Spatial Preference Heterogeneity in Forest Recreation

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1. Introduction

This paper analyzes the preferences for forest recreation, with a focus on spatial preference heterogeneity. Spatial heterogeneous preferences may be a result of spatial sorting where individuals select their location of residence according to their preferences. If access to forest recreation is correlated with the preferences, it is important to consider the endogeneity of travel distance in the application of the travel cost method (Parsons, 1991; Randall, 1994). Furthermore, non-marginal changes in the access to recreation sites may have different short-term and long-term welfare effects because the preference composition of the local population over time may change when recreation opportunities influence the choice of residence location (Klaiber and Phaneuf, 2009).

In this study, we applied a choice experiment where respondents chose between the forest they usually went to and two hypothetical forests. Asking the respondents to make hypothetical choices allowed us to account for potential endogeneity of site attributes (e.g., travel distance) and thus reduced the potential estimation bias in applications based on revealed preferences. We modeled forest choice by applying a random parameter error component model that allowed us to account for preference heterogeneity as well as for the repeated choice panel structure of the data. Due to the repeated choices made by each respondent, we were able to estimate individual-specific utility model coefficients. These estimates were used in a second-stage analysis where we estimated the potential spatial determinants of the preferences for forest recreation. To our knowledge, this has not been previously attempted in the environmental valuation literature. Individual-specific willingness-to-pay estimates for rural landscape improvements have been derived from a mixed logit model and spatially analyzed in Campbell et al. (2008, 2009). Their spatial analysis is only explorative and does not attempt to estimate spatial determinants of preferences. An explorative analysis of spatial distribution of preferences was also carried out by Baerenklau (2010) who applied a latent class approach to the estimation of backcountry hiker preferences in southern California. Distance decay functions are included in the economic valuation of spatial delineated ecosystem services and are especially important when aggregating individual values and carrying out benefit transfer (e.g., Bateman et al. 2006). Distance decay functions are not necessarily associated with spatial preference heterogeneity but, in the case of use values, reflect variations in transport costs. Other environmental valuation studies have addressed spatial preference heterogeneity on a rather coarse scale by, for example, including regional dummies in the estimated choice model or estimating separate models for different locations (e.g., Bergmann et al., 2008; Brouwer et al., 2010).

The main objectives of this study were: (1) to estimate recreational users' preferences for forest attributes; and (2) to estimate the determinants of the preference heterogeneity. Compared to previous studies on preference heterogeneity (Birol et al., 2006; Campbell, 2007; Campbell et al., 2008, 2009; Baerenklau, 2010; Brouwer et al., 2010), we included a variable representing the spatial proximity to a recreation site where the considered site attribute is present. Our study used empirical data from a choice experiment with recreational attributes of forests in Lorraine. A previous survey conducted in 1997 (Normandin, 1998) on ecological and recreational services of forests in Lorraine reveals that Lorraine forests are heavily visited, with in average of 40 visits/family/year and only 4% of households that never go. For this study, we carried out a Web-based survey by sending the questionnaire to an Internet panel of residents in Lorraine. We found significant heterogeneity in the preferences for different forest attributes, describing the forest structure and the presence of recreational facilities. In a spatial analysis of the individual preferences, we found little evidence of a link between the strength of preferences for one of the attributes considered and the

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local access to forests with this attribute. This suggests that spatial sorting is indeed present in our data, although results are not unequivocal.
The next section reviews the economic literature on spatial aspects and feedback effects in the valuation of recreational sites and amenities. In the third section we describe our empirical approach for estimating forest recreation values, addressing spatial issues explicitly. Next, we describe the data used, followed by the estimation results. Finally, we conclude the paper with a discussion of the results and the implications of spatial preference heterogeneity for recreational modeling and forest policy.

2. Spatial heterogeneity and preferences for amenities

The economic analysis of changes in access to recreational sites or changes in quality of environmental sites is inherently spatial (Baerenklau et al., 2010). First, the distance between the site and the potential visitor influences the costs of visiting a site and, accordingly, the probability that the site will be visited. Consequently, the aggregate demand for recreational use of a given site strongly depends on its distance from population centers. However, alternative sites that may serve as substitutes or complementary sites (Troy and Wilson, 2006; Termansen et al., 2008) also influence the demand for recreational use of a given site. This implies that the spatial configuration of the recreational sites is important for the economic value. Therefore, consideration of the distance effect on the demand side and the spatial configuration of the recreational sites must be included when taking account of spatial issues in the valuation of recreation sites. Secondly, an additional source of spatial heterogeneity of the economic value of recreation sites is preference heterogeneity. Benefit estimations of recreation have revealed significant variation in preferences for forest recreation and for different forest site characteristics (Brey et al., 2007; Christie et al., 2007; Termansen et al., 2008). Spatial preference heterogeneity is theoretically consistent with the sorting models inspired by Tiebout (1956) and has been confirmed in empirical analyses based on Roback's (1982) hedonic model framework. This framework assumes that house prices and wages depend, in part, on access to natural amenities and reflect peoples' amenity-dependent residential location choices (e.g., Schmidt and Courant 2006). In an empirical study of the amenity value of forests in Arizona and New Mexico, Hand et al. (2008) found that increasing forest density in a region implies higher rents and lower wages in that region. Spatial heterogeneity in preferences for environmental amenities has been confirmed in many empirical studies. Schläpfer and Hanley (2003) reported that attitudes to landscape protection are strongly associated with the local landscape. Spatial heterogeneity is reflected in the existence of distance decay functions in valuation studies (Bateman et al., 2006). For example, Birol et al. (2006) found that the utility of wetland management attributes depends on the distance from the location of residence to the wetlands considered, and Brouwer et al. (2010) found that water quality improvement in a river system depends on the location of the respondents. Campbell et al. (2009) reported significant regional differences in the preferences over rural landscape improvements in Ireland.
If households choose their residential location according to their preferences access to forests, we would consequently expect that preferences are spatially heterogeneous and may depend on the spatial configuration of the environmental quality. Furthermore, if preferences for forest recreation depend on income and other socio-demographic factors and these factors influence the residential location choice, we also expect to find spatial heterogeneity in preferences for forest recreation (Kuminoff 2009; Baerenklau, 2010). Spatial sorting due to heterogeneity in preferences and in the access to recreation sites has implications for the welfare economic analysis of policies: the travel distance between a visitor and the recreation site cannot be considered exogenous if spatial sorting occurs. Instrumental variables have typically been used to cope with endogenous quality attributes (travel distance, among others) in applications of the travel cost method (Parsons, 1991; Murdock, 2006; Bayer and Timmins, 2007; Timmins and Murdock, 2007) and in the hedonic pricing model (Irwin et al., 2001, Irwin, 2002, Cavailhès et al., 2009). An alternative approach is to apply a general equilibrium framework where spatial sorting is explicitly modeled. Feedback between aggregate behavior and site attributes has been modeled in a hedonic model framework by Sieg et al. (2004), Smith et al. (2004), Wu et al. (2004), Walsh (2007), and Klaiber and Phaneuf (2010), among others. Explicit modeling of feedback mechanisms in travel cost models have been attempted in Leplat and Le Goffe (2009). Ignoring feedback effects may not only lead to wrong welfare estimates but may also lead us to overlook important distributional effects of environmental quality changes (Klaiber and Phaneuf, 2009).
To sum up, the combination of (1) preference heterogeneity, (2) potential feedback effects, and (3) spatial heterogeneity in environmental resources should be considered in environmental valuation. Otherwise, the welfare impacts of a non-marginal improvement in spatially delineated environmental resources may be over- or underestimated and important distributional impacts, neglected. In the economic valuation of recreational site quality, it is important to address the endogeneity of site attributes as well as the preferences of the local population. In our empirical approach, we took the potential endogeneity of site attributes into account, applying an experimental survey design, i.e., a choice experiment. However, the objective of the

present study is not to establish a general equilibrium model in which we will be able to explicitly account for relocation of households as a function of changes in access to forest recreation.

3. Methodology

3.1. Choice modeling

We applied the familiar random utility model (RUM, McFadden 1974) that has become popular in the valuation of recreational site quality since the study by Bockstael et al. (1987). Basically, we processed information about the trade-offs individuals make between travel costs and site attributes in order to value the latter. We estimated the RUM model using stated preference data obtained from a discrete choice experiment (Adamowicz et al., 1994; Hanley et al., 1998; Hanley et al., 2002; Christie et al., 2007). The advantages of using stated preference methods include a reduction in the co-linearity of the attribute levels by the stated preference statistical designs and the possibility of *ex ante* modeling of new recreational opportunities not presently available, i.e., recreation site attribute levels outside the range of current levels. Furthermore, the problem of endogenous attribute levels can be avoided (Hanley et al., 2002; von Haefen and Phaneuf, 2008; Whitehead et al., 2008).

3.2. Survey design

Five attributes describing forests were identified for use in the survey (see Table 1). The first attribute, dominant tree species, is related to forest management, i.e., the choice of tree species and management system. Three levels were used to depict this attribute: forests dominated by coniferous species (more than 70% of trees are coniferous), forests dominated by broadleaf species (more than 70% of trees are broadleaf), and mixed species forests (neither coniferous nor broadleaf species represent more than 70% of the forests). A priori, based on the focus group interviews and expert judgement, we would expect that mixed species forests are preferred to broadleaf forests and broadleaf forests are preferred to coniferous stands. The second and third attributes are related to recreational facilities, i.e., marked hiking paths and parking and picnic facilities. Once again, we have three levels where the first level has no facility, the second level has one hiking path and one facility (picnicking or parking), and the third level has more than one hiking path and both parking and picnic facilities. The fourth attribute, the absence or presence of lakes or rivers in the forest was included because it was considered that the recreational value of a forest would increase with water bodies in the forests. It was explained that fishing, sailing and canoeing on the lakes or rivers was not allowed. The final attribute is the distance between the residence and the forest, measured in kilometers. We applied a fractional factorial design, implying that potential interaction effects between attributes cannot be estimated – only the mean effects. The orthogonal fractional design included 18 pair-wise comparisons of alternative forests. They were allocated into three blocks, each with six choice sets, since this was found to be a suitable number of choice sets per respondent in the focus group interviews. Each choice task consisted of a status quo alternative defined as the forest the respondent had visited the most often over the past 12 months and two experimentally designed alternatives. Before they were given the choice tasks, respondents were asked to characterize the forest they had visited the most often over the past 12 months according to the same attributes and levels used in the experimental design. Focus group interviews suggested that this way of asking respondents to describe the forest visited, in line with the pre-defined list of attributes and levels, was an effective way of informing them about the attributes and preparing them for the subsequent choice tasks. A pilot test was carried out based on 79 respondents. On the basis of results from this pilot test, an experimental design with an informative Bayesian update to improve design efficiency was constructed using NGENE software (Scarpa et al., 2007a).

Table 1. Attributes and attribute levels

Attributes	Levels
Dominant tree species	Conifers
	Broadleaves
	Mixed tree species
Hiking paths	No marked hiking paths
	One marked hiking path
	More than one hiking path
Facilities	No facilities
	Parking or picnic places
	Parking and picnic places
Access to water	No water body
	River or lake in the forest
Distance from your home	0.5, 2, 5, 10, 20, 50 km

3.3 Econometric specification

Econometric modeling is carried out in a two-stage estimation procedure. We first estimate a choice model based on the responses to the choice experiment questions, and we use this model to estimate respondent-specific marginal utilities of the forest attributes. These utilities are carried on to the second stage where we estimate a random effect model, applying procedures used for panel data.

Estimation of choice model and respondent-specific marginal utilities

The model applied in the parametric analysis of responses is a mixed logit model that can be derived in a number of different ways (Hensher and Greene, 2003; Train, 2003). In the present case, a model formulation that incorporates random parameters as well as an error component was found suitable. This model specification avoids major limitations of the multinomial logit model. Importantly, it explicitly accommodates repeated choices as well as unobserved taste heterogeneity, i.e., random taste variations across respondents but not across observations from the same respondent, and is not restricted by the Independence of the Irrelevant Alternatives (IIA) property (Revelt and Train, 1998; Hensher and Greene, 2003; Train, 2003). Furthermore, it is a computationally practical and flexible model that can approximate any random utility model (McFadden and Train, 2000).

Following Scarpa et al. (2005) an Alternative Specific Constant (ASC) is specified for the status quo alternative (SQ) in order to capture the systematic component of a potential status quo effect. Furthermore, an error component in addition to the usual Gumbel-distributed error term is incorporated into the model to capture any remaining status quo effects in the stochastic part of the utility. The error component, which is implemented as an individual-specific zero-mean normally distributed random parameter, is exclusively assigned to the two non-status quo alternatives. By specifying a common error component across these two alternatives, correlation patterns in the utility over these alternatives are induced. It therefore captures any additional variance associated with the cognitive effort of evaluating experimentally-designed hypothetical alternatives (Greene and Hensher 2007; Scarpa et al. 2007b; Scarpa et al. 2008). This results in the following general utility structure:

$$U_{ntj} = \begin{cases} V(x_{ntj}, \tilde{\beta}_n, \mu_n) + \varepsilon_{ntj}, \ \ j = 1,2; \\ V(ASC, x_{ntj}, \tilde{\beta}_n) + \varepsilon_{ntj}, \ \ j = \mathrm{SQ} \end{cases} \qquad (1)$$

where the indirect utility, *V*, is a function of the vector of explanatory variables, x_{njt}, as well as the vectors of individual-specific random parameters, $\tilde{\beta}_n$. For the two experimentally-designed policy alternatives, the common individual-specific error component μ_n enters the indirect utility function, while it is replaced by the *ASC* for the status quo alternative. The unobserved error term ε_{ntj} is assumed to be Gumbel-distributed. The individuals are referred to as *n*, while *j* is the alternative and *t* is the choice set. $\tilde{\beta}_n$ varies over individuals in the population with density $f(\beta|\theta)$, where matrix is a vector of the true parameters of the taste variation, e.g., representing the mean and standard deviation of the β's in the population. Assumptions concerning the distribution of each of the random parameters, i.e., the density function $f(\beta|\theta)$, are necessary. The true distribution is unknown, so, in principle, any distribution could be applied (Carlsson et al., 2003; Hensher and Greene, 2003). The normal is the most easily applied distribution (Train and Sonnier, 2005).

In the present paper, we assume that the parameters associated with all forest attributes as well as the distance attribute are normally distributed random parameters. This allows for both negative and positive preferences that could be expected on the basis of focus group interviews and a pilot test.

One important advantage of the specified random parameter error component model that we use in this paper is the ability to calculate estimates of individual-specific preferences by deriving the conditional distribution based (within sample) on their known sequence of choices (Train, 2003; Hensher et al., 2006). It should be mentioned that these conditional parameter estimates are strictly same-choice-specific in the sense that they are the mean of the parameters of the subpopulation that would have made the same choices when faced with the same choice situation. Hence, it is, strictly speaking, not a unique set of estimates for the individual but rather a mean and standard deviation estimate of the subpopulation that makes the same choices (Hensher et al., 2006). The estimates of individual-specific parameters are obtained using Bayes' theorem under which the conditional density for the random parameters is given by the following equation:

$$p(\beta_n|Y_n, X_n, \theta) = \frac{L(Y_n|\beta_n, X_n, \theta) f(\beta_n|\theta)}{\int_{\beta_n} L(Y_n|\beta_n, X_n, \theta) f(\beta_n|\theta) d\beta_n} \qquad (2)$$

where Y_n denotes the respondents' chosen alternatives in their sequence of choices over the T_n choice occasions, X_n denotes all elements of x_{ntj} for all *t* and *j*, and where the elements of θ are the underlying parameters of the distribution of β_n. The first term in the numerator is the likelihood of an individual's sequence of choices given that they had this particular β_n. The second term is the distribution in the population of the β_ns. The denominator is the unconditional choice probability for the individual respondent. Since the integrals in the probabilities in Equation 2 have no closed form solution, estimation is undertaken through simulation to obtain maximum likelihood estimates. In this paper, we estimate the log-likelihood functions using 300 Halton draws, which was found to be a suitable number of draws to produce stable results. Estimation of the above-described model was done using Nlogit 4.0 software.

Spatial determinants of marginal utilities

In a second stage, we used an approach similar to the approach used in Campbell (2007) to analyze the individual-attribute parameters estimated above. In our model, we modeled the marginal attribute utility, i.e., the parameter values in the indirect utility function, whereas Campbell (2007) used estimated marginal willingness to pay as the dependent variable. The reason for this is that we modeled the coefficient of the distance attribute as a random parameter in the first stage estimation. Typically, in valuation studies, the variable representing the marginal utility of income (which is similar to our distance attribute in the sense that distance can be viewed as a cost) is kept fixed in order to avoid a number of severe problems associated with specifying a random price parameter (Train, 2001; Hensher and Greene, 2003; 2003; Hensher et al., 2005; Hess et al., 2005; Train and Sonnier, 2005; Train and Weeks, 2005; Campbell et al., 2006; Meijer and Rouwendal, 2006; Rigby and Burton, 2006). We believe that it may be important in the current case to let the distance be specified as a random variable because the costs associated with a certain travel distance may significantly depend on each individual's means of transport (car, bike or walking) and the alternative costs of time. Furthermore, our study deviates from Campbell's because a key issue for us is to explore the potential link between local access to forests and the preference for forest recreation.

Let V_{na} be the marginal utility of forest attribute/level a (where a={broadleaved, mixed tree species, one hiking path, more than one hiking path, parking or picnic, parking and picnic, lake or river}) for respondent *n* (i.e., $V_{na} = \beta_{na}$). The regression of V_{na} can be written as an error component model: $V_{na} = \beta_0 + \lambda_a + \pi_a h_{na} + \gamma_a ac_{na} + \delta z_n + \varepsilon_{na}$ (3) where: $\varepsilon_{na} = \alpha_n + e_{na}$.

In this model, the error term is composed of a random and unobservable individual specific effect α_n and a remainder disturbance e_{na}. In the case of a random effects model, $\alpha_n \sim IID(0, \sigma_\alpha^2)$, $e_{na} \sim IID(0, \sigma_e^2)$ and the α_n are independent of the e_{na}. Furthermore, the λ_a are assumed to be fixed parameters specific to the attribute and to be estimated, and β_0 is the constant term. h_{na} is a vector of variables characterizing the respondent n with respect to attribute a, z_n are the characteristics of respondent n (independent of the forest attribute a), $ac_{na} = \sum_J^K \frac{1}{d_{nj}^\phi} s_{aj}$ where s_{aj} is equal to one if the attribute and level a is present in forest j and zero otherwise, d_{nj} is the distance between the residence of visitor n and forest j, and ϕ is a parameter defined by the analyst. π_a, γ_a and δ are the associated parameters to be estimated. The variable ac_{na} is an index representing the proximity of forests where the attribute/level a is present (i.e., s_{aj}=1). The index is relatively high when the respondent's residence is relatively close to a forest with s_{aj}=1 and/or when there are relatively many nearby forests where this attribute is present. Model (3) is more flexible than the model in Campbell (2007) since we have included attribute-fixed effects and attribute-specific parameters, reflecting that characteristics of the individual and local access to forests may not have the same effect on the marginal utility for all attributes. Compared to Campbell (2007), Model (3) also includes the variables ac_{na} that allow us to estimate and test if preferences for forest recreation are independent of access to forest recreation. Furthermore, compared to Campbell (2008, 2009) who analyzes the spatial distribution of preferences in an explorative way, our model includes spatial explanatory variables (obtained from GIS maps).

4. Survey and data

The administration of our questionnaire was Web-based, a survey mode that has gained popularity in choice experiment surveys (Olsen, 2009). An e-mail with a link to the server with the questionnaire was sent to an Internet panel of inhabitants in Lorraine. A response rate of two percent was projected by the company maintaining the applied panel. Thus, in the main survey, 53,000 people were sent an e-mail that briefly described the survey and with a link to the questionnaire on the Web. If the respondents gave their e-mail address and completed the questionnaire, they would be able to participate in a lottery with the chance to win one of 50 USB memory keys. E-mail reminders were sent after two and four weeks. In all, 1837 respondents began to answer the online questionnaire (3.5%), and out of these, 1144 actually completed the questionnaire (2.2%). A total of 1061 (2.0%) respondents who had completed the questionnaire had visited a forest during the past 12 months and were asked to complete the choice experiment. Compared to other surveys using the same panel, the response rate was relatively high, although compared to other stated preference surveys in general, the response rate was relatively low. In Table 2, the main demographic and socioeconomic characteristics of the effective sample used to estimate the choice model are presented and compared with the total population in Lorraine. The share of female respondents is lower in the sample than in the population and the 40-60-year-old respondents are overrepresented in the sample. The sample exhibits an overrepresentation of people in high income classes. The relatively high rates of middle-aged people and high-income groups in the sample are not unusual for Internet and mail surveys (Olsen, 2009). Thus, even though the response rate might raise some concerns regarding the representativeness of the sample, the skewness of the sample for central socio-demographic characteristics does not seem to be much worse than similar surveys with much higher response rates.

Table 2. Sample and population characteristics

	Sample	Lorraine
Gender distribution (% women)	52	37
Age distribution (%)		
20 - 39 years	27	34
40 - 59 years	51	37
60 - 74 years	21	18
75- years	1	11
Household income		
€0 – 9,400	6	25
€9,401 – 13,150	5	14
€13,151 – 15,000	4	8
€15,001 – 18,750	5	13
€18,751 – 23,750	10	11
€23,751 – 28,750	13	8
€28,751 - 38,750	22	10
€38,751 – 48,750	15	5
> €48,750	21	6

Source: Age and gender: INSEE – *Population estimations;* Income: Taxable income 2008. www2.impots.gouv.fr/documentation/statistiques/ircom2007/region/region.htm

The majority of the respondents (96%) had visited a forest more than once during the past 12 months, whereas 77% had visited different forests during the period. Forest visitors had visited a forest 27 times during the past year on average. The second-stage analysis used only the 651 respondents with residences (primary or secondary) in Lorraine and who had visited a forest in Lorraine during the past 12 months[2]. In Table 3, the variables representing potential determinants of preference heterogeneity are defined. These include socio-demographic characteristics (age, employment status, income, recreational habits and attitude to nature conservation) of the respondents obtained from the questionnaire. As in Campbell (2007), the effect of non-attendance of an attribute in the respondents' trade-offs is estimated. After having carried out the choice experiment, the respondents were asked if they had ignored attributes when they made their choices of forest. If they replied that they had ignored a given attribute, the variable NATT was equal to zero; otherwise it was equal to one. Of the 651 respondents analyzed in the second stage, 20% replied that they had not used the species attribute when making the choice (Table 4). For the hiking path and access to water attributes, the non-attendance rate was the same as for the species attribute. The non-attendance rate was 32% in the case of facilities. The variable representing accessibility to forests with a given attribute was calculated using a recently established GIS database with data characterizing forests in Lorraine (Thirion, 2010) and a GIS road map. Variables describing tree species composition of the forest were obtained from the French National Forest Inventory (IFN). Data describing the presence of hiking paths were obtained from the French Hiking Association (Fédération Française de Randonnée Pédestre), while data concerning the presence of recreational facilities, lakes and rivers in forests were obtained from the French National Geographic Institute (IGN). The definition of forest is the one used by Thirion (2010). Basically, forests are continuous land with forest cover. If a forest is very large (typically, greater than 1,000 hectares), it is divided into two forest units that are considered to be a unity in our analysis. The division of forests into units was, among other things, determined by existing structures in the forest, e.g., roads or rivers. The first 11 lines in Table 4 give the distribution of attribute levels in the forests in Lorraine. Forests dominated by broadleaves are the most frequent type in Lorraine. Twenty percent of the forests have one marked hiking path, while only two percent have more than one marked hiking path. A total of 86% of the forests have no recreation facilities

[2] 410 of the respondents who participated in the choice experiment were, according to their own information provided in the questionnaire, not living in Lorraine or had not visited a forest in Lorraine during the past 12 months.

(parking and picnic places), while 11 percent have either a picnic or a parking place and only three percent have both types of facilities. A total of 17% of the forests have access to water, i.e., lakes and/or rivers.

The distance between a respondent and a given forest is the road distance between the town hall of the municipality (*commune*) where the respondent had his/her residence (or the municipality where the respondent was temporarily residing when going to the most visited forest during the past 12 months) and the centroid of the forest. In the empirical results presented in Section 5, the accessibility index is calculated using , i.e., each forest where the attribute of interest is present was weighted with the inverse of the quadratic distance. Furthermore, we assumed a minimum distance between the forest and respondent of 1 km, i.e., if distance < 1 km, then d = 1 km; otherwise d = distance. This lower limit on distance reflects that the exact address of the respondents was not available and that the town hall in some municipalities was located very close to the centroid of the nearest forest. In municipalities where the town hall was very close to the centroid of a forest, the calculated accessibility index was relatively high without necessarily reflecting the respondent's access to the forest since we did not know the respondent's exact address within the municipality. Table 4 describes both an average attribute accessibility index and attribute-specific index. As expected, forests characterized by the most frequent attributes (e.g., broadleaves) were also the most accessible ones according to our accessibility index.

Table 3. Description of variables used in second-stage analysis

Variable	Variable explanation	model
V_{na}	Marginal utility for individual *n* for attribute *a*	V_{na}
sp_br	Is 1 if attribute *Dominant tree species* = *Broadleaves*; otherwise 0	
sp_mix	Is 1 if attribute *Dominant tree species* = *Mixed tree species*; otherwise 0	
pa_one	Is 1 if attribute *Hiking paths* = *One marked hiking path*; otherwise 0	
pa_more	Is 1 if attribute *Hiking paths* = More *than one marked hiking path*; otherwise 0	
fa_p	Is 1 if attribute *Facilities* = *Parking or picnic places* indicates presence of picnic or parking place; otherwise 0	
fa_pp	Is 1 if attribute *Facilities* = *Parking and picnic places* indicates presence of picnic or parking place; otherwise 0	
natt	Is 1 if attribute is used in trade-off in the choice experiment, i.e., nonattendance of attribute if natt = 0	h
access	Accessibility for respondent *n* to forests with attribute *a*	ac_{na}
hunter	Is 1 if the respondent is a hunter; otherwise 0	z
hiker	Is 1 if the respondent is a hiker; otherwise 0	z
age	Respondent's age	z
income	Annual income classes in €: 1: < 9,400, 2 : [9,401, – 13,150], 3: [13,151 – 15,000], 4: [15,001 – 18,750], 5: [18,751 – 23,750], 6 : [23,751–28,750], 7: [28,751– 38,750], 8: [38,751 – 48,750], 9: > 48,750	z
profsup	Is 1 if respondent holds a managerial position; otherwise 0	z
profemp	Is 1 if working but does not hold a managerial position; otherwise 0	z
ngo	Donations to nature protection NGOs; 1,…,5 where 1 = never, 3 = sometimes 5 = often	z

Table 4 Descriptive statistics: second-stage variables

Variable	Mean	Std. Dev.	Minimum	Maximum	Number of observations
s_{na}					
a=Coniferous	0.07	0.25	0	1	2263
a=Broadleaf	0.67	0.47	0	1	2263
a=Mixed tree species	0.27	0.44	0	1	2263
a=No hiking path	0.79	0.41	0	1	2263
a=One hiking path	0.19	0.39	0	1	2263
a=More than one hiking path	0.02	0.14	0	1	2263
a=No facilities	0.86	0.35	0	1	2263
a=Parking or picnic	0.11	0.31	0	1	2263
a=Parking and picnic	0.03	0.17	0	1	2263
a=No lake or river	0.83	0.37	0	1	2263
a=Lake or river	0.17	0.37	0	1	2263
ac_{na} (access)	0.00029	0.00036	2.46E-06	2.87E-03	4557
a=Broadleaf	0.000946	0.000366	0.000111	0.002254	651
a=Mixed tree species	0.000314	0.000256	0.000054	0.001477	651
a=One hiking path	0.000243	0.000149	0.000041	0.001404	651
a=More than one hiking path	0.000057	0.000087	0.000002	0.001143	651
a=Parking or picnic	0.000195	0.000196	0.000028	0.001243	651
a=Parking and picnic	0.000035	0.000034	0.000006	0.000576	651
a=Lake or river	0.000235	0.000146	0.000042	0.001370	651
Marginal attribute utility (V_{na})	0.53	0.34	-0.41	1.93	4557
natt) attendance of attribute in choice task	0.769	0.421	0	1	4557

a= Broadleaf *a*=Mixed tree species,	0.80	0.40	0	1	1302
a= One hiking path *a*=More than one hiking path	0.81	0.39	0	1	1302
a=Parking or picnic, *a*=Parking and picnic	0.68	0.47	0	1	1302
a=lake or river	0.80	0.40	0	1	651
ngo	1.911	1.100	1	5	651
profsup	0.197	0.397	0	1	651
profemp	0.324	0.468	0	1	651
income	6.336	2.253	1	9	651
age	49.04	12.34	11	80	651
hunter	0.057	0.232	0	1	651

5. Results

5.1. Results from the first-stage analysis

The parameter estimates obtained from the random parameter error component model are reported in Table 5. With a McFadden's pseudo-R^2 of 0.232, the specified model fits the data quite well. All parameters have the expected sign and only one parameter, namely parking and picnic place is not significantly different from zero at a conventional 10% level of statistical significance. The utility of visiting a broadleaf forest is higher than visiting a forest dominated by conifers. Visitors generally prefer a forest with one marked hiking path to a forest without a marked hiking path, and they prefer to have more hiking paths rather than just one. However, in the case of picnic and parking facilities, only one of the facilities is preferred. On average, the respondents obtain less utility when both parking and picnic facilities are present than when only one of these two are present. This may be because the two facilities are not seen as complementary but instead as potentially conflicting facilities due to different uses. It is possible that people consider that a picnic place is less attractive if there is a parking lot close to the picnic place or that a parking place will make the picnic place more crowded. It is also important here to consider the significant standard deviation of the random parameter of the picnic and parking attribute level. Combining this evidence of preference heterogeneity with the insignificant mean parameter estimate indicates that a rather large percentage (43%) of the respondents experience a negative utility when both facilities are present. This percentage is lower (33%) when only one of the facilities is present. The respondents prefer visiting forests with lakes or rivers and forests that are close to their residential location. Not surprisingly, we found significant preference heterogeneity for all parameters except for the parameter for one hiking path. This could be an indication that all visitors generally prefer having at least one hiking path, whereas some people find a forest with more hiking paths attractive while others may consider such a forest to be too "organized" or crowded. The positive parameter estimate for the ASC captures a systematic status quo effect. All other things being equal, respondents prefer the status quo alternative, i.e., the forest they have visited most often in the past 12 months. In other words, respondents show an affinity for this alternative beyond what the specific attribute levels for this alternative relative to the two other alternatives would predict. The significant error component further adds a stochastic element to the status quo effect. As this parameter estimate is common to the two experimentally designed alternatives, it also implies significantly differing covariance structures across the utilities of these two alternatives and those of the status quo alternative (Scarpa et al. 2005, 2008).

Table 5. Estimation results: The random parameter error component model

Attribute	Coefficient		St. error	z	P(z>|Z|)
Mean estimates					
Broadleaf	0.6659	***	0.0657	10.13	0.0000
Mixed species	0.86177	***	0.0737	11.7	0.0000
One hiking path	0.49499	***	0.0643	7.69	0.0000
More hiking path	0.77337	***	0.0664	11.64	0.0000
Parking or picnic	0.15233	**	0.0640	2.38	0.0173
Parking and picnic	0.09982		0.0658	1.52	0.1290
Lake or river	0.6695	***	0.0573	11.68	0.0000
Distance	-0.0509	***	0.00353	-14.42	0.0000
ASC	0.55075	***	0.0821	6.7	0.0000
Random parameter standard deviations					
Broadleaf	0.414	**	0.173	2.39	0.0166
Mixed species	0.807	***	0.107	7.56	0.0000

One hiking path	0.350		0.214	1.63	0.1027
More hiking path	0.572	***	0.128	4.47	0.0000
Parking or picnic	0.351	**	0.157	2.24	0.0248
Parking and picnic	0.536	***	0.144	3.72	0.0002
Lake or river	0.673	***	0.112	6.02	0.0000
Distance	0.048	***	0.003	13.99	0.0000
Error component, μ	2.016	***	0.094	21.34	0.0000
# respondents	1061				
# choice observations	6366				
McFadden's Pseudo-R^2	0.2320				
Log likelihood at convergence	-5363				

5.2. Results from the second-stage analysis

Table 6 presents the estimates of the model outlined in Equation 3 obtained by the GLS method on the random effect model. The first six estimates in Table 6 are the dummy variables representing the different attribute levels. The lake or river attribute is excluded to avoid the dummy trap problem. This implies that the estimates represent the marginal utility in addition to the marginal utility of having a lake or a river in the forest visited. Neither the variable representing the attitude to nature protection (ngo) nor the variables describing the employment status (profsup, profemp) have a significant effect on the marginal utilities. Income has a significant positive impact on the marginal utility of visiting a forest with a lake or a river. The impact of income on the utility of the hiking paths is significantly different (lower) than the impact of income on the lake and river attribute (but not different from zero). The marginal utility of all attributes significantly decreases with age. This is especially the case for the lake or river attribute. Six percent of the respondents stated that they were hunters and eight percent that they were members of a hiking club. It could be expected that preferences for different forest attributes may depend on the recreation activities of the respondent (Hanley et al., 1998; Christie et al., 2007). However, we found no significance of hiking club membership and the model is re-estimated without the hiking club membership dummy. Nevertheless, being a hunter has a strong negative impact on the preference for lake and river and a significant negative effect on the preference for more than one marked hiking path in the forest as well. The coefficients of the interaction of the attendance variable (natt) with the attribute dummies are positive for all attributes apart from the broadleaf attribute. However, only the influence of the attendance attribute on water and mixed forest is significantly different from zero. One of the objectives of this study was to test for spatial sorting. A significant impact on the marginal attribute utility of accessibility to forest (access) with the respective attribute is interpreted as evidence of spatial sorting. If a positive parameter on the accessibility variable is found, it may be because people choose their location of residence close to forests with attributes that they have strong preferences for (Baerenklau, 2010). We found no significant effect of accessibility to forest on the marginal utility of forest attributes, except for both picnic and parking places that is significantly higher than the access to forest with lake or river (at the 10% level). As described in Section 4, the variable representing accessibility to forest ac_{an} is calculated assuming ϕ = 2 and under the assumption that no forest can be closer than 1,000 meters to the residence. The model was also estimated using different assumptions about the minimum distance and with different parameters. The results are generally robust to such changes. We found a weakly significant correlation in all cases between forests with parking and picnic places and the preferences for this attribute.

The test results for appropriateness of using the random-effects model included the Lagrange multiplier test of the hypothesis that σ_α^2 is equal to zero, developed by Breusch and Pagan (1980). This was largely rejected, indicating that there were (random) individual specific effects and that our use of panel data procedures increased estimation efficiency. The Hausman test was used to test the hypothesis that the random individual effects are independent of the explanatory variables. This hypothesis could not be rejected and thus justifies the use of the GLS estimation method on the random effect model.

Table 6 Estimation results from the second stage

Variable	Parameter	Standard error	P>|z|
sp_br	-0.0472	0.0554	0.3940
sp_mix	0.1023	0.0529	0.0530
pa_one	-0.2119	0.0532	0.0000
pa_mor	0.0106	0.0519	0.8380
fa_p	-0.5594	0.0514	0.0000
fa_pp	-0.6433	0.0512	0.0000
ngo	-0.0015	0.0027	0.5860

profsup	-0.0113	0.0081	0.1620
profemp	-0.0086	0.0068	0.2060
natt_br	-0.0067	0.0269	0.804
natt_mix	0.0600	0.0269	0.026
natt_one	0.0102	0.0273	0.709
natt_mor	0.0099	0.0273	0.718
natt_p	0.0121	0.0251	0.629
natt_pp	0.0046	0.0251	0.854
natt_water	0.0696	0.0190	0.000
income	0.0075	0.0035	0.0300
income*sp_br	-0.0071	0.0049	0.1420
income *sp_mix	-0.0064	0.0049	0.1880
income *pa_one	-0.0088	0.0049	0.0710
income *pa_more	-0.0086	0.0049	0.0790
income *fa_p	-0.0019	0.0049	0.7020
income *fa_pp	-0.0034	0.0049	0.4850
age	-0.0005	0.0003	0.0810
age *water	-0.0025	0.0007	0.0000
access	-73.0	62.9	0.2460
access*sp_br	47.5	89.5	0.5950
access*sp_mix	84.6	67.3	0.2090
access *pa_one	78.3	70.8	0.2690
access *pa_more	101.1	119.6	0.3980
access *fa_p	57.7	85.5	0.5000
access*fa_pp	402.8	244.2	0.0990
hunter*sp_br	0.0069	0.0335	0.8360
hunter *sp_mix	-0.0378	0.0334	0.2580
hunter *pa_one	-0.0086	0.0334	0.7960
hunter *pa_more	-0.0571	0.0334	0.0870
hunter *fa_p	-0.0108	0.0334	0.7450
hunter *fa_pp	-0.0465	0.0334	0.1640
hunter *water	-0.1291	0.0334	0.0000
constant	0.7424	0.0427	0.0000
N=651, *a*=7 (4557 observations)			
	R^2 within = 0.70, R^2 between = 0.04, R^2 overall = 0.67		
Hausman test	χ(8) = 11.90 (p=0.31)		
Breusch and Pagan (test for random effects)	χ(1) = 15.39 (p=0.0001)		

6. Discussion

We present here a study on forest visitors' preferences for recreational attributes of forests, applying a two-stage procedure model. In the first stage, we estimated individual-specific marginal utility of forest attributes, applying a random parameter error component logit model and, in the second stage, we analyzed the estimated individual-attribute preferences and their determinants. The results from the first stage showed strong evidence of preference heterogeneity. Consequently, our results confirm the results of other studies that have found preference heterogeneity for recreation (e.g., Christie et al., 2007; Termansen et al., 2008; Baerenklau, 2010) and environmental services (e.g., Campbell et al., 2007; Brouwer et al., 2010). For example, the mean marginal utility of having access to a forest with both picnic and parking places as compared to a forest without these facilities is not significantly different from zero. However, our results also show that this is not because respondents have no preference for these facilities. Some respondents obtain a positive utility from these facilities when visiting a forest, while others, on the contrary, obtain a negative utility. The presence of parking alone and picnic places alone in the forest generally had a significantly positive marginal utility for visitors, although this attribute level is also subject to preference heterogeneity (see Termansen et al., 2008; Bestard and Font, 2010). Overall, this indicates that public forest managers should consider a differentiated supply of recreational facilities in the forests of Lorraine. Some forests should be equipped with none or only one of these facilities; others with both parking and picnic places.

Generally speaking, forests dominated by broadleaf and mixed tree species seem to be preferred to forests dominated by coniferous tree species, which is consistent with the results reported by Scarpa et al. (2000) and Nielsen et al. (2007). However, Termansen et al. (2008) found some preference for coniferous forests, contrary to their expectations. Positive utility of hiking paths has also been found by Christie et al. (2007) and Bestard and Font (2010). The presence of water bodies in forests also reveals a positive impact on the utility of a visit, as was also reported by Termansen et al. (2004). Finally, respondents prefer forests close to their residence (i.e., a negative marginal utility of distance), as expected. The second-stage analysis showed that visitor's age, income and being a hunter had an impact on the marginal utility of forest attributes, while there were no significant effect of attitude to nature protection, being a member of a hiking club, and employment status. Income was also found to be a significant determinant of preferences in Campbell (2007). However, we found that the income effect was attribute-dependent, i.e., having only a positive impact on the marginal utility of the “lake and river” attribute. As expected, we found a significantly negative impact of non-attendance of an attribute in the choice tasks (Campbell, 2007).

Heterogeneity is present among forest visitors as well as forests in Lorraine are heterogeneous both in terms of their ecological components and their facilities. With significant preference heterogeneity and variability in the access to forests, i.e., distance to the nearest forest with the demanded quality (attribute levels), and given that individuals include accessibility to forests in their choice of residence location, we would expect spatial sorting to occur. This would imply that preferences for forest attributes would be correlated with the accessibility to forests with these attributes. In the second-stage analysis we included a variable representing the proximity or access to the forest with a given attribute. This variable was found to be insignificant in accounting for preference heterogeneity, except for the forest with picnic and parking facilities. Due to this weak link between access and preferences, we cannot conclude that there is empirical evidence of spatial sorting due to preferences for forest recreation: individuals do not choose their location according to their preferences for forests in Lorraine. Several explanations could be proposed to account for the fact that spatial variation in access to forest recreation is not correlated with preference heterogeneity. The most obvious one is that Lorraine is relatively densely forested and the residents are therefore always relatively close to a forest corresponding to their preferences, implying relatively little variation in data. This, in combination with rather imprecise residence location data (information only about the commune but no specific addresses), might make the link in our data weak. The reason that we find no evidence of spatial sorting could also be that individuals do not choose a location according to their preferences for recreational uses in forests but according to preferences for other uses or benefits provided by forests such as green views or open spaces (Baerenklau, 2010). This may also be due in large part to unobserved factors (school quality, sport facilities, etc.) that also influence the location choice. Therefore, a more general model of location choice should be considered in future research to reveal potential spatial sorting (see Klaiber and Phaneuf, 2010). Another possibility for future research would be to address whether different subgroups are more or less prone to spatial sorting (Epple et al, 2010). Such groups could, for example, be defined by different moving costs. One of the reasons for not finding a correlation between respondents’ marginal attribute utility and accessibility to the forest could be an imperfect housing market where transaction costs exceed the gains of relocating according to preferences for forest recreation.

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