Reliability of benefit value transfers from contingent valuation data with forest-specific attributes.

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Abstract. We investigate the reliability of transferring benefit estimates of forest recreation obtained from discrete choice CV data and conditional on forest-specific attributes. The transfer reliability is checked against the forest-specific estimates of mean and median willingness to pay. We report and discuss the outcomes of formal tests of the null hypothesis of no difference for 26 recreational forests in Ireland, when the value transfer is based on single and double-bounded data collected at the remaining 25 forests. Contrary to the unconditional value transfers of Downing and Ozuna [6] we find that value transfers conditional on site-specific recreational attributes are mostly transferable.

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1. Introduction

The best way to investigate the magnitude of benefits from recreation at one natural resource site[1], such as a forest park, is to conduct an *ad hoc* study at the site.

However, this is often costly and time consuming. If information on the economic benefits produced by similar sites (the *study* sites) is already available, then one may consider the much cheaper option of 'transferring' these to the site of interest (the *policy* sites), and base the policy decision on these values. In the literature, this practice is referred to as 'benefit transfer' (BT), and it has been regarded as so important to natural resource management agencies that in 1992 a whole monographic issue of Water Resources Research was dedicated to the practical assessment of this technique [3,13,14,24,26]. Further research on this issue has been done recently by Downing and Ozuna [6] (henceforth D&O), Kirchhoff *et al.* [10], Feather and Hellerstein [7], and Smith *et al.* [25]. As Kirchhoff *et al.* point out:

"Although BTs are currently used in decision making by public agencies, the scientific debate over BT continues and many issues remain unresolved." ([10], p.75)

BT estimates are of interest to practioners only in as much as they are adequate surrogates of on-site estimates achievable by conducting costly full-scale studies. In other words, the BT estimates must show *convergent validity* [2]. That is, they must show theoretically meaningful and statistically significant relationships with alternative measures of the same theoretical construct such as other site-specific estimates of the same welfare change.

However, both BT estimates and on-site estimates are random variables, hence a measure of reliability must account for the probabilistic nature of these values.

In the present study we are concerned with assessing the reliability of BTs from benefit estimates for forest recreation obtained from a large scale contingent valuation (CV) study. In this context, BTs from CV surveys conducted on *study* forests are considered *reliable* if they are not significantly different from those that would be obtained by conducting a full-scale study in the *policy* forest.

We assess reliability by obtaining estimates of location parameters of willingness to pay (WTP), such as median and mean WTP for access to the policy forest from the benefit function estimated from data collected at the study forests. If the BT function is conditional on forest attributes, then the study forest estimates can be obtained by 'plugging-in' the values of the forest attributes of the policy site into the estimated conditional function. Following Poe *et al.* [19], we employ an asymptotically unbiased test of no difference between the on-site estimates and those transferred using conditioning on forest-specific attributes. Then we report on the results of such a strategy to investigate the reliability of BTs when forest(site)-specific attributes are used as conditioning variables in the estimation of the probability of a positive response, and used as predictors in the benefit estimate transfer.

Our results would seem to indicate that transfers are frequently reliable when forest attributes are used as predictors. We speculate that previous negative results on transfer reliability obtained in similar contexts (namely D&O) may have suffered from mis-specification and preference instability, or both. We believe our data and estimation procedure to be less prone to these problems. Results also show that when data sets are sufficiently large, and sufficient variation across site attributes is present, then DC-CV can be effectively used for BTs without the need to incur the additional effort and potential bias involved in alternative stated preference-methods, such as choice-experiments [9,12,21].

2. Conditional and unconditional BT from discrete choice CV responses.

In the context of benefit estimation from DC-CV survey responses, the econometric task is the estimation of the probability of positive response conditional on the proposed bid amount t, and possibly on other covariates. In our opinion[2], the benefit function from which the estimates are derived and transferred ought to accomodate a vector $\mathbf{q}$ of site-specific variables, as well as the conventional money measure t and a vector of socio-economic variables $\mathbf{s}$. The adequate values of $\mathbf{q}$ can then be used as predictors in the transfer phase. Similarly, the value estimates of location parameters for $\mathbf{s}$ can be obtained by pre-existing statistics on the potential population of visitors to the policy site.

For the i^{th} recreationist characterised by $\mathbf{s}_i$, who visits the j^{th} forest with attributes $\mathbf{q}_j$, in a parametric probability estimation context, we are therefore postulating a *conditional* benefit function of the form:

$$B(\mathbf{s}, \mathbf{q}; \hat{\theta}) = f[Pr(Yes\,|t, \mathbf{s}, \mathbf{q}; \hat{\theta})] \tag{1}$$

instead of an *un*conditional one of the type:

$$B(\hat{\theta}) = f[Pr(Yes\,|t; \hat{\theta})] \tag{2}$$

as used, for example in D&O.

Here $\hat{\theta}$ may be the maximum likelihood estimates maximizing:

$$ln(L) = (\mathbf{R}_{ij}|t_{ij}, \mathbf{s}_i, \mathbf{q}_j), i = 1, \cdots, N; j = 1, \cdots, J \tag{3}$$

over the parameter space, and $\mathbf{R}_{ij}$ is the recorded discrete-choice individual response in the random sample observation, which maybe with or without a follow-up.

That forest attributes play a role in explaining the magnitude of the benefits enjoyed in forest recreation makes both intuitive and economic sense[3], no matter whether the theoretical paradigm underlying the analysis is a RUM one [8,16] or a valuation function one [4,14]. It is also practically advantageous: the identification of a set of significant relationships with forest-specific attributes is of particular relevance when transfering estimates as it allows the analyst to make a conditional prediction by 'plugging-in' to the benefit function the values of the attributes observed for the policy site. This produces a conditional prediction which might be more precise than an unconditional one, such as in the case, for example, of the D&O study [6]. That site quality varaibles play an important role in benefit trasfer has already been empirically shown in met-analysis studies [20].

Suppose one has CV responses to the *same* CV survey for J sites and wishes to evaluate the performance of a benefit function conditional on site attributes. One may estimate the parameters of the conditional probability the likelihood in equation 3 by using the CV responses collected at $J-1$ study sites, here indexed with $-j$. These parameter estimates can then be used to predict the benefit transfer at the j^{th} site as:

$$\hat{B}(\mathbf{s}_j, \mathbf{q}_j; \hat{\theta}_{-j}) \tag{4}$$

this value can then be compared in terms of its statistical properties with the unconditional estimate obtained only from the responses collected on policy site j. This can be done by formally testing the null hypothesis of no difference between the two:

$$\Delta\hat{B}_{j,-j} = B(\mathbf{s}_j, \mathbf{q}_j; \hat{\theta}_{-j}) - B(\hat{\theta}_j) = 0 \tag{5}$$

One way of conducting this test is by formulating the null and the alternative as follows:

H_o :

$$\Delta\hat{B}_{j,-j} = 0 \tag{6}$$

H_a :

$$\Delta\hat{B}_{j,-j} \neq 0 \tag{7}$$

Failing to reject the null will provide evidence of transferability of the benefit value estimate (though not of the benefit function, for which we did not test in this study).

The question we seek to answer in this study is the following: *how do benefit transfers perform when conducted conditional on site-specific attributes relevant for recreation?* In order to answer this question one must systematically test the hypothesis of no difference between the transfer estimate and the on-site estimate. We conduct this systematic test across 26 forests and find encouraging results in that a number of mean and median WTP transfers fail to reject the null at conventional significance levels.

3. Benefit function estimation and reliability test.

In general, benefit estimates are known to be crucially sensitive to many judgment calls the analyst must make in the process of estimation. Choice of distributional assumption, functional form of the deterministic component of the model, nature of the data and their fit to the estimating framework are all important. In particular, in DC-CV analysis, tests that allow a discrimination across alternative choices are known to have little power [1]. Hence, much rests with the 'wisdom' incorporated in the choices of the analyst.

The estimates obtained at the end of this nested decision process are conditional on these value judgments. For this reason, in our benefit estimation procedure we kept things simple and adopted a well known random utility specification: the log-logistic probability model. This model ensures non-negativity and asymmetry (left-skewness) of the distribution of WTP for access to forests for recreation[4].

The generic form of the argument of the RHS of equation (1) was therefore specialised in:

$$Pr(\,Yes\,|t, \mathbf{s}, \mathbf{q}; \theta) = \frac{1}{1 + e^{-[\alpha + ln(t)\beta + \mathbf{s}\gamma + \mathbf{q}\delta]}} \tag{8}$$

where the generic vector $\theta = \{\alpha, \beta, \gamma, \delta\}$.

While the first three elements of θ can always be estimated, δ can be identified only when the sample pools individual responses from a sufficiently large number of forests. In the context of forest recreation as well as in other forms of outdoor recreation it is quite plausible that WTP be associated with site-specific attributes.

Under the specification in equation 8 both median and mean WTP have close-form solutions, leading to two difference functions.

The first is the difference between median WTP estimates:

$$\Delta\hat{M}(WTP) = \mathbf{exp}\left(-\frac{\alpha_{-j} + \mathbf{s}_j\gamma_{-j} + \mathbf{q}_j\delta_{-j}}{\beta_{-j}}\right) - \mathbf{exp}\left(-\frac{\alpha_j}{\beta_j}\right) \tag{9}$$

The second is $\Delta\hat{E}(WTP)$, the difference between expected WTP estimates, which are obtained by multiplying the first and second terms of equation 9 respectively by: $\frac{\pi}{\beta_{-j}}/\sin(\pi/\beta_{-j})$ and $\frac{\pi}{\beta_j}/\sin(\pi/\beta_j)$ to account for asymmetry of the WTP distribution with this log specification.

Since benefit estimates are highly non-linear functions of parameter estimates they have unknown sampling distributions, and so do their differences. Checking for the overlaps in confidence intervals, as done in D&O, is an inadequate procedure biased towards the rejection of the null [18]. We therefore proceed by parametrically bootstrapping directly the differences [19], and checking either for the presence of zeros — which implies no difference — or for under- or over-prediction. This is done by checking the representative percentiles of the simulated distribution obtained using the Krinsky and Robb [11] parametric bootstrap procedure. If the LHS percentile of the chosen confidence interval is negative and the RHS is positive then the H_o cannot be rejected and the transfer is reliable.

To sum-up, the test for validity of the BT estimate is conducted for each of the 26 forests, and it involves six steps:

1. Single out one forest as the policy site and use all the CV data from the other forests as study site data;
2. Estimate the parameters α_{-j}, β_{-j} and γ_{-j}, along with the relative variance-covariance matrix Ω_{-j} of the BT function conditional on forest attributes in $\mathbf{q}$ from the study site data (leave-one-out BT function);
3. Estimate the parameters α_j and β_j along with their variance-covariance matrix Ω_j from the data of the candidate policy site;
4. Parametrically bootstrap 10,000 times [11] both $\Delta\hat{E}(WTP)$ and $\Delta\hat{M}(WTP)$ using the two estimated variance-covariance matrices and parameter vectors;
5. Check if zero is contained in the relevant percentiles of the simulated distributions of differences, or for over- and under-prediction;
6. When zero is contained, the BT function is defined to be reliably transferable.

Model estimation and no-difference tests are repeated under single-bound, double-bound (interval-data) assumptions, with a restricted (national) and extended (entire island) set of forests. Altogether this procedure required the estimation of $26 \times 2 + 26 \times 2 = 104$ models with covariate and $26 \times 2 = 52$ without covariates (on-site estimates), for a total of 156 models[5].

4. Data, results and discussion.

4.1. Data.

In 1992, the Queen's University of Belfast conducted a CV survey as part of a larger forest recreation study [5]. The survey was administered by conducting on-site and face-to-face interviews in 14 forest parks in Northern Ireland[6] and 13 in the Republic of Ireland (figures 1 and 2). The summary of the CV discrete-choice responses are presented in table 1. Over 9,400 visitors were interviewed by trained interviewers who completed the task in a period of a few weeks, short enough to ensure preference stability. All the CV surveys shared an identical design across forest sites. 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?"

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

The initial (first bound) bid amounts t used were: 50, 100, 150, 250, 400 (in pence). They were uniformly distributed across visitors. Respondents who answered 'yes' were presented with a follow-up question that probed the WTP at a higher bid amount th: 100, 150, 250, 400, 700, respectively. Instead, respondents who answered 'No' were asked the same question again, with a lower bid amount tl: 30, 60, 80, 150, 250, respectively. 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 $\mathbf{s}$ vector. However, only household income had a statistically significant effect and was stable for different functional forms. This was combined with data on the site attributes deemed relevant for outdoor recreation, which made up the $\mathbf{q}$ vector. The forest attributes relevant for this paper are in table 2.

4.2. Results and discussion.

Tests of the null were conducted at the three conventional levels of significance. A higher α value is associated here with a more conservative assessment of reliability of the transfer, as the portion of the simulated sampling distribution including zero is smaller. For this reason three stars were associated with those transfers that were reliable at 10 percent, two stars with those at 5 percent and 1 star for those at 1 percent. A plus sign indicates that the BT estimate was an overprediction at all the three levels, while a minus sign an underprediction.

Table 3 shows the results of the convergence validity tests from single bound and double bound leave-one-out estimates from the entire pooled sample across all forest parks as well as from Northern Ireland and Republic of Ireland separately. This latter distinction allows us to evaluate the effect of restricting to the national context the set of sites from which the forest-attributes conditioning the response probabilities are drawn.

These results can be used to discuss five aspects of reliability of benefit transfer:

1. median versus mean WTP transfer;
2. double bound (DB) versus single bound (SB) effects on reliable BTs;
3. effects on reliability of BTs of estimates from an extended set of forests (all forests) versus those from a reduced set (only national forests);
4. the prevalence of over or under prediction of the transfer with respect to the on-site study estimates; and
5. the choice of α values amongst the three conventional ones.

Out of 100 comparisons[7], there are 62 reliable mean transfers and 51 reliable median transfers at *any* significance level. Of these, for the mean 42 are transferable at a 10 percent significance level, 7 at 5 percent and 13 at 1 percent. For the median, 41, 3 and 7 respectively. The number of underpredictions are 12 in mean transfers and 18 in median ones, while the number of overpredictions are 26 and 31 respectively.

Table 4a, reports the statistics for the on-site and transferred values estimates, while Table 4b reports the statistics for the observed widths of the simulated confidence intervals around $\Delta\hat{B}_{j,-j}$. The relative magnitudes of these are related as one would anticipate. That is, smaller for DB estimation than for SB, for the increased precision of the former. And larger for mean WTP estimation than for median WTP, due to the 'fat tail problem' of the log-in-the-bid specification.

Median transfers perform quite well in Northern Ireland forests from SB estimates obtained from both pooling all sites in the island, and from those in Northern Ireland alone. In the Republic of Ireland, instead, mean transfers seem to be more frequently reliable than median ones.

When DB estimates are used for the median BT the number of transferable estimates markedly decreases to only five forests in the case of estimates from Northern Ireland sites, and down to four for the median transfers from thepooled sample estimates. This is due to the increased efficiency of the DB over the SB estimates which translates into tighter confidence intervals around the point estimates at any given value of α, and hence into a lower transferability.

DB estimations produce gains in efficiency by assuming *a priori* that first and second responses are drawn from the same distribution, as a result the confidence interval around the point welfare estimates is typically tighter than with the SB estimates. The implication for our reliability test is that fewer transfers should pass the test when moving from SB estimates to DB ones. This expectation is in agreement with the results shown in tables 3, especially in the case of the median transfers.

A similar pattern is observed for mean transfers, which are less transferable also due to their higher variability.

Estimates from the set of sites of the entire island do not seem to pass the transferability test more frequently than those from the national subsets, 57 percent versus 56. So, extending the sets of sites from which to draw an estimate of the benefit function does not seem to improve convergence validity of the BT in our case, although it clearly reduces estimation problems due to collinearity of the forest attributes. This is visible in that none of the convergence problems found in the ROI subsample were present in the pooled sample.

Finally, the number of overpredictions dominates that of underpredictions in both mean and median transfers, but this might be due to the choice of specification which is log-linear in the bid amount. The choice of specification is partly dictated here by the desire to compare these results with those obtained by D&O.

In Northern Ireland, the forests for which it is generally possible to transfer both median and mean CV estimates are Castlewellan, Drum Manor, Castlearchdale and – with one median trasfer exception – Gortin Glen.

In the Republic of Ireland, only for Killykeen, although Dun a Ree is also always transferable, save in the case of mean transfer for the SB model estimated on national forests, and Lough Key is also transferable, save in the two median transfer from the pooled model.

On the other extreme, J. F. Kennedy forest is the only one for which there is never a reliable transfer, although benefit estimates for Hazelwood forest are tranferable only in one case, while in Northern Ireland no forest produces estimates that are never trasferable in at least some form.

Altogether these results, which are building on the findings by Poe *et al.* [18,19], provide evidence leading to conclusions contrary to those reported in D&O. When the effect of important determinants of WTP

are accounted for, such as site attributes, and an unbiased convergence validity test is employed, CV estimates appear to be frequently transferable across sites, and therefore of reliable practical use[8]. Transfers from SB estimates and from a larger set of forests tend to perform better than those from DB estimates and from a reduced set of forests. Conclusions with regards to mean/median WTP are more difficult to draw, although this particular set of results shows that mean WTP is more frequently transferable.

5. Conclusions

Forest attributes important for recreation are plausible determinants of forest recreation benefits from both intuitive and theoretical standpoints.

Starting from this observation we systematically investigate the effect of estimating a benefit function conditional on selected forest attributes, from a large scale discrete-choice contingent valuation study, and use these estimates for the purpose of benefit value transfer. The assessment of the value transfer reliability is made on the basis of a comparison with forest-specific estimate obtained from on-site responses, which represent a conceptually superior alternative, but a more costly one, in applied policy analysis.

Following Poe *et al.* [18,19], the null hypothesis of no difference between the on-site and transfer benefit estimates is tested by means of an unbiased test based on simulated distributions.

The study is conducted so as to allow the investigation of various effects, such as one extra bound, the number of forest sites from which the benefit function estimate is obtained, the use of the two most frequently used measures of welfare (mean and median WTP), and a comparison with previous studies (i.e. Downing and Ozuna [6]).

We find that forest attributes show significant and plausibly signed coefficients and value transfers based on a benefit function conditional on these attributes are often reliable. This finding produces evidence contrary to previous findings from similar research by Downing and Ozuna [6] and to speculations of inadequacy of CV data to be used in this context in favour of more informative [9], yet less robust [12,21] estimates from choice-experiments. It confirms the important role of site quality determinants in benefit transfers which was already pointed out in meta-analysis studies [20].

The data requirement, however, is quite high as a critical sample mass of CV responses is required across numerous sites and a homogeneous set of site-specific attributes must be chosen to describe the recreational appeal of each forest. We recognise that very often, when doing a transfer, analysts do not have access to multi-site data set as good as the one supporting the present analysis. However, our results suggest that when these data are available, transfers of benefit estimates may in many cases be not significantly different from those obtained from on-site surveys.

It may therefore be concluded that when a system of relatively homogeneous recreational sites exists and the benefits associated to on-site recreation can be significantly and plausibly linked to a set of site-specific attributes, the technique of benefit value transfer applied via referendum CV data may be expected to provide reliable values to inform policy action. We would argue that generating multi-site data sets like ours in other contexts would probably be a good application for agencies managing natural resource with recreational use, as it would generate the basis for quite fast and reliable transfers in those contexts, and possibly further reliability studies.

This may apply to systems of outdoor resources for which the benefits of the visits are strongly determined by site-attributes over which the managing agencies have some control, such as forests, pathways, freshwater lakes and rivers and hunting estates.

As a concluding note we think that further research efforts are required in the field of benefit transfer to answer many open questions. For example, in order to determine the conditions under which the cost of conducting those on-site surveys necessary to estimate the benefit transfer function are offset by the saved expenses of an extra on-site survey. Or to determine under what circumstances the null hypothesis of no-difference in the benefit function parameters need not be violated before proceeding to the transfer of the benefit estimate.

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Notes

[1] In the remaining part of the text the terms *site* and *forest* are used as synonymous.

[2] The role of site attributes was also emphasized by Opaluch and Mazzotta [17].

[3] Notice that this approach would be perfectly consistent with the findings by D&O with respect to the significance of site-specific constants for the slope and constant parameters.

[4] It is worth pointing out that a different set of assumptions might affect the benefit transfer reliability tests conducted here. Investigating the extent to which these results are sensitive to alternative estimation assumptions is beyond the scope of this study, but certainly a worthwhile subject for further research.

[5] Detailed model estimates are available from the authors. A specification estimated on the whole set of 26 forests is reported in Scarpa *et al.* [22], while econometric evidence that forest benefits varied systematically across forest sites is presented in another study [23].

[6] One forest park from Northern Ireland was dropped from the BT study because of its anomalous pattern of recreation.

[7] The procedure broke down computationally in 4 cases (because of a non-invertible variance-covariance matrix), corresponding to medians and means estimation of Glendalough and Avondale forests.

[8] In our Northern Ireland samples, a log-likelihood test conducted to check for the reliability of the unconditional benefit function – in a similar (they used t-ratios) fashion to the one conducted by D&O (i.e. to test for the significance of site-specific slope and constant dummies in the pair-wise pooled samples) – *always* rejected the null of both dummies being zero. This exercise requires the estimation of $K^2 - K - (K^2 - K)/2$ models, which for a number of sites K = 13, gives 78. Each needs to be estimated in the constrained (no site-specific dummies) *and* unconstrained (with site-specific dummies) form, for a total of 156. The result, as mentioned earlier, is fully consistent with the fact that forest attributes play a role in determining WTP for a recreational experience. When not explicitly accounted for, such as in a mis-specified model, the differences across sites are captured by the slope and constant site-specific dummies, which therefore show significance. Notice that this is not evidence of non-transferability *per-se*, but the consequence of having chosen a specification which is eccessively parsimonious, maybe as a consequence of data inadequacy. The issue in D&O is whether it makes sense to assess transferability of the benefit function on the basis of such a parsimonious and clearly mis-specified model, rather than focussing on the transferability of the value estimates, as we do here, and accept as plausible the benefit function estimates. While the link "*Transferable Benefit Function* $\Longrightarrow$ *Transferable Welfare Estimates*" may hold if the specification of the benefit function is correct, expecting to find transferability of the benefit function when its specification is evidently too parsimonious to be correct is an exercise bound to provide little insight.

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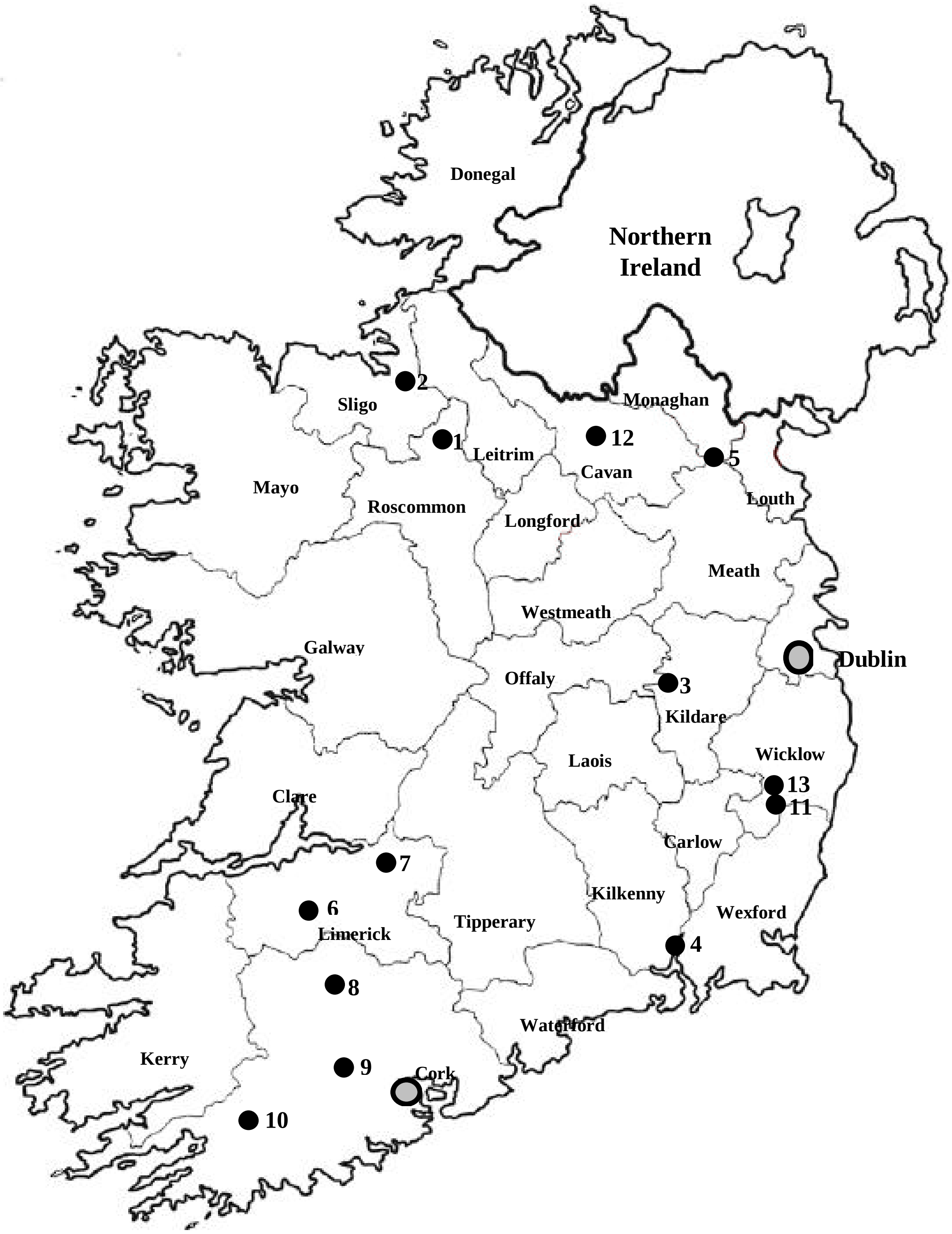

Figure 1. Forest parks and administrative districts in the Republic of Ireland.

1. Lough Key.
2. Hazelwood.
3. Donadea.
4. John F. Kennedy.
5. Dun-a-Ri.
6. Currachase.
7. Cratloe.
8. Douneraile.
9. Farran.
10. Guaghan Barra.
11. Avondale.
12. Killykeen.
13. Glendalough.

Figure 2. Forest parks and administrative districts in Northern Ireland.

1	Tollymore	8	Glenariff
2	Castlewellan	9	Ballypatrick
3	Hillsborough	10	Somerset
4	Belvoir	11	Florencecourt
5	Gosford	12	Lough Navar
6	Drum Manor	13	CastleArchdale
7	Gortin Glen	14	Crawfordsburn

Table 1a. Break-down of responses to CV elicitation questions by forest site in Northern Ireland.

Tollymore, *N*=498

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	63	37	16	3	1
Yes-No	29	42	37	29	11
No-Yes	2	12	22	29	25
No-No	5	7	25	40	63

Castlewellan, *N*=497

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	47	42	13	2	1
Yes-No	45	32	41	18	4
No-Yes	2	16	26	32	27
No-No	6	9	20	47	67

Hillsborough, *N*=491

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	24	13	3	0	0
Yes-No	39	28	16	7	3
No-Yes	9	16	38	20	12
No-No	26	42	42	71	82

Belvoir, *N*=476

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	20	16	5	2	1
Yes-No	43	25	25	8	3
No-Yes	5	17	28	12	13
No-No	28	38	38	72	77

Gosford, *N*=489

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	57	22	9	0	1
Yes-No	34	49	31	19	3
No-Yes	6	23	45	40	19
No-No	2	5	12	39	73

Drum Manor, *N*=370

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	40	23	2	1	1
Yes-No	20	17	20	9	7
No-Yes	5	13	25	23	8
No-No	9	21	27	41	58

Gortin glen, *N*=341

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	34	21	4	0	0
Yes-No	25	29	25	11	3
No-Yes	7	14	24	31	15
No-No	3	5	15	26	49

Glenariff, *N*=480

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	64	42	20	6	0
Yes-No	28	37	51	20	15
No-Yes	1	11	21	42	26
No-No	2	5	5	29	55

Ballypatrick, *N*=90

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	11	4	1	0	0
Yes-No	7	11	2	2	0
No-Yes	0	3	9	1	1
No-No	0	0	6	15	17

Somerset, *N*=243

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	9	3	1	0	0
Yes-No	21	11	9	2	1
No-Yes	5	5	12	3	4
No-No	14	30	27	43	43

Florencecourt, *N*=167

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	14	9	4	0	0
Yes-No	13	5	8	4	4
No-Yes	3	9	7	4	6
No-No	5	10	15	25	22

Lough Navar, *N*=265

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	23	27	6	0	0
Yes-No	23	11	25	12	5
No-Yes	1	10	10	17	15
No-No	6	5	12	24	33

Castlearchdale, *N*=465

£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	49	39	8	2	1
Yes-No	34	30	34	22	4
No-Yes	2	13	20	24	16
No-No	6	10	30	47	74

Table 1b. Break-down of responses to CV elicitation questions by forest site in the Republic of Ireland.

	Lough Key, *N*=482					Hazelwood, *N*=493					Dun a Dee, *N*=195					J.F. Kennedy, *N*=498				
£	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0
Yes-Yes	81	53	20	8	0	45	14	5	0	0	19	10	1	0	0	88	69	36	8	2
Yes-No	12	34	49	17	1	33	34	26	16	4	15	10	15	7	1	11	23	45	41	16
No-Yes	1	2	19	46	23	1	8	26	18	8	0	8	11	8	6	0	5	14	29	31
No-No	3	8	9	24	72	18	44	42	63	88	5	11	12	24	32	1	2	5	22	50

	Dun a Ree, *N*=249					Currachase, *N*=498					Cratloe, *N*=160					Douneraile, *N*=273				
£	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0
Yes-Yes	41	24	3	0	0	63	36	7	2	2	1	3	0	0	0	29	17	4	1	0
Yes-No	5	14	22	6	0	28	36	39	28	8	21	6	9	3	0	23	20	25	5	0
No-Yes	0	6	14	15	12	5	19	41	29	20	3	7	8	5	2	2	10	15	20	10
No-No	4	5	11	30	37	4	9	12	40	70	7	16	15	24	30	2	7	11	28	44

	Farran, *N*=491					Guaghan Barra, *N*=135					Avondale, *N*=318					Killykeen, *N*=199				
£	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0	0.5	1.0	1.5	2.5	4.0
Yes-Yes	49	30	10	5	0	20	13	6	2	0	40	21	4	0	0	21	15	5	1	0
Yes-No	33	25	37	9	7	6	10	9	9	4	21	23	24	9	3	14	9	13	6	5
No-Yes	2	15	34	32	15	0	4	6	7	4	3	11	24	24	8	0	7	12	12	8
No-No	15	28	19	50	76	2	1	5	9	18	0	9	12	30	52	6	9	9	20	27

	Glendalough, *N*=496				
£	0.5	1.0	1.5	2.5	4.0
Yes-Yes	74	63	26	12	3
Yes-No	15	24	42	33	18
No-Yes	1	1	14	19	21
No-No	9	11	17	35	58

Table 2a. Site attributes for Northern Ireland 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*
					Conifers	Broadleaves	Larch	Bracket
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

* Income bracket was: 1 = under £3,999; 2 = £4000-£7,999; 3 = £8,000-£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.

Table 2b. Site attributes for Republic of Ireland 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*
					Conifers	Broadleaves	Larch	
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
J.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

* Income bracket was: 1 = under £3,999; 2 = £4000-£7,999; 3 = £8,000-£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.

Table 3a. Tests for reliability of benefit transfer from CV in Northern Ireland Forest Parks.

	SB estimates from NI		DB estimates from NI		SB estimates from all		DB estimates from all	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Tollymore	***	***	*	**	+	+	+	+
Castlewellan	**	***	***	*	**	***	***	***
Hillsborough	***	***	+	+	**	+	+	+
Belvoir	***	***	+	+	***	*	+	+
Gosford	+	+	+	+	+	***	***	+
Drum Manor	***	***	***	***	***	***	**	***
Gortin glen	***	***	***	+	***	***	***	***
Glenariff	+	***	*	+	+	***	***	+
Ballypatrick	***	**	–	***	***	*	–	–
Somerset	–	*	+	+	–	**	+	+
Florencecourt	–	***	***	–	–	***	***	–
Lough Navar	*	***	*	–	–	***	*	–
Castlearchdale	***	***	***	***	***	***	***	***

SB = Single Bound, DB = Double Bound, NI = Northern Ireland, ROI = Republic of Ireland, + = transfer overestimate, – = transfer underestimate, *** = transferable at 10% level, ** = transferable at 5% level, * = transferable at 1% level .

Table 3b. Tests for reliability of benefit transfer from CV in the Republic of Ireland Forest Parks.

	SB estimates from ROI		DB estimates from ROI		SB estimates from all		DB estimates from all	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Lough Key	***	***	***	***	***	+	***	+
Hazelwood	+	+	+	+	*	–	+	+
Dun a Dee	***	–	**	–	***	*	**	–
J. F. Kennedy	+	+	+	+	+	+	+	+
Dun a Ree	–	*	*	***	*	***	***	***
Currachase	*	–	–	–	***	***	**	***
Cratloe	***	–	+	+	*	–	***	***
Douneraile	***	***	***	***	–	–	–	–
Farran	+	+	+	+	***	–	+	+
Guaghan Barra	*	–	+	+	***	***	***	***
Avondale	n.a.	n.a.	n.a.	n.a.	–	*	*	–
Killykeen	***	***	***	***	***	***	***	***
Glendalough	n.a.	n.a.	n.a.	n.a.	*	+	+	+

SB = Single Bound, DB = Double Bound, NI = Northern Ireland, ROI = Republic of Ireland, n.a. = not available,
+ = transfer overestimate, – = transfer underestimate, *** = transferable at 10% level, ** = transferable at 5% level,
* = transferable at 1% level .

Table 4a. Statistics of estimated $\hat{B}_{j,-j}$ in pence.

	Single Bounded			
	$B(\mathbf{s}_j,\mathbf{q}_j;\hat{\theta}_{-j})$		$B(\hat{\theta}_j)$	
	$M(WTP)$	$E(WTP)$	$M(WTP)$	$E(WTP)$
Mean	139	198	134	189
St.deviation	44	63	44	52
Minimum	9	11	55	88
Lower quartile	125	182	104	159
Median	141	205	132	175
Upper quartile	161	232	155	214
Maximum	239	327	250	343

	Double Bounded			
	$B(\mathbf{s}_j,\mathbf{q}_j;\hat{\theta}_{-j})$		$B(\hat{\theta}_j)$	
	$M(WTP)$	$E(WTP)$	$M(WTP)$	$E(WTP)$
Mean	133	179	154	209
St.deviation	39	53	36	62
Minimum	10	12	98	123
Lower quartile	122	166	132	162
Median	137	185	145	188
Upper quartile	154	206	179	245
Maximum	214	289	240	408

M(*WTP*) = median *WTP* estimate; *E*(*WTP*) = expected *WTP* estimate.

Table 4b. Statistics of the widths of the simulated confidence intervals around $\Delta \hat{B}_{j,-j}$ in pence.

Single Bounded

	$\Delta M(WTP)$			$\Delta E(WTP)$		
	α =0.1	α =0.05	α =0.01	α =0.1	α =0.05	α =0.01
Mean	44	53	70	108	149	490
St.deviation	17	21	28	69	116	819
Minimum	23	27	35	44	54	76
Lower quartile	32	39	50	65	82	119
Median	39	48	63	85	106	155
Upper quartile	48	57	78	128	176	354
Maximum	108	128	172	336	538	3,407

Double Bounded

	$\Delta M(WTP)$			$\Delta E(WTP)$		
	α =0.1	α =0.05	α =0.01	α =0.1	α =0.05	α =0.01
Mean	37	45	61	92	119	229
St.deviation	17	21	32	94	133	381
Minimum	17	20	26	23	28	38
Lower quartile	26	31	42	42	50	67
Median	32	38	51	64	80	118
Upper quartile	40	48	65	100	126	173
Maximum	90	110	161	480	676	1,909

$\Delta M(WTP)$ = difference from transferred median *WTP* estimate and on-site median *WTP* estimate; $\Delta E(WTP)$ = difference from transferred expected *WTP* estimate and on-site expected *WTP* estimate.