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Heterogeneity in the WTP for recreational access: distributional aspects

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In this study we have addressed appropriate modelling of heterogeneity in willingness to pay (WTP) for environmental goods, and have demonstrated its importance using a case of forest access in Denmark. We compared WTP distributions for four models: (1) a multinomial logit model, (2) a mixed logit model assuming a univariate Normal distribution, (3) or assuming a multivariate Normal distribution allowing for correlation across attributes, and (4) a mixture of two truncated Normal distributions, allowing for correlation among attributes. In the first two models mean WTP for enhanced access was negative. However, models accounting for preference heterogeneity found a positive mean WTP, but a large sub-group with negative WTP. Accounting for preference heterogeneity can alter overall conclusions, which highlights the importance of this for policy recommendations.

Keywords: forests access; Denmark; random parameters logit; mixture of truncated normal distributions

1. Introduction

Environmental valuation techniques have been developed to assign a monetary value, a welfare measure, to changes in environmental externalities. Such externalities are often of a public good or common pool nature. By providing such measures, it is the expectation that decision makers can better take into account the external costs and benefits of decision alternatives and ensure an optimal provision of these goods. The assumption is that if welfare gains (losses) are expected from a given policy, this policy will (not) be implemented.

The supply of public or common environmental goods rarely depends on individual welfare gains and decisions. Rather, it depends on a collective or political demand and decision, and this makes the outcome much less straightforward than obtained welfare measures might suggest (Bowen 1943). It is textbook knowledge (e.g. Stiglitz 2000) that even with full information on the welfare effects of a public good related decision, the policy process may arrive at inefficient provision levels. As pointed out repeatedly since Bowen (1943), one reason why democratic processes may lead to under- or over-provision of public goods is the differences between the interest of the median and mean of the voters in the electorate (Lizzeri and Persico 2001). Even if on average voters are to gain from a specific decision, politicians may decide against it if the median voter

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(majority) or significant groups of voters stands to lose, depending on, for example, voting procedures (Morton 1987; Lizzeri and Persico 2001).

While welfare measures of effect of changes environmental externalities is a prerequisite for socially optimal decisions, it may not be sufficient. The policy process distribution of gains and losses across individuals matters too. The political decision process is as much about deciding on distributional outcomes as it is about identifying and implementing the overall beneficial decisions regarding provision of a public good. Consequently research also needs to address this issue.

In this paper, we investigate alternative models of the WTP variation for a public good. We use as a case data on the Danish population's preferences for increasing their right of access in a significant share of the privately owned forests in Denmark. At present, the public is allowed access to private forests (on foot and on bike), but only on roads and paths. The current Danish debate on access rights concerns an extension to include access outside – but in reasonable proximity of – forest roads and paths (known as the Anemone rule). There is high and intense recreational use of forests in Denmark, with the Danish population making 75 million visits a year (Jensen and Koch 2004) to (parts of) the approximately 500,000 hectares of forest. In some areas this leads to congestion, rivalry and conflict among different user groups (Vedel, Thorsen, and Jacobsen 2009).

We first estimate a standard MNL model showing a highly significant and negative WTP for increased access, and positive, significant WTP for the conservation attributes. In a standard Mixed Logit (RPL) model, assuming a univariate Normally distributed WTP for access, the mean WTP is negative and significant. The standard deviation of the distribution is significant and large (coefficient of variation around nine). We evaluate this standard model against two alternative RPL models. The first implements a multivariate Normal distribution for the attributes, allowing correlation in preferences across attributes. Importantly, we find that modelling this aspect of heterogeneity increases the estimated mean WTP of access to a positive number significant at the 5% level, and reduces the standard deviation to a factor around three. The final model explicitly allows for differences between sub-samples having negative and positive preferences, using a mixture of (two) truncated Normal distributions, where correlation with the other random parameters is accommodated and, importantly, the truncated distributions are assumed independent. We comment on a number of unique features of this final model. First, is the use of truncated Normal distributions, which are (surprisingly) very rarely used in RPL models. Second, this is the first paper to use a mixture of two truncated Normal distributions. We argue that this is superior to a mixture of Normals, since it avoids the inevitable overlapping of distributions and the resulting potential identification issues. Finally, this model facilitates multivariate distributions within each latent class, which is a feature that has yet to be accounted for in other applications of combined latent class mixed logit models (e.g. Greene and Hensher 2013). Results from this model reveal that the mean across the two distributions is again positive, but the median is slightly negative. We find that this model provides a better fit to the choice data, although using more variables. Across all models and attributes we find that accounting fully for possible heterogeneity in preferences is important to avoid potentially significant misspecification bias in WTP estimates.

The remainder of the paper is structured as follows. In the next section, we present existing approaches to model heterogeneous preferences for recreational services, and relate these to the Danish case study. Next, we describe the econometric models employed. We proceed to presentation of results and close the paper with a concluding discussion.

2. Methods and evidence on heterogeneous preferences for recreation

Several studies have found significant WTP for preserving existing or improving access to forest and nature areas, trail improvements and recreational facilities. Although the baseline for access and recreational uses varies a great deal between countries, a positive mean WTP for increased access or recreational quality enhancements has been observed in many contexts, and various models have been applied to analyse preference heterogeneity. The introduction and use of the RPL model and the Latent Class (LC) model (see e.g. Train 2003) for discrete choice models of recreation saw early applications such as Provencher, Baerenklau, and Bishop (2002) and Provencher and Bishop (2004), who investigated the preferences of anglers using revealed preference data. They focused on the mean preferences of (subsets) of the angler population. Several other studies have examined the preference variation among recreational groups using revealed preference type data (Scarpa and Thiene 2005; Scarpa, Thiene, and Tempesta 2007; Hynes, Hanley, and Scarpa 2008). A further extension is the use of WTP-space estimations in similar studies relying on revealed preference data (Thiene and Scarpa 2009). In these studies, the focus is often on the preference variation across an often very well-defined finite set of groups of recreational users that are assumed to share preferences for several attributes of the recreational service (applying LC models), or on the preference variation at the population level (applying RPL models). Distributional impacts of policy changes are sometimes calculated, e.g. across distinct classes in LC models and distributions across individuals investigated (e.g. Scarpa and Thiene 2005).

All of the above papers investigated preference heterogeneity among recreational users using revealed data. However, public policies addressing recreational use of the environment may impact non-users as well, for example, due to concerns about habitat protection and sustainable use. To capture such aspects, the use of stated preferences has been applied. Beharry-Borg and Scarpa (2010) investigated preference variation in snorkellers' and non-snorkellers' preferences for changes in various recreational aspects in the Caribbean coastal waters, and again RPL and LC models were used to describe the preference heterogeneity among and between these distinct groups. Related more closely to the current study, Christie, Hanley, and Hynes (2007) investigated the stated preferences for changes in forest recreational options among several distinct groups of actual and potential users.

Irish studies by Howley *et al.* (2012) and Doherty *et al.* (2013) investigated the heterogeneous preferences among the general public for walking trails and facilities connected to these in the Irish farming landscape. They found dissimilarities between users and non-users and people of different socio-economic groupings. Although the majority of respondents expressed positive preferences for the provision of trail attributes (e.g. car parking, paths and signage), they found that a substantial proportion of respondents had negative preferences for the same trail facilities – based on the large standard deviation in the RPL model. Moreover, they found that respondents in lower socio-economic groups were more likely to choose the status quo (stay home) option, as were older people and people with younger children. Furthermore, studies in UK of people's attitudes and preferences for access to nature have shown that people in higher socio-economic groups and older people have stronger positive preferences for access to the countryside (Swanwick 2009).

Morris *et al.* (2009) investigated the public's preferences in England for their rights of way consisting of a network of routes on private land. In rural areas these networks define access to the countryside and are a prerequisite for a great deal of recreation and tourism activities. They also identified different preferences for subsets of groups.

The choice between RPL and LC models is not trivial. Hynes, Hanley, and Scarpa (2008) discussed this choice, acknowledging the different restrictions implied by the approaches as they are typically applied. The LC model fares best when it is reasonable to assume that preference variation comes in the form of 'types', i.e. a limited set of groupings of individuals, who within each group share a specific set of preferences across all attributes studied. Such an assumption may be justified, for example, in cases where recreational users specialise in different activities and select experiences with very similar bundles of characteristics. There are other cases where the population in question is unlikely to select or experience similar bundles of goods or attributes, and hence may hold a continuum of preferences, in particular across attributes. The standard use of the RPL model allows for preference heterogeneity at the individual level across all attributes by condensing the issue of heterogeneity to the feature that preferences for each attribute can be described by a distribution. While this may be and often is assumed independent of the distribution of the other attributes, the RPL can encompass and estimate free correlations across attributes. Therefore, it may give a better description of data in situations where individual's preferences do not cluster in groupings across attributes. Examples of such cases could be larger environmental projects addressing both use and non-use values. The drawback of the RPL is that for each attribute the analyst has to make assumptions on the appropriate distribution. Clearly, assumptions may very well be a poor representation of the underlying empirical distribution.

We studied the Danish population's WTP for additional access rights in privately owned forests in a significant part of Denmark. From previous studies it is known that the Danish population will ask for significant compensation for reductions in their current access rights to forest and other habitats (Jacobsen, Lundhede, and Thorsen 2012), and derive value from current access (Zandersen, Termansen, and Jensen 2007). However, related studies have found small and often insignificant WTP for additional access on heath land and in national parks (e.g. Jacobsen *et al.* 2008; Jacobsen and Thorsen 2010; Jacobsen *et al.* 2011) and even a negative WTP for enhanced access to a wetland area (Jacobsen *et al.* 2011). Considerable and significant preference heterogeneity was also found in studies applying simple RPL model approaches assuming preferences for access to have a Normal distribution in the population (Jacobsen and Thorsen 2010; Jacobsen *et al.* 2011).

Some of the above-mentioned studies referred to possible correlations between attributes when examining heterogeneity (e.g. Jacobsen *et al.* 2011; Jacobsen, Lundhede, and Thorsen 2012), but, unlike the current paper, they did not take this explicitly into account.

3. Forest access in the case study

The Danish public has the right to access on all privately owned forests – at present from 6 am to sunset. However, the public is allowed only to walk on all roads and small paths and, moreover, to bicycle on all consolidated paths within this time period. In publicly owned forests, which constitute approximately 25% of the total forest area, the public has right to access 24 hours a day, and furthermore the Act permits access on foot to all forest areas, including the forest floor outside roads and paths. In the countryside outside the forest, the public has access to field roads and unfenced, uncultivated areas. Formerly these field roads made up a dense grid, providing widespread access to the countryside. However, the number of field roads has been greatly reduced during the second half of the twentieth century as agricultural practices and ownership structures changed, resulting in fewer opportunities for access (Hojring 2002).

For more than a decade the Danish debate on access rights has revolved around a possible extension of rights to include access outside, but in reasonable proximity to, forest roads and paths (known as the Anemone rule). In spite of strong proponents, e.g. the Danish Outdoor Council, the issue continues to divide the policy arena. Proponents for enhanced access have focused on health benefits and the importance of providing an increased understanding of nature for the general public. The audible opposing voice is mainly the forest owners' associations and here the main arguments have been the reduction of private ownership and the disturbance of wildlife and habitats (Reventlow and Soendergaard 2011). At present a similar debate among landowners, conservationists and recreationists is on-going regarding access to watershed protection zones along lakes and streams (Gjerskov 2012).

Related studies often have as departure point settings where the right of access is relatively restricted, and provision of access based on the establishment of trails may provide the fundamental access for the public (Buckley, van Rensburg, and Hynes 2009). This study deals with a case where the public's right of access to forest and nature areas has been ensured for more than 40 years. Furthermore, current use levels are quite intense in significant parts of the country (Jensen and Koch 2004), including the regions addressed here, which contain the capital and the majority of the larger cities in the country. While this reflects the demand and value of forest access to the public, there are also factors which could negatively affect preferences for further access. To an increasing extent forests are used for many different types of recreational activities at the same time – especially near urban areas. In the most intensively visited forests this creates conflicts between different types of users (dogs not on a leash, biking, other sports, walkers) and may also increase erosion of trails and damage the forest floor's flora and increase the amount of litter (Vedel, Thorsen, and Jacobsen 2009). Therefore some people may hold negative preferences for further access: (1) they may perceive a high degree of rivalry among users for the high quality forest recreational experiences, and believe that enhanced access could reduce quality of current use experiences; (2) nature conservation concerned citizens may think of enhanced access as a threat to habitats that they care about. Hence, valuation of enhanced access may also reflect the dis-utilities some expect from other people's use of this right.

To investigate this issue, an attribute describing such enhanced access was included in a choice experiment (CE) study, which more broadly investigated various management changes in the broadleaved forests of the South Eastern part of Denmark.

4. The CE method and the econometric model

The CE method relies on the theory that the utility of a good is derived from its attributes (Lancaster 1966), and as a result of this, the value of a good is the sum of the values of all its attributes. The CE method combines this line of thinking with random utility theory which states that when people are choosing from a number of alternatives, they will choose the alternative which yields the highest expected utility (McFadden 1973). Further details of utility maximisation in a discrete choice setting can be found in Train (2003).

In this paper we explore the implications of different distributional assumptions for dealing with heterogeneity. Starting with the conventional specification of utility in preference-space, where respondents are indexed by n, chosen alternatives by i, the cost attribute by p and the vector of non-cost attributes by x, we have:

$$U_{ni} = -\alpha p_{ni} + \beta' x_{ni} + \varepsilon_{ni},$$

where α and β are the coefficients for the cost attribute and the vector of non-cost attributes respectively to be estimated and ε is an *iid* Gumbel distributed error term. Given our desire to explore distributional assumptions of WTP we prefer to work in WTP-space (e.g. Train and Weeks 2005; Scarpa, Thiene, and Train 2008). In this case, instead of the standard preference-space specification described above, the utility function is represented as follows:

$$U_{ni} = -\alpha p_{ni} + (\alpha w)' x_{ni} + \varepsilon_{ni},$$

where $w = \frac{\beta}{\alpha}$. The advantage of this specification is that the distribution of WTP is estimated directly. Moreover, the coefficients obtained for WTP are independent from those obtained for the price coefficient, meaning that the instability associated with marginal WTP estimates derived from the ratio of random variables in preference-space is reduced (see Balcombe, Fraser, and Di Falco 2010 for further details).

Given the assumption of the *iid* Gumbel distributed error, the probability of respondent n's sequence of choices can be represented by a MNL model:

$$Pr(y_n | p_n, x_n) = \prod_{t=1}^{T_n} \frac{\exp(-\alpha p_{nit} + (\alpha w)' x_{nit})}{\sum_{j=1}^{J} \exp(-\alpha p_{njt} + (\alpha w)' x_{njt})}$$

where y_n gives the sequence of choices over the T_n choice occasions for respondent n, i.e., $y_n = \langle i_{n1}, i_{n2}, \ldots, i_{nT_n} \rangle$.

While the MNL model is a useful starting point, its inability to explain the heterogeneity in WTP across the sample of respondents is a major shortcoming. Indeed, in the environmental economics literature it is now common practice to use models, such as mixed logit specifications, to capture this type of heterogeneity (cf. the discussion in Section 2). Moreover, McFadden and Train (2000) have shown that mixed logit models provide a flexible and computationally practical econometric method, which with adequate data quality, in principle may be used to approximate any discrete choice model derived from random utility maximisation.

Heterogeneity across respondents can be addressed by allowing random variation in α and w. Denote the joint density of $[\alpha_n, w_{n1}, w_{n2}, \ldots, w_{nK}]$ by $f(\theta_n | \Omega)$, where θ_n represents the vector comprised of the random parameters and Ω denotes the parameters of these distributions (e.g. the mean and variance). The unconditional choice probability is the integral of the logit formula over all possible values of α_n and w_n:

$$Pr(y_n | p_n, x_n, \Omega) = \int \prod_{t=1}^{T_n} \frac{\exp(-\alpha_n p_{nit} + (\alpha_n w_n)' x_{nit})}{\sum_{j=1}^{J} \exp(-\alpha_n p_{njt} + (\alpha_n w_n)' x_{njt})} f(\theta_n | \Omega) d(\theta_n).$$

In this RPL model parameters of the continuous distributions (i.e. Ω) are obtained. This generally leads to significant gains in model performance and, importantly, greater insights into choice behaviours and WTP for the CE attributes.

A key element with the specification of the random parameters is the assumption regarding their distribution (Hensher and Greene 2003; Hess, Bierlaire, and Polak 2005; Rigby, Balcombe, and Burton 2009). Random parameters can take a number of predefined functional forms. While this affords the analyst with some control and flexibility, the random parameters are not observed and there is typically little *a priori* information about the shape of its distribution except possibly a sign constraint (Fosgerau and Hess 2009). Consequently, the chosen distribution is essentially an arbitrary approximation (Hensher and Greene 2003), which may mean that some possibly strong or unwarranted distributional assumptions about individual heterogeneity need to be made (Greene and Hensher 2003). In this regard, specification testing and assessing the suitability of different distributional assumptions is warranted (see Fosgerau and Bierlaire 2007 and Fosgerau 2008 for an overview of such tests). In this paper, we explicitly assess the suitability of different model specifications regarding heterogeneity, which are however not all strictly nested and hence cannot be tested up against each other, apart from model fit evaluations. Given the theoretical expectations of disutility for price and the widespread practice in WTP-space models (Scarpa, Thiene, and Train 2008; Thiene and Scarpa 2009; Balcombe, Fraser, and Di Falco 2010), we specify α as having a Log-Normal distribution to ensure strictly negative values for the price coefficient as follows: $\alpha = -\exp(\mu + \sigma v)$, where v is a standard Normal deviate and μ and σ are the parameters to be estimated. We stress that it is not possible to separately identify the price and scale parameters, which means that the distribution of α that we estimate is effectively the product of the price and scale parameters. For the distributions of w we begin with the assumption that they are all Normally distributed as follows: $w = \mu + \sigma v$, where v is a standard Normal deviate.

While very large estimated standard deviations relative to the estimated mean preferences in a population imply significant heterogeneity, it could also signal that the chosen distribution is not well suited to the empirical variation in WTP across respondents. Indeed, given the likelihood of correlation in preferences and tastes for the various attributes, an important first step could be to facilitate correlation across the random parameters.[1] In this paper, we specify multivariate distributions as follows:

$$\alpha = -\exp(\mu_\alpha + s_{1,1}v_1)$$
$$w_1 = \mu_{w_1} + s_{2,1}v_1 + s_{2,2}v_2$$
$$w_2 = \mu_{w_2} + s_{3,1}v_1 + s_{3,2}v_2 + s_{3,3}v_3$$
$$\vdots$$
$$w_{W_K} = \mu_{W_K} + s_{K,1}v_1 + s_{K,2}v_2 + s_{K,3}v_3 + \cdots + s_{K,K}v_K$$

where v_k are independent standard Normal deviates, μ_α and μ_{w_k} are the means of the (underlying Normal) price/scale and W_K WTP distributions respectively and $S_{j,k}$ are the diagonal and off-diagonal terms of the Cholesky matrix.

Finally, we relax the assumption that all respondents belong to the same overall taste distribution, whatever their view on increased access rights. Specifically, we test another distribution for access, namely a mixture of two distributions. The advantage of this is that it does not rely on a strict symmetry assumption and, importantly, it facilitates the possibility of a bi-modal distribution. Indeed, using a mixture of distributions is useful when it is believed there may be separate subgroups within the sample since they can be characterised by a unique WTP distribution:

$$Pr(y_n|p_n, x_n, \Omega) = \sum_{c=1}^{C} \pi_c \int \prod_{t=1}^{T_n} \frac{\exp(-\alpha_n p_{nit} + (\alpha_n w_{c_n})' x_{nit})}{\sum_{j=1}^{J} \exp(-\alpha_n p_{njt} + (\alpha_n w_{c_n})' x_{njt})} f(\theta_{c_n}|\Omega_c) d(\theta_{c_n})$$

where w, θ and Ω now all have a subscript c to represent the fact that in each of the c subgroups the WTP distributions is free to be estimated with different parameters.

The unconditional probability associated with each subgroup is given by π_c and a MNL model is specified in which membership can be regressed on the characteristics of the respondents:

$$\pi_c = \frac{\exp(\gamma_c + \tau_c' z_n)}{\sum_{c=1}^{C} \exp(\gamma_c + \tau_c' z_n)}$$

where, γ_c denotes the constant corresponding to group c and τ_c is a vector representing the effect that the z individual characteristics have on membership to subset c. For identification purposes we constrain γ_c and τ_c to be zero for one group. While we acknowledge that the inclusion of individual characteristics in this manner may raise concerns of endogeneity, it has the appeal of providing a straightforward insight into the possible profile of respondents without further complicating the model.

While a mixture of Normals is a popular choice when applying a mixture of distributions (e.g. see Doherty, Campbell, and Hynes 2013), it has the flaw that overlap is inevitable (the distributions all range between $-\infty$ and $+\infty$). This does allow the identification of a unique subgroup-specific distribution. For this reason, we avoid any overlap by mixing a right-truncated Normal distribution and a left-truncated Normal distribution. Specifically, given our interest in identifying subgroups with negative and positive marginal WTP estimates, we specify a distribution which is truncated below zero and a distribution which is truncated at zero and above. Permitting correlation we derive a correlation matrix for each class, where the correlation for random parameters other than access, which are not class-specific, are the same in both classes. The correlation matrices only differ with respect to the access attribute.

5. Data collection and survey design

Data were collected through an online survey of a sample selected to be representative for the Danish population with regard to gender, age, region and several other socio-economic characteristics. The survey was carried out using SurveyXact software and distributed by a polling agency to the pre-selected nation-wide panel in August–September 2011.

The questionnaire was tested in focus groups, resulting in a redesign of some attributes and some specific elements in the questionnaire. Afterwards the online version was tested on a pilot sample. The final questionnaire started with information on the case study area (see Figure 1), the forest areas addressed and the environmental values, which could be affected by forest management changes. This section had the twofold purpose of eliciting information on forest use and motivations together with presenting information on the attributes to come. The CE was presented together with follow-up questions contingent on the respondent's choices. This was followed by a section on household consumption patterns and attitudes to environmental subsidy schemes. The final part consisted of socio-economic questions regarding the respondent and their household. Throughout the questionnaire it was not possible to go back to earlier answered questions.

The attributes in the CE (Table 1) were selected to align with on-going policy initiatives related to the implementation of NATURA2000 and various certification schemes. The purpose and provision role of attributes were described carefully prior to the choice sets. In

Figure 1. The part of Denmark where the forest types in focus are situated.

the choice sets the various attribute levels were described using icons and text. At each choice set a link allowed access to a webpage repeating the attribute level descriptions. The payment (additional income tax per year) was described thoroughly just before the choice sets, but without indicating the levels to avoid an anchoring effect.

A full factorial design would require 648 choice sets, so a design optimised by NGene 1.0.2. for D_B-efficiency was used. The assumed model in the design was a WTP-space model, where the attribute 'natural processes' was dummy coded and the others continuously coded. Each choice task included two alternative scenarios and a status quo (SQ) option. All levels of all attributes, including all SQ levels, could appear in the non-SQ alternatives. Furthermore, some interactions were included, and priors from the pilot study were used. The final design had 36 choice sets divided into six blocks, resulting in six tasks to be answered by each respondent. The D-error at the generation stage was 0.000331.

The response rate was 29%, with a total of 811 people who completed the questionnaire. From this sample 16 respondents were identified as protesters based on objections regarding payment vehicle or lack of faith in the scenarios. They have been omitted in the following analyses leaving 4770 choice observations for our analysis.

Table 1. Attributes investigated in the CE.

Attribute description and abbreviation	Status quo	New attribute levels				
Access on foot outside roads and paths (Access)	Access on road and path and on 25% of the area also outside road and path	Access on and outside road and path allowed on 50% of the area			Access on and outside road and path allowed on 100% of the area	
Number of the 660 endangered species which are ensured survival (SP50, SP100)	No species are ensured survival	50 species are ensured survival through specific initiatives			100 species are ensured survival through specific initiatives	
Opportunity for natural processes in the forest (NP1, NP2, NP3)	Low level: Dead trees left in forests only occasional. 0.01% untouched forest reserves	Medium level: 5 trees are left to natural decay per hectare (100m x 100m). Area of untouched forests reserves unchanged (0.01%)		High level: 7% of the broadleaved forest area is set aside as untouched forest reserves	Very high level: 7% of the broadleaved forest area is set aside as untouched forest reserve *and* 5 trees/ha are left to natural decay in the rest of the forest	
Increased recharge of groundwater, metered in number of households' consumption (Wat2, Wat4)	The amount of groundwater for drinking purposes under forests is the same as today	Groundwater recharge increases with 20 million m^3 – corresponding to the annual consumption of 200.000 households. This corresponds to approx. 10% of the households in the case study area			Groundwater recharge increases with 40 million m^3 – corresponding to the annual consumption of 400,000 households. This corresponds to approx. 20% of the households in the case study area	
Additional income tax per year for your household (Price)	0 DKK	250 DKK	500 DKK	750 DKK	1000 DKK	1250 DKK

6. Results

We present results from all models in Table 2. The first model is a standard MNL model estimated using maximum likelihood estimation. We compare this against three RPL models. Since the choice probabilities in these models cannot be calculated exactly (because the integrals do not have a closed form), they are estimated by simulating the log-likelihood with 250 quasi-random draws per respondent and random parameter via modified Latin hypercube sampling.

Table 2. Estimation results.

		Model 1		Model 2		Model 3		Model 4	
		est.	|t-rat.|	est.	|t-rat.|	est.	|t-rat.|	est.	|t-rat.|
Price	μ	-8.56^*10^{-4}	10.89	−5.98	90.39	−5.49	77.78	−5.30	42.13
	σ			0.04	0.28	1.21	8.22	1.20	9.27
SP50	μ	943.58	9.39	791.11	13.47	1148.10	21.63	1147.80	15.77
	σ			642.44	8.92	887.07	9.84	896.26	12.55
SP100	μ	1439.00	10.82	1163.30	14.35	2050.70	11.45	1983.80	14.49
	σ			1127.20	11.62	2179.37	15.51	2144.79	18.45
NP1	μ	751.34	6.97	556.80	10.60	619.09	12.81	617.35	8.61
	σ			2.91^*10^{-6}	0.00	604.29	19.07	594.98	12.27
NP2	μ	888.09	8.49	680.45	12.22	881.87	15.63	849.64	11.49
	σ			533.41	6.69	1173.64	10.34	1132.07	20.79
NP3	μ	1255.70	7.26	686.06	8.55	742.17	26.88	724.45	10.15
	σ			819.51	9.95	564.14	11.89	522.40	9.52
Wat2	μ	191.04	2.43	228.12	4.92	600.44	4.81	570.57	8.04
	σ			354.61	4.53	781.57	21.44	754.32	18.60
Wat4	μ	400.94	5.60	382.30	7.05	815.04	4.55	777.92	10.34
	σ			824.03	10.85	1224.82	19.94	1170.30	17.90
Access	μ_1	−245.79	−2.74	−108.89	1.96	150.51	2.60	136.95	0.58
	θ_1			919.74	13.12	415.00	33.62	447.17	2.30
	μ_2							241.87	10.92
	θ_2							527.16	129.04
SQ	μ	−110.11	−1.12	−141.64	3.10	−175.13	8.38	−201.70	6.56
Const	γ							−0.23	0.61
High_Inc	τ							−0.07	0.10
High_Edu	τ							−0.07	0.14
Female	τ							0.09	0.21
Urban	τ							0.06	0.12
Child	τ							0.93	1.86
LL		−4538.57		−3901.94		−3513.03		−3499.66	
K		10		19		55		71	
ρ^{-2}		0.132		0.252		0.319		0.319	

Notes: For ease of comparison, in Models 3 and 4 we report the standard deviations of the random parameters. We report the elements of the Cholesky matrices in Table 3. High_Inc, High_Edu, Female, Urban and Child are dummy variables denoting respondents with an annual personal income over DKK 700,000, education levels of longer education (Bachelor degree or the like and above), who are female, reside in an urban area and have children aged below 18 years, respectively.

Results from Model 1 (the MNL model) reveal that, as expected, increases in the price attribute are associated with increased disutility. With the exception of the access attribute, the WTP values for the environmental attributes are positive and significant. In addition, monotonicity in the magnitude of WTP for the various attribute levels is observed, which provide some reassurance relating to the internal validity of the CE, e.g. WTP estimates for SP100 and NP3, both of which are in excess of DKK 1200 per year, and both representing the largest changes in terms of securing biodiversity levels and natural dynamics. The WTP for increased groundwater recharge is also significant and confirmed earlier results (Hasler, Lundhede, and Martinsen 2007). Turning to the access attribute, we find a negative, and significant, WTP connected with increased access. The access attribute had three levels (cf. Table 1), but as the 50% and 100% access levels were not significantly different from each other in any of the models investigated, these were merged into one 'increased access' attribute level. We note that Jacobsen, Lundhede, and Thorsen (2012) found a high WTP to avoid reductions in access, whereas Jacobsen *et al.* (2008, 2011) found limited WTP for increased access in various landscapes. We further note that the alternative specific constant for the SQ option, which is also estimated in WTP-space, is found to be negative, although not significant.

Inspecting the parameters of the WTP distributions retrieved from the first RPL model (Model 2) indicates that for all attributes except NP1, there is significant heterogeneity across respondents. The most striking degree of heterogeneity is retrieved for the access attribute. In fact, while the mean WTP estimate remains negative, the coefficient of variation is around 9, which, perhaps, signals that the univariate Normal distribution is not the most appropriate distributional form for this attribute. We also note that in some cases the means of the WTP distributions are lower than those uncovered in the MNL model (especially in the case of the NP and Wat attributes). The SQ parameter is now also found to be significant. Finally, compared to the MNL model, the RPL model fit is observed to be much superior. While we acknowledge that this improvement also reflects the fact that it takes the panel nature into account, we note that there is an improvement of over 600 log-likelihood units. This comes at the expense of nine additional parameters, which contributes to a significant likelihood ratio test.

Moving our attention to the RPL that permits correlation among the random parameters (Model 3), this reveals many similarities with the previous RPL model – although we do note an increase in the magnitudes of the WTP distributions bringing them closer in range to those of the MNL model. The standard deviation for NP1 is now found to be significant. Although we recognise that this standard deviation ignores the additional information obtained in the Cholesky matrix, it does signal that Model 2, which was based on univariate Normals, was not capable of describing the significant heterogeneity in WTP for NP1. Of central interest are the parameters associated with the access WTP distribution. Unlike the case where it was assumed univariate Normal, Model 3 captures its correlation with the other random parameters. Looking first at the predicted mean of the WTP for Access under Model 3, we note that this is completely different to what is estimated in the previous models. It is now estimated as being positive and significant, which is surprising, given the fact that the means of the predicted distributions in Models 1 and 2 were both significantly less than zero. This is of great interest from a policy viewpoint, since it implies that measures of central tendency of WTP distributions are highly sensitive to whether the correlation in the unobserved factors are accounted for or not – the latter potentially resulting in a misspecification bias.. We highlight that this appears to extend to measures of dispersion. Based on the

Table 3. Cholesky decomposition (lower triangle matrix) and correlation (upper off-diagonal) results.

Model 3	Price	SP50	SP100	NP1	NP2	NP3	Wat2	Wat4	Access
Price	−1.21	0.17	0.39	0.68	0.70	0.42	0.62	0.34	0.21
SP50	−152.40	873.88	0.90	0.69	0.80	0.87	0.34	0.47	0.66
SP100	−843.28	1,851.80	−780.62	0.64	0.88	0.71	0.47	0.49	0.84
NP1	−409.83	349.70	189.54	197.47	0.91	0.91	0.69	0.67	0.28
NP2	−815.65	814.93	−79.19	193.75	43.38	0.85	0.69	0.64	0.61
NP3	−235.20	458.87	216.61	70.58	−18.87	10.72	0.48	0.55	0.35
Wat2	−485.57	185.14	−54.70	365.74	248.19	244.66	287.36	0.89	0.43
Wat4	−410.72	509.98	−32.38	785.06	333.42	458.87	258.05	−256.38	0.38
Access	−86.18	261.38	−262.21	−36.93	12.23	98.74	70.81	90.74	56.65

Model 4	Price	SP50	SP100	NP1	NP2	NP3	Wat2	Wat4	Access (C1)	Access (C2)
Price	−1.20	0.23	0.40	0.66	0.70	0.41	0.62	0.37	0.07	0.12
SP50	−205.61	872.36	0.92	0.78	0.83	0.85	0.37	0.51	0.54	0.73
SP100	−860.70	1,823.60	−730.62	0.73	0.89	0.67	0.48	0.53	0.72	0.88
NP1	−390.91	386.57	143.89	176.22	0.94	0.91	0.68	0.71	0.22	0.39
NP2	−789.92	779.65	−84.54	205.53	19.15	0.80	0.69	0.68	0.47	0.63
NP3	−213.86	406.82	238.46	47.39	−48.03	15.69	0.42	0.52	0.13	0.33
Wat2	−466.11	177.52	−81.01	363.77	165.15	245.49	306.25	0.88	0.43	0.42
Wat4	−429.75	506.50	−36.66	759.36	275.15	398.18	218.00	−261.95	0.36	0.45
Access (C1)	−33.52	238.60	−315.97	−3.40	0.80	126.63	103.42	116.46	42.01	0.00
Access (C2)	−64.31	379.75	−333.95	−1.10	−19.64	105.76	71.17	25.06	0.00	−27.64

standard deviation of the access WTP distribution, we find that the coefficient of variation falls to less than 3 in Model 3 (which remains the largest out of all the WTP distributions).

With an improvement in almost 400 likelihood units, we note that a more flexible distribution leads to a much improved model fit. This improvement is also supported by the ρ^{-2}statistic, even after accounting for the 36 additional parameters. We conclude that the univariate distribution does not adequately describe the heterogeneity in the WTP nor the price/scale distributions particularly well.

As alluded to above, the reported standard deviations are not independent, so in Table 3 we report the Cholesky decomposition matrix and the correlation matrix. We note that the elements in the lower triangle are terms of the Cholesky matrix and the terms in the upper off-diagonal (shaded) are the terms of the correlation matrix. Focusing on the access attribute we find cross-product correlations in particular with the number of endangered species protected. Related to this, we find that there is a high degree of correlation between the WTP for access and both levels of the species protected attribute. This suggests that in this model, respondents who have a high WTP for access are also likely to have a high WTP for protecting endangered species. Table 3 also shows the strong correlation between NP1 and many other attributes, explaining why the univariate RPL model was not capable of describing the heterogeneity.

In the final model (Model 4), the WTP distribution for access is estimated as a mixture of truncated Normals. Having also tried a specification using a mixture of three truncated

Normals, we settled on a mixture of two, since it was better suited for identifying two unique (i.e. a low and a high) distributions, which was our primary interest. While we also estimated models in which the truncation boundaries were estimated, given our interest in identifying and investigating subgroups with negative and positive marginal WTP estimates, we specified the truncation. Specifically, one distribution was truncated below zero while the other was truncated at zero and above. We also included a number of covariates in the membership equation to tease out whether socio-demographic factors may help predict group membership. Focusing on the access attribute we find a subgroup of respondents associated with a truncated distribution that is entirely negative, cf. Figure 2. Note that the mean and standard deviations estimated are those describing the form of the truncated distributions. They are not the mean and standard deviation of the

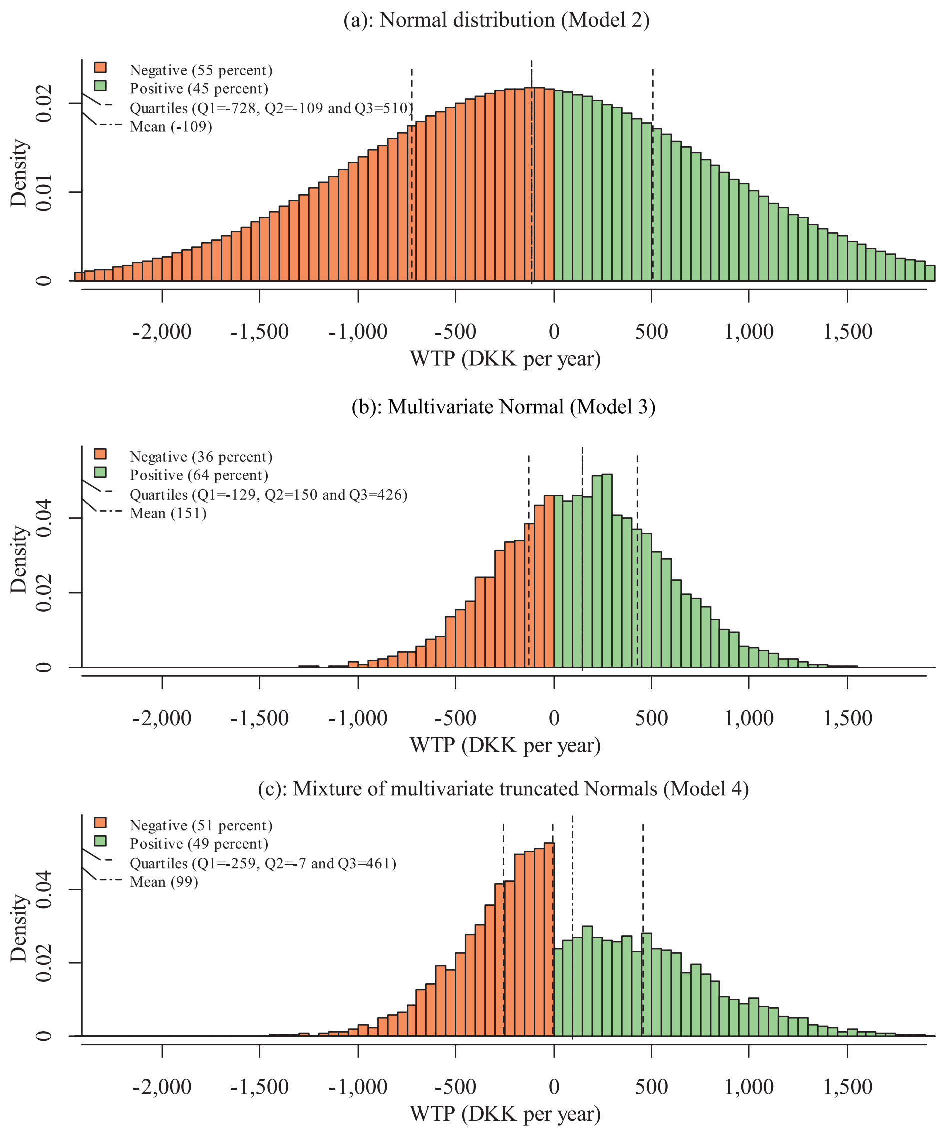

Figure 2. WTP distributions for the access attribute across the three RPL-type models.

WTP in the truncated distributions, conditional on being above or below the truncation limit. Calculating the mean and standard deviation of the underlying multivariate Normal distribution truncated below zero of DKK 137 and 447, respectively, therefore equates to an actual mean and standard deviation of WTP over the support of the truncation of −311 and 246, respectively. Similarly, the parameters of the underlying multivariate Normal distribution truncated above zero of DKK 242 and 527, respectively, imply a mean and standard deviation of 522 and 363, respectively. The insignificant membership constant implies that, other factors held constant, the size of the subgroup with negative WTP is not significantly different to the subgroup with positive WTP. This is an important finding. It gives an indication that the proportion with negative values is much the same as those with positive values. Therefore, the overall mean WTP for access remains positive. This is contrary to the inferences that would be reached from all previous models, and it reinforces the need to move away from the standard distributions and promotes the exploration of more flexible distributions, especially those that do not assume symmetry and can facilitate more than one mode.

Similar to Model 3, an inspection of the Cholesky matrix in Table 3 suggests that the cross-product correlations with the number of endangered species protected is important for the negative and even more so for the positive WTP for access distributions. We also observe that larger cross-product correlations with the natural process WTP distributions are relatively larger in the positive WTP distribution. Stemming from this, the diagonal element relating to the negative access WTP distribution is found to be relatively larger, suggesting that, compared to the positive access WTP distribution, less of its variation is due to cross-product correlations with the other random parameters. A view of the elements of the correlation pertaining to the access WTP distributions reflects the greater degree of correlation of the positive WTP distribution with the WTP distributions of the other attributes. Note that the two access WTP distributions are independent and, hence, have zero correlation.

Inspecting the coefficients relating to the membership covariates reveals that, with the possible exception of respondents with children, socio-demographic characteristics do not appear to have any bearing on membership. Nevertheless, calculating the unconditional class membership probabilities, cf. Table 4, for each of the socio-demographic profiles, reveals some important differences. In particular, the vast majority of respondents (70%) who have an annual personal income less than or equal to DKK 700,000, do not have a university qualification, are female, reside in an urban area and have children aged below 18 years are predicted to have negative WTP for access. In contrast, only a minority (41%) of respondents who have an annual personal income greater than DKK 700,000, have a university qualification, are male, reside in a rural area and do not have children aged below 18 years are predicted to have negative WTP. Weighting by the number of respondents in each profile, we find that the average unconditional probabilities for negative and positive WTP for access to be almost the same (51% and 49%, respectively), which places the median WTP slightly into the negative.

We note that Model 4 is associated with the best overall model fit, and represents an improvement over the previous RPL models. We note that while this improvement is not reflected by the ρ^{-2}statistic, due to the introduction of 16 extra parameters, we trade this off against the additional insight that this model offers. As none of the membership covariates were found to be highly significant, we could have removed them. This would have decreased the degrees of freedom and led to a relatively better and more convincing improvement in model fit. Nonetheless, we decided to retain the covariates as they show

Table 4. Unconditional class probabilities for each socio-demographic profile.

High_Inc	High_Edu	Female	Urban	Child	Pr(class 1)	Pr(class 2)	Sample number
0	0	0	0	0	0.444	0.556	158
0	0	0	0	1	0.669	0.331	40
0	0	0	1	0	0.458	0.542	66
0	0	0	1	1	0.681	0.319	16
0	0	1	0	0	0.466	0.534	114
0	0	1	0	1	0.688	0.312	33
0	0	1	1	0	0.480	0.520	62
0	0	1	1	1	0.700	0.300	11
0	1	0	0	0	0.428	0.572	27
0	1	0	0	1	0.654	0.346	21
0	1	0	1	0	0.441	0.559	26
0	1	0	1	1	0.667	0.333	15
0	1	1	0	0	0.450	0.550	30
0	1	1	0	1	0.674	0.326	23
0	1	1	1	0	0.464	0.536	40
0	1	1	1	1	0.686	0.314	11
1	0	0	0	0	0.426	0.574	12
1	0	0	0	1	0.652	0.348	7
1	0	0	1	0	0.439	0.561	12
1	0	0	1	1	0.665	0.335	3
1	0	1	0	0	0.448	0.552	18
1	0	1	0	1	0.672	0.328	7
1	0	1	1	0	0.462	0.538	10
1	0	1	1	1	0.684	0.316	3
1	1	0	0	0	0.410	0.590	8
1	1	0	0	1	0.637	0.363	3
1	1	0	1	0	0.423	0.577	4
1	1	0	1	1	0.650	0.350	2
1	1	1	0	0	0.432	0.568	2
1	1	1	0	1	0.658	0.342	1
1	1	1	1	0	0.446	0.554	9
1	1	1	1	1	0.670	0.330	1
0.128	0.281	0.472	0.366	0.248	0.508	0.492	795

that the memberships to the two distributions are not typified by these important socio-demographic characteristics.

To illustrate our findings regarding the access attribute, Figure 2 shows the (unconditional) distributions of the WTP distributions for the increased access attribute under the three RPL models. The distributions follow continuous distributions that are simulated based on 10,000 random draws. To simplify illustration, we fit the distributions to the same height, which implies the y-axis is not comparable across the panels. However, the simplification shows a better presentation and it is in any case the differences between the negative and positive proportions and the differences in means and medians that matter for our points. These are unaffected by the simplification.

Beginning with the univariate Normal distribution assumption (Figure 2(a), Model 2), the histogram clearly demonstrates the issue – a distribution which is effectively centred around zero (albeit with a slightly higher proportion in the negative domain and a mean WTP slightly in the negative), with a high degree of dispersion. Given the symmetrical properties of the Normal distribution, the mean and median are equivalent. The distribution which accounts for cross-product correlations with the other random parameters (Figure 2(b), Model 3) is, in accordance with earlier inferences, much less dispersed relative to the distribution derived from Model 2. The implications of this are clear to see – the predicted interquartile range under Model 2 is just over 1200, whereas it falls to just over 550 under Model 3. There is also a change in sign, which is especially important as it could have serious repercussions for policy appraisal. Related to this we find that the majority (over 65%) of respondents are predicted as having positive WTP estimate for increased access, which, again, is in contrast to what is inferred from the previous models. Finally, for the mix of two truncated Normals (Figure 2(c), Model 4), which uses the weighted average unconditional class membership probabilities, we find a similar result emerging, but in this case, due to the marginally larger weighted average unconditional class size of class 1, the median is very slightly less than zero. The overall mean remains positive, due to relatively more dispersion in the positive distribution. Nevertheless, we observe a widening of the interquartile range, which can be taken as a sign of more dispersion compared to the distributions attained from Model 3.

7. Concluding discussion

To the extent that generally enhanced access to an area can be assumed a public good for the individual, one would expect its value to be at least non-negative. Under that assumption the finding of a negative WTP for a significant proportion of the population may seem erroneous, and the lack of scope sensitivity too. However, this assumption overlooks two effects that are possibly quite important in the current case where forest land is used heavily for recreation and at the same time constitutes an important habitat for biodiversity conservation. First, respondents in some recreational groups may experience widespread rivalry and congestion decreasing the quality of their recreational experience and thus they perhaps see increased access mainly as increased pressure on a common pool resource. Second, respondents may worry about the effects on biodiversity and habitats, and hence factor in these as externalities of increased access rights lowering their value. Such respondents may consider the value of any increases in access rights for all an overall negative change and show little sensitivity to scope of enhancement in access as they basically oppose the idea.

Indicative of such concerns, being true for at least some respondents, was a set of voluntary comments received from respondents in open-ended text fields in the online survey. Some respondents explicitly raised the concern that increased access implies a threat for habitats and wildife, e.g. “I don’t think that everybody should be able to walk around in private forests especially not outside the trails. Think about the pheasants, hares and roe deer etc. as these animals absolutely have a right to have peace”. Others complained about other forest users ruining the quality of their household’s experience, e.g. “I don’t think it is a good idea to let people walk outside roads and paths in private or public forests, since people generally lack respect, (throw) litter, shout, and disturb the nature in other ways too”.

To capture such potential variation in preferences for better access, we estimated a set of models using more flexible distributions, in the form of multivariate Normals and the discrete mixture with two truncated Normal distributions. This revealed that the significant and negative mean WTP in the MNL and simple RPL models was in part an artefact and a misspecification bias However, in both of the more flexible models, we find that the overall mean WTP is in fact positive, when heterogeneity is fully accounted for. The mixture of two truncated Normals further reveals that the sub-group of respondents having strictly negative WTP for increased access may be as large as the group showing positive preferences. Consequently, using the more flexible distributions reveals a dilemma of large (and classic) importance for policy: would it be acceptable to increase the right of access (as indicated by the overall positive mean WTP), and thereby force a relatively large disutility on a non-trivial sub-group of the population in order to provide a (modest net) gain in utility for another non-trivial sub-group of people? While this is a political choice, the econometric choice model used to evaluate the pattern of WTP must be able to reveal such important information for results to be used wisely.

7.1. Caveats and further work

In this paper we have relied on extensions to the RPL allowing for correlations, mixing distributions and asymmetries. One classic approach we have not reported on here is the use of a standard LC approach. However, this approach comes with the restriction discussed in Section 2, that all respondents within a LC share the mean WTP (the WTP distribution) across attributes, and this may limit the models' ability to capture the empirical preference heterogeneity of a given attribute adequately.

One potentially fruitful avenue to pursue in future research could be to investigate the use of latent attitude approaches (Stolz *et al.* 2011) to investigate further group identities across preference classes. In such models latent variables that can explain the variation are estimated simultaneously by the use of a group of characteristics on opinion and/or socio-demographic variables.

7.2. Who are the groups?

In this study, we addressed the obvious question of what characterises those who benefit and those who lose, using membership functions for the mixing distributions. An immediate thought would be that forest owners would be negative towards increased access on their property whereas the rest of the population may be positive. However, the forest owners constitute such a small proportion of the population (< 1%) that they are unlikely to cause the pattern shown. As is standard, we investigated the effect of a number of socio-economic variables of relevance to policy in predicting class membership for the access variable. We have shown a subset of these, but found only the presence of young children (below 18 years) to have some predictive value for class membership (at the 10% level). Thus, we conclude that the divide on attitudes towards and valuation of enhanced access in private forests runs across all these standard socio-demographic groupings. While this is the overall finding, a calculation of unconditional class probabilities across socio-demographic profiles do however disclose which profiles are more likely to belong to the sub-group with negative WTP for increased access.

Further research needs to address other aspects of group identification focusing more on, for example, opinion-based variables. The survey included some attitudinal questions, including opinions on nature and humans' use and protection of it. Answers to these questions were able to predict quite clearly the class memberships, showing that people who are in general more environmentally concerned are more likely to be in the group with negative WTP for access, whereas those less concerned and more confident that environmental problems are not imminent tended to belong in the group with positive mean WTP. In spite of this, class membership could still not be predicted on the basis of, for example, membership of green organisations.

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Note

1. We are grateful to a reviewer for stressing this point.

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