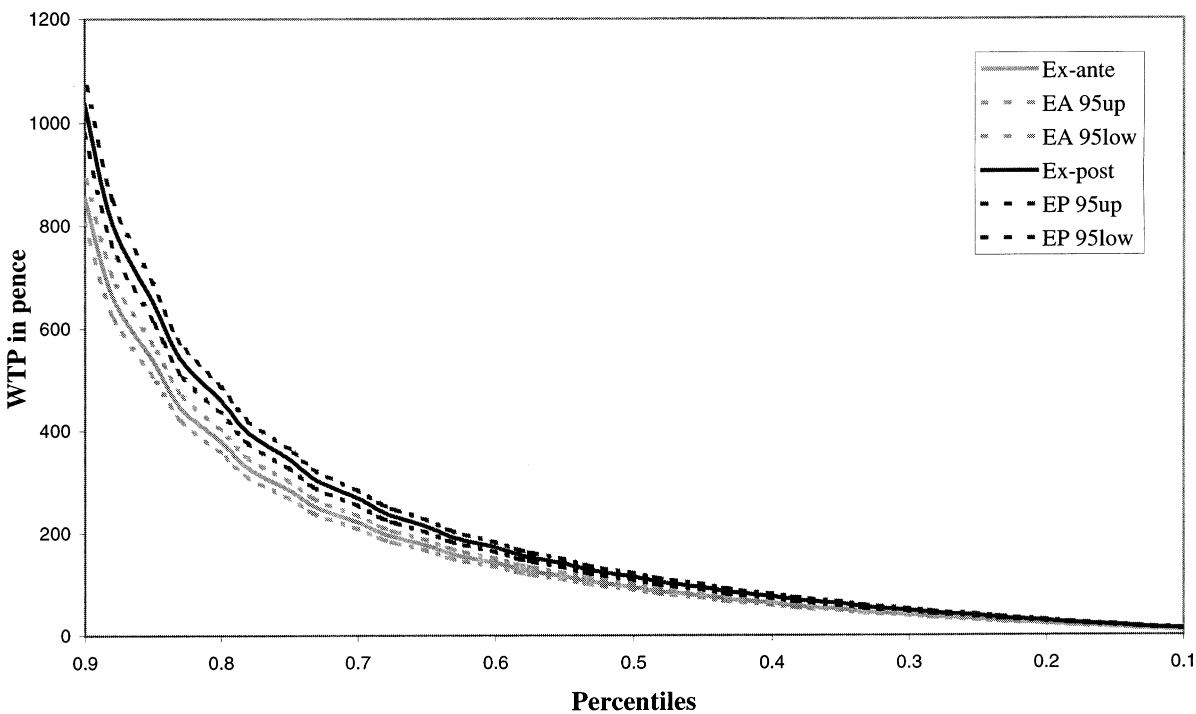

Fig. 1. Distribution of WTP for a visit at Tollymore forest, before and after the creation of a nature reserve.

Table 4
Predicted changes in per visit WTP to forests without a nature reseserve, after creating one

Northern Ireland forests							
Tollymore		Castlewellan		Hillsborough		Gosford	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
37 (27–48)[a]	27 (20–35)	37 (27–48)	27 (20–35)	22 (15–28)	16 (11–21)	34 (24–44)	25 (18–33)
Drum Manor		Gortin Glen		Ballypatrick		Somerset	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
31 (22–39)	23 (17–29)	37 (27–47)	27 (20–35)	37 (27–48)	28 (20–35)	36 (26–47)	27 (19–34)
Republic of Ireland forests							
Lough Key		Hazelwood		Dun a Dee		John F. Kennedy	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
51 (35–71)	38 (26–52)	46 (30–64)	34 (22–48)	41 (29–54)	30 (22–40)	47 (33–63)	35 (24–46)
Dun a Ree		Currachase		Cratloe		Douneraile	
Mean	Median	Mean	Median	Mean	Median	Mean	Median
38 (27–49)	28 (20–36)	50 (34–69)	37 (26–51)	35 (25–45)	26 (19–33)	56 (36–80)	41 (27–59)
Farran		Guaghan Barra		Killykeen			
Mean	Median	Mean	Median	Mean	Median		
32 (23–41)	24 (17–30)	37 (26–47)	27 (20–35)	31 (22–39)	23 (17–29)		

[a] 90% confidence interval.

7. Conclusions

To estimate the effect of creating NRs in Irish forests, we extend the classical random utility model interpretation of CV responses to account for forest attributes. We then estimate the parameters of this model to predict the probability of the WTP for a forest visit from a large-scale CV survey across 26 forests. Both SB and DB estimates support the hypothesis that forest attributes are strong determinants of the utility of a visit. In particular, the presence of a NR has a

Table 5
Predicted welfare changes due to the introduction of a nature reserve, for the population of visitors at each site (pound sterling per year)

Northern Ireland forests			
Tollymore	Castlewellan	Hillsborough	Gosford
58 186	40 790	110 310	15 743
Drum Manor	Gortin Glen	Ballypatrick	Somerset
7109	11 081	5656	2743
Republic of Ireland forests			
Lough Key	Hazelwood	Dun a Dee	John F. Kennedy
76 515	45 510	40 610	40 291
Dun a Ree	Currachase	Cratloe	Douneraile
22 950	25 150	10 434	22 284
Farran	Guaghan Barra	Killykeen	
15 950	9150	9198	

significant positive effect on the WTP. Other forest characteristics significantly influencing WTP are forest area, site congestion, number of old trees, and proportion of conifers, broadleaf species and larches (this least common species being most important). The models are applied to estimate the WTP distributions for each forest site as well as their mean and medians. We then predict the effects on the welfare of visitors from a policy that establishes new NRs in each forest currently without one. The total welfare change for the set of forests investigated here exceeds 570 thousand pounds per year. At the current frequency of forest visits this constitutes a considerable flow of benefits. A capitalization at a conservative discount rate of 3% gives a present value of ≈ 19 million pounds. A more conservative figure would use the lower bound of the 90% confidence interval. This would still give a present value of welfare change from introducing NRs of $\approx$£7.5 million for Northern Ireland and 8.8 for the Republic of Ireland.

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Appendix A

The deterministic component of the utility difference is partitioned into two vectors of variables **q** and **z**. The vector **q** collects forest-specific attributes affecting the outdoor recreational experience and determining the site's recreational quality. The vector **z** collects socio–economic variables which characterize the visitor's idiosyncratic profile.

The observable component of the utility from the visit is defined as $u(m-t, \mathbf{q}, \mathbf{z})$ where m is the visitor's income, and t is the proposed access charge; we assume that the unobservable component is ε^1, so that the total utility level is:

$$u(m-t,\mathbf{q},\mathbf{z}) = v(m-t,\mathbf{q},\mathbf{z}) + \varepsilon^1 \tag{1a}$$

Similarly, for the utility level in the absence of the visit we have:

$$u(m,\mathbf{z}) = v(m,\mathbf{z}) + \varepsilon^0 \tag{2a}$$

The individual would agree to pay the amount t as an admission charge only if:

$$v(m-t,\mathbf{q},\mathbf{z}) + \varepsilon^1 \geq v(m,\mathbf{z}) + \varepsilon^0 \tag{3a}$$

Rearranging the arguments and using Δ to indicate the differences we have:

$$v(m-t,\mathbf{q},\mathbf{z}) - v(m,\mathbf{z}) \geq \varepsilon^0 - \varepsilon^1 \rightarrow \Delta v = \Delta\varepsilon \tag{4a}$$

In terms of probability, using the definition of cumulative distribution function $F_\eta(\cdot)$ for the event $\Delta\varepsilon$, the probability of observing a 'Yes' response at a given bid amount t is:

$$Pr(\text{Yes}|t,\mathbf{q},\mathbf{z}) = Pr(\Delta\varepsilon \leq \Delta v) = Pr(\eta \leq \Delta v) \equiv F_\eta(\Delta v) \tag{5a}$$

$$\rightarrow Pr(\text{No}|t,\mathbf{q},\mathbf{z}) = 1 - F_\eta(\Delta v) \tag{6a}$$

This is the well-known random utility difference interpretation popularized by Hanemann (1984) of the dichotomous choice response to CV elicitation questions. In our case we estimate the utility function from M forests, each with a different combination of recreational features **q**. The recreational experience in one forest is similar, but not identical to that in another because each has a peculiar combination of recreational attributes $\mathbf{q}_j$. For the classic single bound case a maximum likelihood estimate can be obtained by maximizing the following modified sample log-likelihood over the space of the parameters in Δv:

$$\Sigma_j\Sigma_i I_{ji}\ln\left[1-F_\eta(\Delta v(t,\mathbf{q}_{ji},\mathbf{z}_{ji}))\right] + \Sigma_j\Sigma_i(1-I_{ji})\ln\left[F_\eta(\Delta v(t,\mathbf{q}_{ji},\mathbf{z}_{ji}))\right],\ i = 1\ldots N,\ j = 1\ldots M \tag{7a}$$

where $I_{ji} = 1$ if visitor i expressed a WTP amount t in forest j,

$$Pr(\text{Yes,Yes}|t,\mathbf{q},\mathbf{z}) = 1 - F_\eta(\Delta v(t^h,\mathbf{q},\mathbf{z})) \tag{8a}$$

$$Pr(\text{Yes,No}|t,\mathbf{q},\mathbf{z}) = F_\eta(\Delta v(t^h,\mathbf{q},\mathbf{z})) - F_\eta(\Delta v(t,\mathbf{q},\mathbf{z})) \tag{9a}$$

$$Pr(\text{No,No}|t,\mathbf{q},\mathbf{z}) = F_\eta(\Delta v(t^l,\mathbf{q},\mathbf{z})) \tag{10a}$$

$$Pr(\text{No,Yes}|t,\mathbf{q},\mathbf{z}) = F_\eta(\Delta v(t,\mathbf{q},\mathbf{z})) - F_\eta(\Delta v(t^l,\mathbf{q},\mathbf{z})) \tag{11a}$$

This leads to the following sample log-likelihood function:

$$\Sigma_j\Sigma_i I_{ji}^1 I_{ji}^2 \ln\,[1-F_\eta(\Delta v(t^h,\mathbf{q}_{ji},\mathbf{z}_{ji}))] + \Sigma_j\Sigma_i I_{ji}^1 (1-I_{ji}^2)\ln\,[F_\eta(\Delta v(t^h,\mathbf{q}_{ji},\mathbf{z}_{ji})) - F_\eta(\Delta v(t,\mathbf{q}_{ji},\mathbf{z}_{ji}))] + \Sigma_j\Sigma_i(1-I_{ji}^1)(1-I_{ji}^2)\ln\,[F_\eta(\Delta v(t^l,\mathbf{q}_{ji},\mathbf{z}_{ji}))] + \Sigma_j\Sigma_i(1-I_{ji}^1)I_{ji}^2\ln\,[F_\eta(\Delta v(t,\mathbf{q}_{ji},\mathbf{z}_{ji})) - F_\eta(\Delta v(t,\mathbf{q}_{ji},\mathbf{z}_{ji}))],\ i=1\ldots N,\ j=1\ldots M \tag{13a}$$

where I_{ji}^1 is the indicator function for a first positive response and I_{ji}^2 is the indicator function for a second positive response.

Distributional assumptions for η: both ε_{ji}^0 and ε_{ji}^1 are i.i.d. extreme value type I, hence η is distributed i.i.d. logistically.

The distribution is often defined over a log transformation of the bid amount t. Monotonicity of the log function preserves percentile estimates, such as the median, M(WTP). However, the expected value is sensitive to the log transform and by Jensen's inequality for a concave transformation $f(x)$, such as the log operation, $E[f(x)] > f[E(x)]$. In fact, in our particular specification it can be shown that (Duffield and Patterson, 1991):

$$E(\text{WTP}|\mathbf{x},t;\alpha,\gamma,\beta) = \exp[-(\alpha+\gamma'\mathbf{x})/\beta][\pi/\beta]/\sin[\pi/\beta] \tag{14a}$$

This formula is employed to derive estimates of expected WTP from the ML estimates of the parameters α, γ, β. This calculation is not defined if the estimated $|\beta|$ coefficient is inside the [0, 1] interval (Duffield and Patterson, 1991; Ready and Hu, 1995). However, in this study this was not a problem.

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