Ecological Economics 119 (2015) 8–23

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Choice experiment assessment of public preferences for forest structural attributes

Marek Giergiczny [a,*], Mikołaj Czajkowski [a], Tomasz Żylicz [a], Per Angelstam [b]

[a] Faculty of Economic Sciences, University of Warsaw, ul. Dluga 44/50, 00-241 Warszawa, Poland
[b] Forest-Landscape-Society Research Network, School for Forest Management, Swedish University of Agricultural Sciences, PO Box 43, 73921 Skinnskatteberg, Sweden

ARTICLE INFO

Article history:
Received 1 October 2014
Received in revised form 15 July 2015
Accepted 26 July 2015
Available online xxxx

Keywords:
Forest characteristics
Recreational value
Choice modeling
Forest management

ABSTRACT

Combining the approach used in landscape research with non-market valuation techniques, the aim of this study is to document human habitat selection for recreational purposes in a gradient of forest naturalness. The results indicate that respondents prefer older stands with vertical layering, irregularly spaced trees and a greater number of tree species. Our study thus indicates that forests that are managed (or left unmanaged) for biodiversity purposes are also likely to be attractive to humans. To conclude, while greater management intensity was associated with higher disutility regardless of the model employed, we do not perceive a risk of conflict between forest management designed to protect biodiversity and management targeting recreational value. Consequently, there is a need for spatially differentiated forest management that discriminates among different functions. The state ownership of all larger Polish forest massifs makes this zoning approach feasible.

1. Introduction

The definition of forest management differs across the world's regions and changes over time in a given country or region. Lehtinen et al. (2004) termed this phenomenon the forest industrial regime. In Europe, sustained yield forestry emerged to satisfy the increased energy needs of metallurgic and other energy-demanding industries (Carlowitz, 1713/2000; Hartig, 1860). Since the emergence of the current discourse concerning sustainable development as a societal process seeking to ensure economic, ecological and social sustainability in the 1980s, a broad range of natural resource sectors such as sustained yield forestry have revised and broadened the suite of objectives that should be satisfied. Paramount among these is the challenge of valuing the environment with respect to both use and non-use values (Merlo and Croitoru, 2005).

Thus, after a long history of local multiple use (e.g., Elbakidze and Angelstam, 2007), the most important value associated with forests in Central and Northern Europe since the industrialization has been the use value derived from timber and pulpwood (Angelstam et al., 2011). However, in the recent decades both biodiversity, in terms of the conservation of species, habitat and natural processes, and the amenity values of forests, such as scenic beauty and recreational value, have become increasingly significant. The terms ecosystem services and green infrastructure capture the efforts to secure human well-being based on natural capital (European Commission, 2013). This rapid transformation of the meaning of forest management poses challenges for policy implementation for several reasons. For example Blicharska et al. (2011) reported that managers' knowledge of new forest policy objectives was limited. Interviewing foresters in countries characterized by strong histories of power and institutional culture, Lawrence (2009) concluded that attitudes depended on both law and education, the authority foresters accumulated through experience, and the acting out of an emotional commitment to the forest. This transition from individual and tangible to multiple and complex forest management objectives stresses the need to estimate the value of both traditional material use values linked to wood production and immaterial values such as biodiversity and the social benefits of tourism and recreation.

As a result of this increased public demand for forest recreational services, a considerable body of literature has been published on public preferences concerning different types of forests and the attributes that characterize them. This substantial literature is primarily rooted in various landscape research disciplines and includes three main approaches. The first is the psychophysical approach. It seeks to relate individual physical attributes of the landscape with overall measures of scenic quality. The second is the psychological approach, in which individuals are asked to select from a checklist of adjectives that describe the landscape, and the relevance of these feelings is then assessed by relating them to overall scenic quality scores (Lee, 2001). The final approach is phenomenological. It is based on in-depth interviews or an analysis of literary sources, which yields rich qualitative data and is intended to evaluate the meanings that individuals attach to the landscape (Sheppard and Harshaw, 2001).

A common criticism of the existing studies on public forest preferences is the selection of the target population. Many such studies are

* Corresponding author.
E-mail addresses: mgiergiczny@wne.uw.edu.pl (M. Giergiczny), miq@wne.uw.edu.pl (M. Czajkowski), tzylicz@wne.uw.edu.pl (T. Żylicz), per.angelstam@slu.se (P. Angelstam).

http://dx.doi.org/10.1016/j.ecolecon.2015.07.032

exclusively limited to experts, and there are conflicting views on the extent to which expert judgments reflect those of the general public (Edwards et al., 2012). Many of these studies are also criticized for their scope and sample size. For example, Ribe (1989) states that the general validity of most empirical studies of forest perception is limited as they focus on a narrow range of forest types and are restricted to small groups of subjects. In addition, most existing studies have failed to link preferences to monetary costs and benefits, i.e., they rely on forest images that are scored (or ranked) by respondents but do not provide monetary estimates arising from marginal changes in forest attributes.

Non-market valuation techniques, including stated preference methods, have been applied to value forest externalities for several decades. However, most published studies have focused on estimating the recreational benefits provided by a given site (see, for example, Riera et al. (2012) for an overview), and few of them have sought to establish a link between forest or landscape attributes and recreational values (e.g., Mattsson and Li, 1994; Horne et al., 2005; Mill et al., 2007; Nielsen et al., 2007). Additionally, these studies often exclusively focus on a small number of forest structural attributes. For example, Nielsen et al. (2007) assessed public preferences for three attributes, i.e., variations in tree species composition, tree height structure and the presence of dead trees. Similarly, Horne et al. (2005) used attributes that were very broadly defined, i.e., the attractiveness of forest scenery. To incorporate forest attributes into forest planning, more comprehensive measurements are needed.

To better understand human habitat selection for recreational purposes, we combine the approach used in landscape research with non-market valuation techniques. The crucial aspect of this choice experiment (CE) study was the identification of the complete range of forest attribute types and their quantity on a management-intensity gradient from more to less natural forest (Peterken, 1996). As forests provide social values, we attempted to include forest attributes that are relevant to public preferences for forest recreation and are thus relevant to sustainable forest management policy.

The landscape and forestry literature identifies a long list of such attributes. Edwards et al. (2012) identified 12 key structural attributes of forests that affect the recreational attractiveness of forests. In our study, we attempted to operationalize forest characteristics as similarly to those in Edwards et al. (2012) as possible. However, in contrast to their study, which was a Delphi-type survey conducted using a panel of foresters and landscape experts, we employed CE and administered our survey to a representative sample of 1000 Polish citizens. As our survey was not administered to experts, we devoted a substantial effort to adequately explain the forest attributes considered. This was achieved by employing various visualization techniques and written descriptions.

To the best of our knowledge, our study is the first to quantify forest structural attributes with respect to both the social and relative contribution of each attribute to recreational value expressed in monetary terms. The WTP estimates can be useful in defining optimal forest management plans for Poland and other European countries. In addition, for each attribute we document the relationship between recreational value and attribute levels. In terms of policy implications, we show that there is a clear conflict between timber production and recreational use, i.e., the forest attribute levels associated with timber-oriented management result in substantial decrease in recreational values. On the other hand the obtained results indicate that forests that are managed (or left unmanaged) for biodiversity purposes are likely to be attractive to humans.

The remainder of the paper is structured as follows. In the next section, we give an overview of the forests in Poland. Section 3 describes forest characteristics which were used in the CE and Section 4 provides the details of the questionnaire structure and the survey work. Section 5 presents modeling approach and is followed by Section 6 which describes design and model specification. We next present modeling results, discuss policy implications and close with the conclusions section.

2. Forests in Poland

Currently, the total area of forests in Poland is 9.14 million hectares, which corresponds to 29.2% of the country's area. This figure places Poland in the group of countries with the largest forest areas in the European temperate forest region, after Germany and Ukraine. The majority of forests in Poland (i.e., 81.3%) are publicly owned, of which 77.4% are managed by the State Forests office. Throughout the post-war period, the forest ownership structure has remained largely unchanged. As Polish forests consist of both larger forest massifs that are suitable for recreation and numerous small patches that are not, the effective proportion of State Forests is even higher. Two additional factors that are important for the recreational use of forests are the structure of tree species and age classes.

Polish forests are primarily found on the poorest soils. This is reflected in the structure of tree species across regions. In the mountainous regions, Norway spruce (in the west) and Norway spruce and beech (in the east) are the main species. However, in most of the country, stands with Scots pine as the dominant species prevail. Thus, the predominant species in Polish forests are coniferous, accounting for 70.3% of the total forest area. In the period 1945–2011, the tree species structure in Poland's forests changed substantially, resulting in an increase in the share of stands with a prevalence of broadleaved species. In the State Forests, where these changes are monitored annually, the increase over this period was from 13% to 23.2%.

Stands aged 41–60 and 61–80 years prevail in the forest age structure and cover 26.7% and 18.5% of the forest area, respectively. Stands aged 41–60 years prevail in all ownership categories, while in private forests, they occupy nearly 40% of the area. Stands older than 100 years, including stands in the restocking class, stands in the class for restocking and stands in the selection harvest class account for 11.7% of the forest area managed by the State Forests, while in private forests, they only account for 2.3%.

3. Forest Characteristics

3.1. Identification of Relevant Forest Characteristics

Edwards et al. (2012) administered a Delphi survey.[1] The aim of their study was to assess public preferences for 12 key structural forest attributes in four European regions, i.e., the United Kingdom, the Nordic Region, Central Europe and Iberia. The attributes were selected based on an extensive literature review, which covered 330 studies, and after consultation with researchers in outdoor recreation (see Edwards et al. (2012) for details). For each of the four regions, a panel of experts with experience in forest preference research was invited to anonymously participate in a questionnaire survey. In total, 46 experts from the four listed regions participated in the survey. The attributes identified as having the greatest impact on the recreational attractiveness of forests are listed in Table 1. In Edwards et al. (2012), the experts were asked to:

(i) Indicate the type of relationship between forests attributes in their region and recreational value as: positive, negative, bell-shaped, U-shaped, or even and
(ii) Assign a weight, on a scale from 1 (low) to 10 (high), to indicate the relative contribution of each attribute to the overall recreational value of the forests in their region.

3.2. Attributes and Levels used in CE

In contrast to the study by Edwards et al. (2012), which was only administered to landscape and forest experts, our study was administered to a representative sample of 1000 Poles. As the subjects in our study

[1] A Delphi survey is a group facilitation technique, which is an iterative, multistage process, designed to transform opinion into group consensus.

Table 1
Structural attributes and levels included in Edwards et al. (2012).

1. Size of trees within stand
Stand age: from establishment to maturity. Canopy height: from low to high
2. Variation in tree size within stand
Variation in tree size: from uniform to diverse. Number of canopy layers: fromone to many
3. Variation in tree spacing within stand
Variation in tree spacing: from regular to different-sized groups of trees and openings
4. Extent of tree cover within stand
Tree cover: from sparse (e.g., retention trees) to moderate (e.g., shelterwood) to full (closed canopy)
5. Visual penetration through stand
Distance visible: from short to long. Understory and shrub layer: from dense to absent
6. Density of ground vegetation cover up to 50 cm in height within stand
Ground cover: from absent to dense
7. Number of tree species within stand
Number of species: from one to many
8. Size of clear-cuts
Size of clear-cuts: from absent to large
9. Residue from harvesting and thinning
Volume of tree stumps, branches and other visible woody residue: from absent to high
10. Amount of natural deadwood (standing and fallen)
Volume of deadwood: from low to high
11. Variation between stands along a 5-km trail through forest
Number of forest stand types* encountered: from one to many
12. 'Naturalness' of forest edges
Proportion of 'natural' looking (i.e., not straight) edges: from low to high

* 'Forest stand types' differ according to stand age, management regime, and/or tree species composition.
Source: Edwards et al., 2012.

were not experts, considerable attention was devoted to properly describing the studied attributes. Respondents were familiarized with the attributes through written descriptions and carefully selected photographs. In addition, we prepared 135 illustrations depicting different combinations of forest characteristics. This was achieved by manipulating a set of hand-drawn, colored tree diagrams developed by Nielsen and used in Larsen and Nielsen (2007) and Nielsen et al. (2007). Using illustrations in the CE component of the study allowed us to present the forest characteristics in an accessible manner.

In addition to the attributes used in Edwards et al. (2012), we added two additional attributes, namely *Level of tourist infrastructure* and *Distance to forest* (in km). Given the large number of attributes studies, the CE was divided into three separate rounds with ten choice tasks each; thus each respondent faced a total of 30 choice tasks, composed of 4 alternatives, three of which were forest visiting alternatives and one was a staying home option.

Each round was described by five overlapping attributes: *Distance*, *Forest type*, *Number of tree species*, *Stand age* and *Age structure*. In addition to these, there were three round-specific attributes in each of the three rounds. The complete list of attributes and their corresponding levels are presented in Table 2. We now provide a detailed description of the presented attributes. We begin with the overlapping attributes, i.e., *Distance*, *Forest type*, *Number of tree species*, *Stand age* and *Age structure*.

Distance to forest – refers to the distance from an individual's home to the forest. This attribute could be used to estimate willingness to pay (WTP) for forest attributes. A similar approach has been used in Hanley et al. (2002) and in Boxall and Macnab (2000). However, in our study, the marginal rate of substitution (MRS) is expressed as the additional kilometers a person would be willing to travel to visit a forest described by a given set of attributes. The following levels of *Distance* were used: 5, 15, 30, and 60 km.

Stand age – the age of the upper tree story in the forest. The following levels were used: 40, 70, and 100 years.

Variation in tree age – variation in tree age within a stand. The following levels and descriptions were used

Even-aged: forest composed of a single age class

Table 2
Attributes and attribute levels used in the stated choice scenarios.

Attributes	Levels	Label
Overlapping attributes		
Distance (in km)	5, 15, 30, 60	Distance
Forest type	Coniferous	Conif1 (base)
	Mixed	Mixed2, Mixed5
	Broadleaved	Broad1, Broad4
Number of tree species	1 (Coniferous), 1 (Broadleaved), 2, 4, 5	
Stand age (in years)	40,	Age_40 (base)
	70,	Age_70,
	100	Age_100
Age structure	Even-aged	Even-aged (base)
	Two-aged	Two-aged
	Uneven-aged	Uneven-aged
Round 1 attributes		
Understory	Absent	Under_absent (base)
	Medium	Under_med
	Dense	Under_dense
Silviculture system	None	None (base)
	Shelterwood	Shelterwood
	Seedtrees	Seedtress
	Clearcutting	Clearcutting
Tourist infrastructure	None	None (base)
	Picnic sites	Picnic
	Picnic site & interpretative walking trail	Picnic_edu_walk
Round 2 attributes		
Dead wood	Low	DW_low (base)
	Medium	DW_med
	High	DW_high
Forest diversity	The same forest type and stand age	Diversity1 (base)
	The same forest type and variation in stand age	Diveristy2
	Different forest types and variation in stand age	Diversity
Residue from harvesting and thinning	Absent	Residue_absent (base)
	Medium	Residue_med
	High	Residue_high
Round 3 attributes		
Ground vegetation height	Absent	Ground_none (base)
	Medium	Ground_med
	High	Ground_high
Tree spacing	Regular	Tree_regular (base)
	Quasi-regular	Tree_quasi_irreg
	Irregular	Tree_irreg
Forest edges	Straight edges & no ecotone	Edge_reg (base)
	Convoluted edges & no ecotone	Edge_irreg
	Convoluted edges & ecotone	Edge_irreg_ecotone

Two-aged: forest with trees of two distinct age classes

Uneven-aged: forest with trees of three or more distinct age classes.

Number of tree species – refers to the number of tree species within a stand. The following levels were used: 1, 2, 4, and 5.

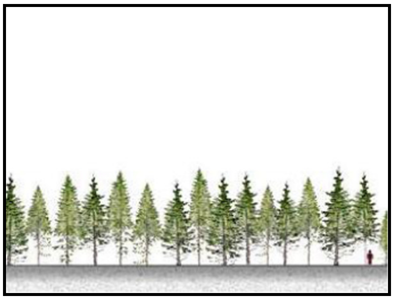
Forest type – the following levels were used: Coniferous, Broadleaved, and Mixed. This attribute is related to the *Number of tree species*, i.e., coniferous forest was always composed of one species only.[2] In our exercise Mixed forest could be composed of 2 or 5 species and broadleaved could be composed of 1 and 4 species.[3]

During the focus groups, these attributes were identified as the easiest to communicate, i.e., we found that written descriptions and the forest diagrams prepared in Photoshop were sufficient for an

[2] Forests in which the dominant species is Scots pine (*Pinus sylvestris*) in the lowland and Norway spruce (*Picea abies*) in the mountain regions are typical in Poland.

[3] These restrictions were necessary to limit the overall number of combinations of different forests that were subsequently presented in the diagrams.

Table 3
Visualization of the overlapping attributes.

			
Forest type	Coniferous	Broad-leaved	Mixed
Number of tree species	1	4	2
Stand age	40 years	70 years	100 years
Variation in tree age	Even-aged	Two-aged	Uneven-aged

adequate explanation. The examples of the prepared diagrams are presented in Table 3.

In each of the three rounds, in addition to *Forest type*, *Number of tree species*, *Stand age* and *Variation in age*, one of the following attributes: *Understory*, *Dead wood* and *Ground vegetation* was also presented on the diagrams depicting forests. During the focus groups, we found that properly communicating the levels of these three attributes required also presenting them using photographs. We attempted to use photographs in which the levels of other structural attributes, apart from the presented ones (i.e., *Understory*, *Dead wood* and *Ground vegetation*), were as similar as possible. These three presented forest attributes are disused briefly below.

Understory – this attribute refers to visual penetration through the forest due to the presence of understory and shrub layer. The following levels were used: Absent, Medium, and Dense. This attribute was used in Round 1. The photographs and diagrams depicting the levels of this attribute are presented in Table 4.

Dead wood – this attribute refers to the amount of natural deadwood (standing and fallen) in the forest. The following levels were used: Low, Medium, and High. This attribute was presented in Round 2. Respondents were informed that this attribute refers to large pieces of natural dead wood to avoid confounding it with the presence of residue from harvesting and thinning, which was described as a separate attribute. The photographs and diagrams depicting the levels of this attribute are presented in Table 5.

Ground vegetation cover – this attribute refers to the height of ground vegetation cover within a stand. The following levels were used: absent, medium and high.[4] This attribute was present in Round 3. The photographs and diagrams depicting the levels of this attribute are presented in Table 6.

[4] In Edwards et al. (2012) instead of the attribute *Height of ground vegetation*, the attribute *Density of ground vegetation* was used. During the focus groups, we found that for most respondents, the *Height of ground vegetation* was more relevant; hence this attribute was used in the final survey.

We now briefly describe the remaining six attributes, which were round-specific. Respondents were familiarized with these attributes through written descriptions and carefully selected photographs. In the CE, the levels associated with these attributes were depicted using specially designed icons.

3.2.1. Round 1 Attributes

Silviculture system – this attribute was used to assess the impact of structures created by different silvicultural systems on the recreational attractiveness of the forest. The following levels and definitions were used:

Clear-cutting – the entire stand is cut at once and is naturally or artificially regenerated.

Shelterwood – partial harvesting that allows new stems to grow under overstory of maturing trees.
Seedtrees – similar to clearcutting but with larger or mature trees left to provide seed for establishing a new stand.
None – no visible traces of felled trees in the forest.

Respondents were informed that different silviculture systems can be used. They were asked to exclusively focus on visual aspects related to the different systems. Respondents were informed that the three silviculture systems imply felling trees in the same area, i.e., they were informed that during a walk in the forest they would encounter a felling site of 1 ha in area every 1 km.[5] Photographs and icons associated with the levels of this attribute are presented in Table 7.

Tourist infrastructure – this attribute refers to the presence of tourist infrastructure in the forest. The following levels were used: None, Picnic sites, and Picnic sites & interpretive walking trails. Respondents were familiarized with this attribute through written descriptions alone. During the CE, the levels associated with *Tourist infrastructure* were depicted using the icons presented in Table 8.

[5] The felling site was described as an area of 100 m^2.

Table 4
Understory.

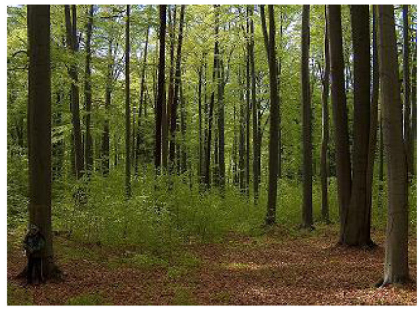
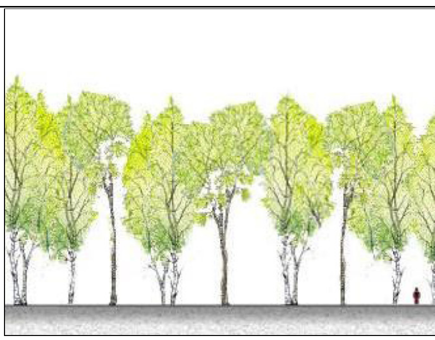
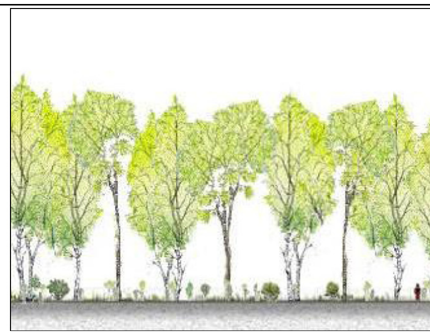
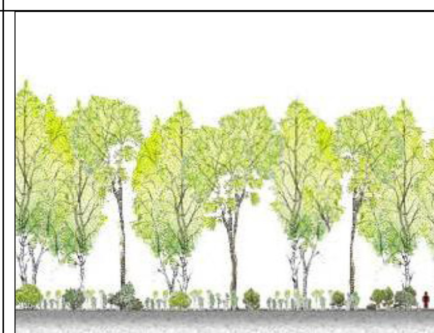
		
Absent	**Medium**	**Dense**
		

Table 5
Dead wood.

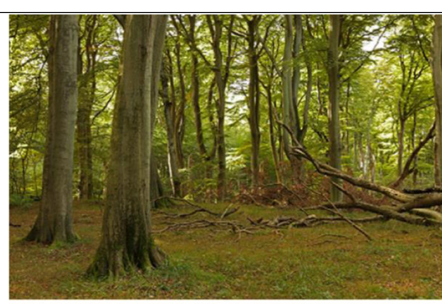
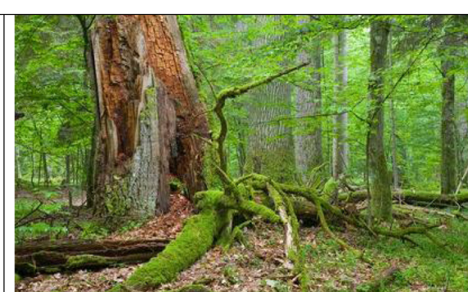
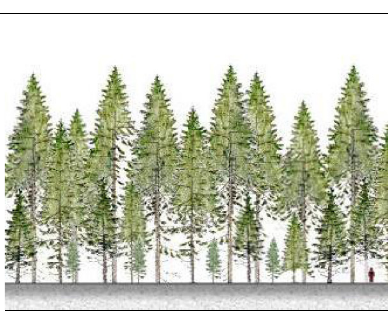
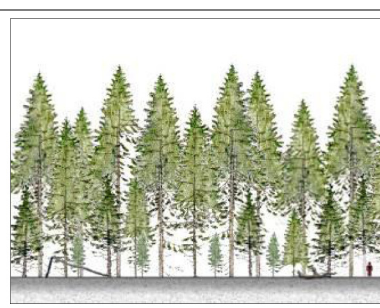
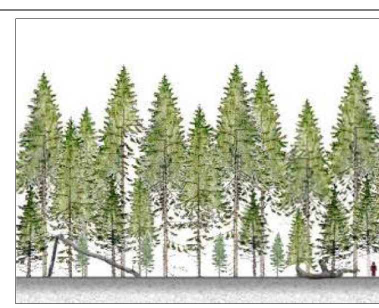
		
Low	**Medium**	**High**
		

Table 6
Ground vegetation height.

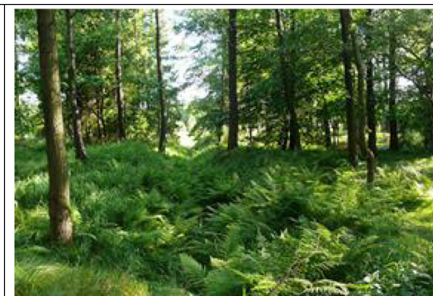
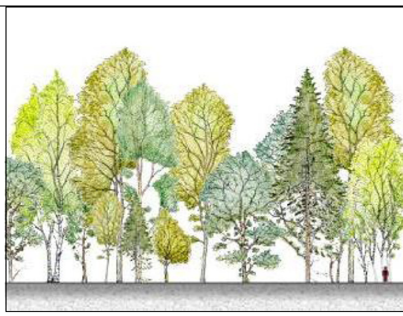
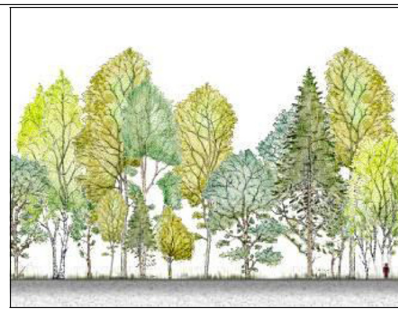
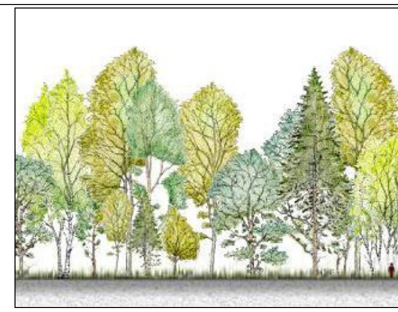
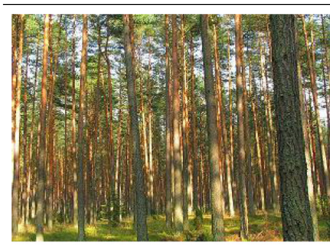
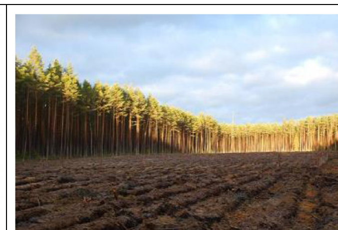
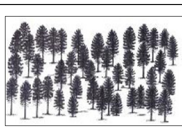
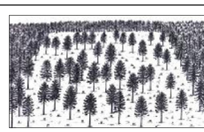
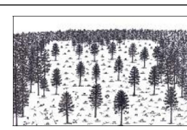
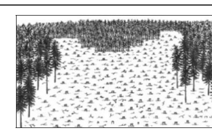
		
Absent	**Medium**	**High**
		

Table 7
Silviculture systems.

			
None	**Shelterwood**	**Seedtrees**	**Clearcutting**
			

3.2.2. Round 2 Attributes

Forest diversity – this attribute refers to the variation between stands along a walk through the forest. The following levels were used: The same forest type and stand age, The same forest type and variation in stand age, and Different forest types[6] and variation in stand age.

To ensure that the *Forest diversity* attribute is consistent with the levels of the overlapping attributes (i.e., *Age*, *Forest type* and *Number of species*), respondents were informed that for the levels: *The same forest type and variation in stand age* and *Different forest types and variation in stand age*, the characteristics of half of the forest area are in accordance with the overlapping ones and the characteristics of the other half of the forest vary respectively in *Age* or in both, i.e., *Age* and *Forest type*.

This attribute refers to spatial diversity; hence it was difficult to depict its levels using photographs. To create a common reference level for all respondents, we used a visualization created by Wang et al. (2006), which depicts horizontal landscape changes from a perspective of 200 m above the forest for which the *Forest diversity* attribute takes the highest level (i.e., *Different forest types and variation in stand age*).[7]

The levels associated with *Forest diversity* were depicted in the CE using the icons presented in Table 9.

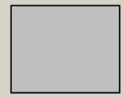
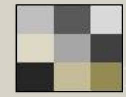
[6] Namely, coniferous, mixed and broad-leaved.

[7] The visualization employed (Fig. 4) can be seen at http://research.eeescience.utoledo.edu/lees/pubs/lup/.

Table 8
Tourist infrastructure.

		
None	Picnic site	Picnic site & Interpretative walking trail

Table 9
Forest diversity.

		
The same forest type and stand age	**The same forest type and variation in stand age**	**Different forest types and variation in stand age**

Residue – presence of residue from harvesting and thinning. This attribute refers to the volume of tree stumps, branches and other visible woody residue. The following levels were used: Absent, Medium and High.

Respondents were asked not to confound this attribute with *Dead wood*. We highlighted that *Dead wood* refers to medium and large natural pieces of dead trees, whereas *Residue* refers to residue from harvesting and thinning.

The photographs and icons used to depict the levels of this attribute are presented in Table 10.

3.2.3. Round 3 Attributes

Tree spacing – this attribute refers to the variation in tree spacing within a stand. The following levels were used: Regular (i.e., trees planted in rows), Quasi-regular and Irregular (i.e., different sized groups of trees and openings). To maintain reliability, we assumed that the *Regular* level could only be combined with the *Even-aged* level i.e., the *Two-aged* or *Uneven-aged* levels could be combined with the *Quasi-regular* or *Irregula*r levels, whereas the *Even-aged* level could be combined with all three levels of *Tree spacing*. The photographs and icons associated with the levels of this attribute are presented in Table 11.

Forest edges – the 'Naturalness' of forest edges and presence of ecotone. The following levels were used:

Straight edges & no ecotone – straight forest edges and a narrow transition area between the forest and surrounding area.

Convoluted edges & no ecotone – the forest edge is curved, and there is narrow transition area between the forest and surrounding area.

Convoluted edges & ecotone – forest edge is curved, and there is broad transition area between the forest and surrounding area.

The photographs and the icons associated with the levels of this attribute are presented in Table 12.

4. Survey Work

The development of the questionnaire was an iterative process involving both experts and laypersons. A first draft of the questionnaire was discussed with foresters, biologists and environmental economists with experience conducting stated preference surveys. This was followed by two consecutive focus groups conducted with laypersons. Furthermore, a pilot study with 100 respondents was performed before the questionnaire was ultimately considered an adequate tool for collecting the data that were subsequently used in the statistical analysis. The main survey was conducted in January 2013 using a representative sample of 1000 Poles. Only respondents who reported having made at least one recreational forest visit during the 6-month period prior to the interview participated in the survey. We selected the sample to be representative for forest recreational visitors with respect to gender, age, education, municipality size and region.[8] Table 13 presents summary statistics of the selected sample and of the general population of Poland. Respondents were selected from an internet panel maintained by SMG KRC Millward Brown.[9] The survey was conducted in the form of computer-aided web interviews (CAWI).

The questionnaire consisted of five parts. The first included questions concerning the respondent's pattern of recreational forest use, i.e., questions regarding: the number of visits to forests, the number of different forests visited, the main purpose of visits, and the types of activities undertaken in forests. During the second part, a detailed description, including visualizations and photographs of valued attributes and corresponding levels, was presented to the respondents. The third part of the survey contained the CEs, which were divided into three rounds to collect the data analyzed in this paper. The examples of cards presented during each of the three rounds are presented in Figs. 1–3. Finally, the fourth part contained debriefing questions and collected standard socio-economic data.

5. Modeling Methodology

In recent years, Mixed Multinomial Logit (MMNL) has been established as the preferred tool for representing taste heterogeneity in a variety of discrete choice modeling contexts. The MMNL model accommodates taste heterogeneity in a continuous specification, by integrating MNL choice probabilities over the assumed multivariate random distribution of the vector of taste coefficients β.

Following Train (2003), a mixed logit model is any model in which the choice probabilities take the form

$$P_{ni} = \int \frac{e^{\beta_n' x_{ni}}}{\sum_j e^{\beta_n' x_{nj}}} \phi(\beta|b,\Omega) d\beta, \tag{3}$$

where: $\frac{e^{\beta_n' x_{ni}}}{\sum_j e^{\beta_n' x_{nj}}}$ is a standard logit formula and $\phi(\beta|b,\Omega)$ is the density of the random coefficients with mean b and covariance Ω.

This simple cross-sectional specification of the MMNL model is directly applicable to cross-sectional data, when respondents face only one choice situation. However, in the presence of multiple observations for each respondent, the use of this specification equates to an assumption that sensitivities vary across choices for a given respondent in the same way that they vary across individual respondents.

The approach advanced by Revelt and Train (1998) has become the standard specification for MMNL models applied to repeated choice data. In this approach, parameters vary across respondents but remain constant across choices for the same respondent. Conditional on β, the

[8] The socio-demographic characteristics of recreational forest visitors people who visit forests were known from the revealed preference study conducted on a representative sample of 4000 Poles. The details of this study can be found in Żylicz and Giergiczny (2012).

[9] The company maintains a panel of 100 000 respondents. In order to minimize the sampling bias the panel is not recruited online (self-recruited) but using telephone invitations. A detailed profile of each panelist is available which allows to draw representative samples with respect to many socio-demographic characteristics. In order to ensure high participation rates the panelists receive incentives for every survey they participate in.

Table 10
Residue.

		
Absent	**Medium**	**High**
		

probability that the decision maker n makes a sequence of T choices is the product of logit formulas:

$$P_{ni} = \prod_{t=1}^{T} \left[\frac{e^{\beta_n' x_{nit}}}{\sum_j e^{\beta_n' x_{njt}}} \right], \quad (4)$$

where t denotes the sequence of choices made by a given respondent. As β_n is not known, the unconditional probability is given by the integral over all possible values of β_n, i.e.,

$$P_{ni} = \int \prod_{t=1}^{T} \left[\frac{e^{\beta_n' x_{nit}}}{\sum_j e^{\beta_n' x_{njt}}} \right] \phi(\beta|b,\Omega) d\beta, \quad (5)$$

with $\phi(\beta|b,\Omega)$ being the density of a random parameter with mean b and covariance matrix Ω.

6. Design and Model Specification

The choice sets employed in our study were prepared using a Bayesian d-efficient design optimized for MNL (Ferrini and Scarpa, 2007; Bliemer et al., 2008). The prior values were taken from the pilot study conducted on a sample of 100 respondents. Given the large number of attributes considered and the associated levels, in each of the three rounds, we prepared a design composed of 30 choice situations. The 30 round-specific choice situations were grouped into three blocks composed of 10 choice tasks each. The same approach was used in Dumont et al. (2015) and Giergiczny et al. (2013). This yielded 3 sets of 30 choice tasks that were equally distributed among respondents. The order of the rounds and the order of the choice tasks within each of the rounds were randomized.

Two models were applied to the data, i.e., a multinomial logit (MNL) with no random taste heterogeneity (Model 1) and a multinomial mixed logit (MMNL) allowing for random taste heterogeneity without correlation between random parameters (Model 2).[10] The utility of the staying home option (SQ) is given by a constant. The utility function for the three forests includes dummy-coded parameters associated with each forest and continuous coefficients for Distance. Using the MNL specification (without interactions), we have:

$$\begin{aligned} U_j = {} & \beta_1 \text{SQ} + \theta \text{Distance} + \beta_2 \text{Mixed2} + \beta_3 \text{Mixed5} + \beta_4 \text{Broadleaved1} + \beta_5 \text{Broadleaved4} \\ & + \beta_6 \text{Age70} + \beta_7 \text{Age100} + \beta_8 \text{Two\_aged} + \beta_9 \text{Uneven\_aged} + \beta_{10} \text{Ground\_med} \\ & + \beta_{11} \text{Ground\_high} + \beta_{12} \text{Quasi\_regular} + \beta_{13} \text{Irregular} + \beta_{14} \text{Edge\_irregular} \\ & + \beta_{15} \text{Edge\_irreg\_ecotone} + \beta_{16} \text{Deadwood\_med} + \beta_{17} \text{Deadwood\_high} \\ & + \beta_{18} \text{Diversity2} + \beta_{19} \text{Diversity3} + \beta_{20} \text{Residue\_med} + \beta_{21} \text{Residue\_high} \\ & + \beta_{22} \text{Understory\_med} + \beta_{23} \text{Understory\_high} + \beta_{24} \text{Shelterwood} \\ & + \beta_{25} \text{Seed\_trees} + \beta_{26} \text{Clearcutting} + \beta_{27} \text{Picnic} + \beta_{28} \text{Picnic\_edu\_walk} + \varepsilon_j \end{aligned}$$

where j = 1,..,4 and ε_j denotes type I extreme value random term, distributed identically and independently across respondents and choices.[11]

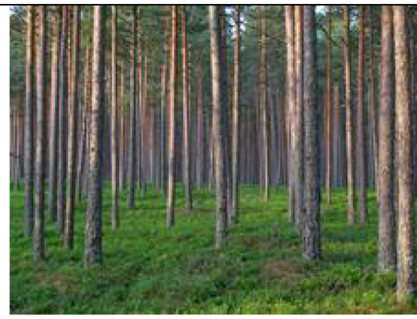
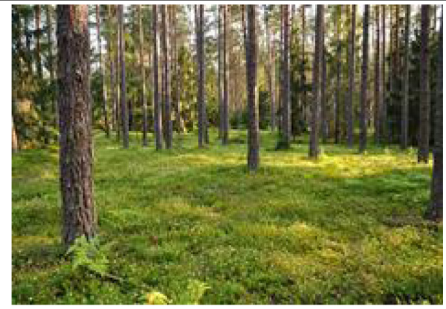
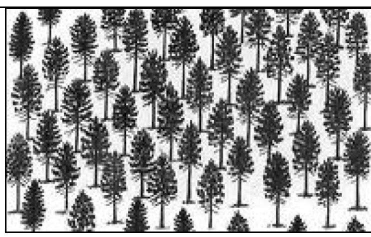
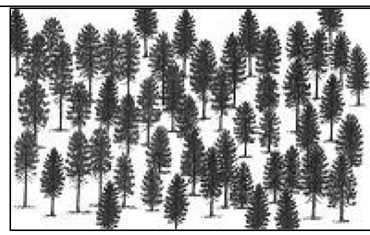
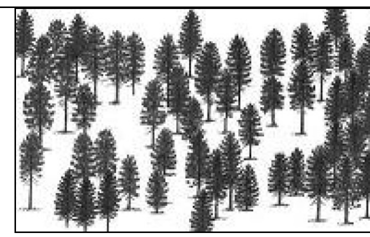
The levels of *Forest type* and *Number of tree species* were combined at the estimation stage. These two attributes were recoded into the five dummy coded variables: *Coniferous forest composed of one species* (the base level), *Broad-leaved forest composed of one species*, *Broad-leaved forest composed of four species*, *Mixed forest composed of two species* and *Mixed forest composed of five species*.

In the MMNL model, all non-cost coefficients were assumed to follow an independent normal distribution, whereas *Distance*, which served as a payment vehicle, was assumed to follow a log-normal distribution.

[10] Allowing for an unrestricted correlation structure among all parameters would require estimating a model with 435 parameters. This could be problematic, as we rely on the panel specification of the MMNL (Revelt and Train, 1998) and there are 1000 respondents in our sample.

[11] Instead of estimating a joint model for the three rounds an alternative approach could be to estimate three separate, round-specific models. If all attributes were round-specific then estimating separate round-specific models and a joint model would be equivalent. However, in the case of our study there are five overlapping attributes and by estimating a joint model we obtain more efficient estimates for these attributes. A similar multi-round approach to CE has been applied in Dumont et al. (2015) and Giergiczny et al. (2013).

Table 11
Tree spacing.

		
Regular	**Quasi-regular**	**Irregular**
		

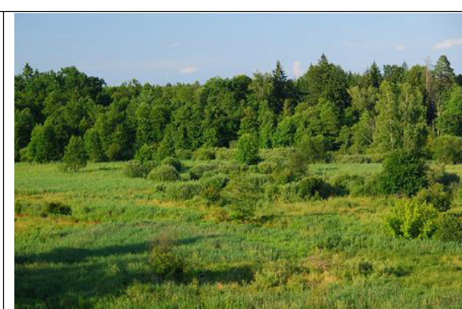
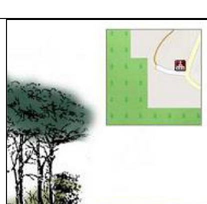
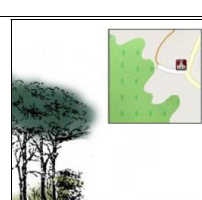
7. Results

7.1. Preference Estimates

The modeling results are presented in Table 14. All models were coded and estimated in NLOGIT 5.0.

Compared to the MNL model, the MMNL model uses 28 additional parameters, namely the mean and standard deviation of the normally distributed logarithm of the inverse of the distance coefficient, which follows a lognormal distribution, and the 27 means and standard deviations of the normally distributed structural forest attributes. We obtain a log-likelihood improvement of 3882.4 units, which is highly

Table 12
Forest edges.

		
Straight edges & **no ecotone**	**Convoluted edges &** **no ecotone**	**Convoluted edges &** **ecotone**
		

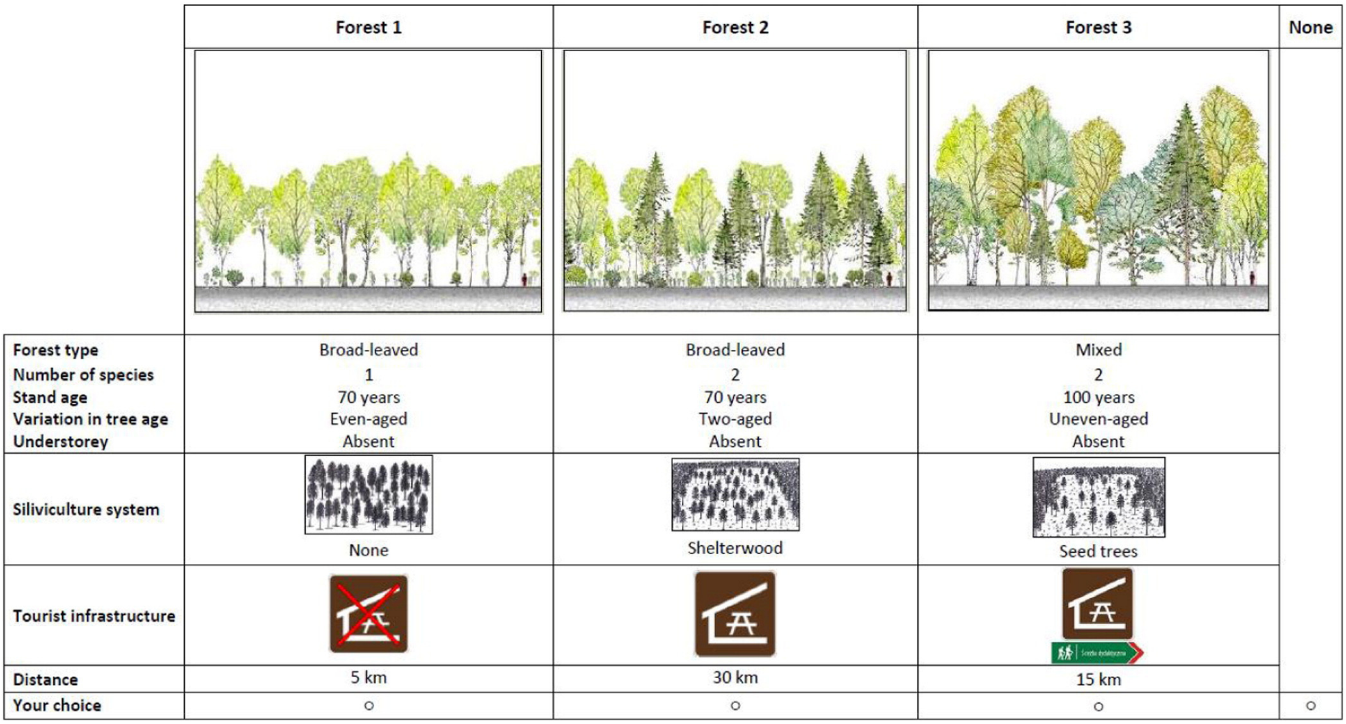


Fig. 1. Example of a card presented in round 1.

significant, indicating that there is substantial preference heterogeneity in the studied sample.

We now proceed with a detailed analysis of the results. In both models, the signs of the coefficients for all significant estimates are identical. The significance levels of the fixed MNL estimates and the means of the MMNL are of similar magnitude. The estimate for the *SQ* constant is negative in both models, indicating that, on average, the respondents associate positive utility with forest visits. The estimate for *Distance* is consistent with a priori expectations and is negative in the MNL model. In the MMNL model, *Distance* was assumed to follow a lognormal distribution, and the mean is significantly different from zero. The standard deviation of lognormal *Distance* is highly significant

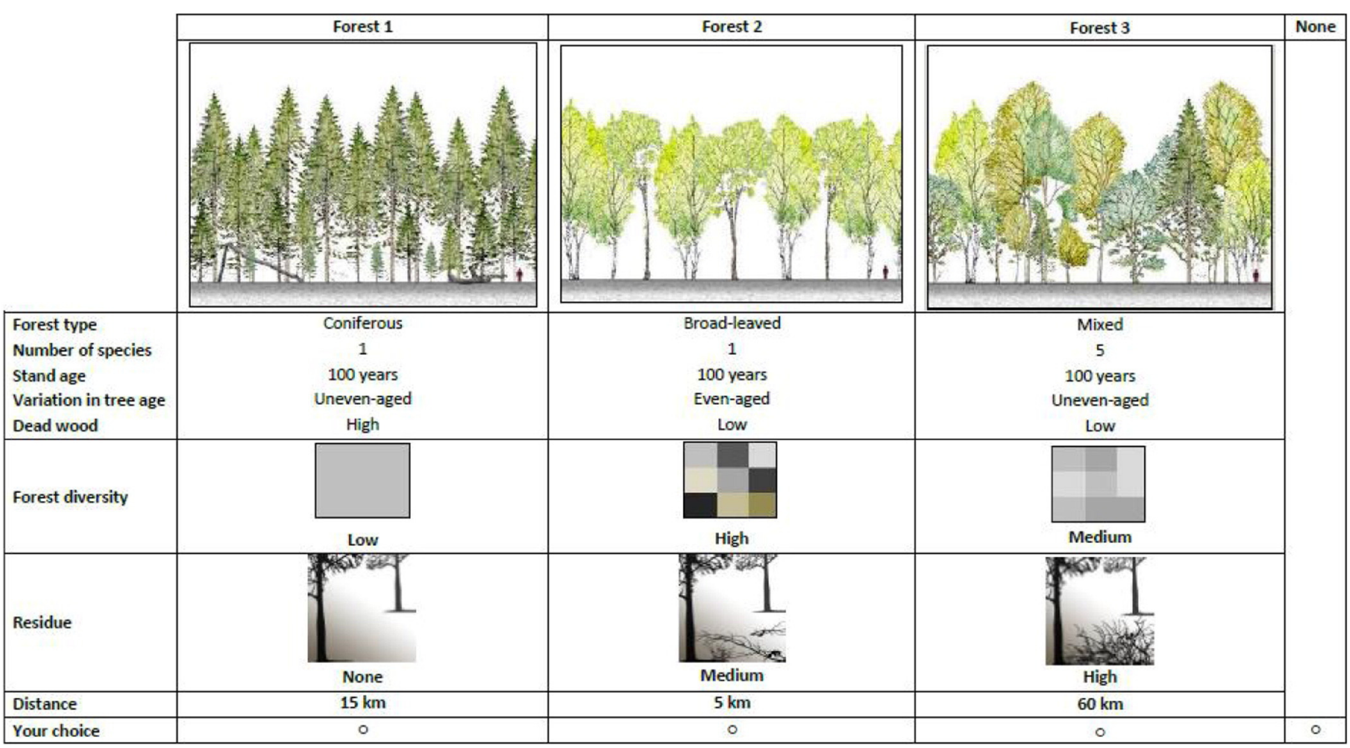


Fig. 2. Example of a card presented in round 2.

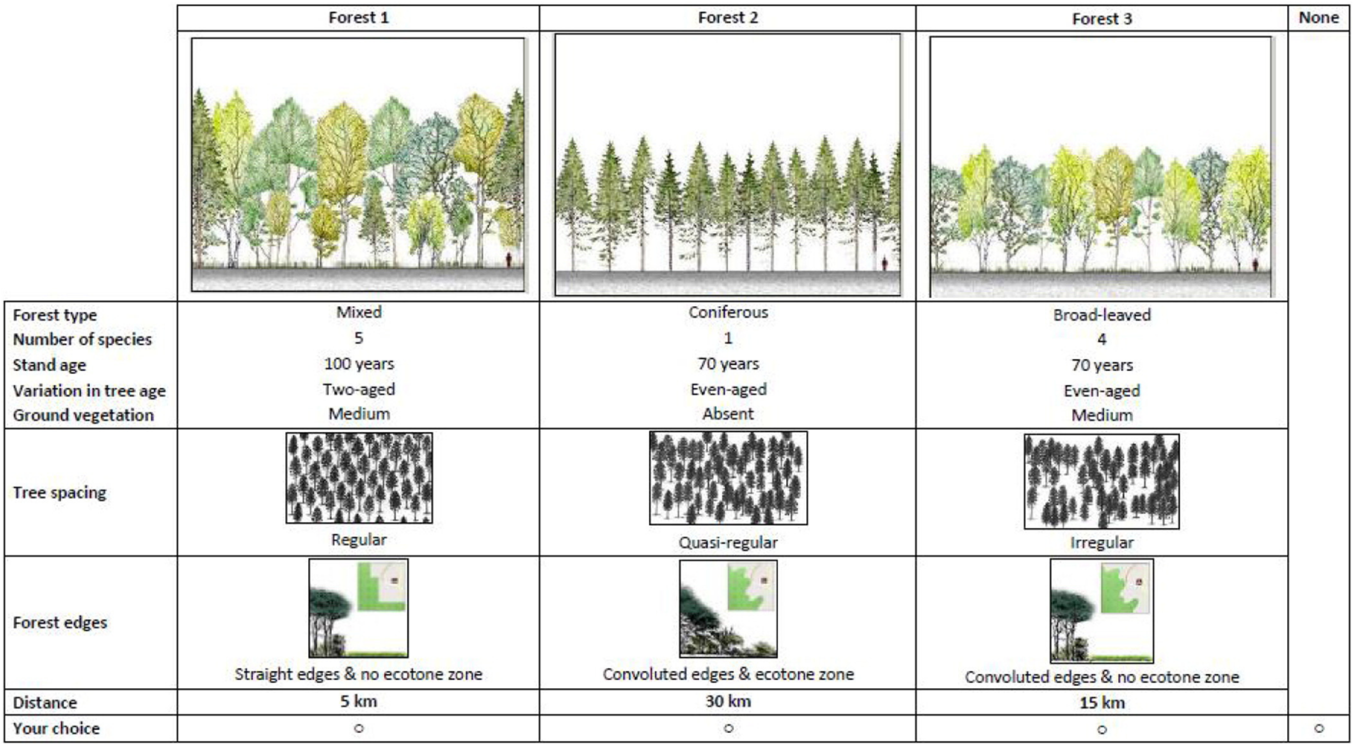


Fig. 3. Example of a card presented in round 3.

(i.e., t-statistic = 71.78), indicating that there is significant random heterogeneity in the distance sensitivity in the studied sample. We found heterogeneity in Distance to be highly significant and thus moved away from the relatively common approach in environmental valuation to keep the cost coefficient fixed. We also avoided relying on the Normal distribution for the cost coefficient as this would have led to undefined moments for the resulting WTP distributions (cf. Daly et al. (2012)), using a negative Lognormal distribution instead.

The positive and statistically significant estimates for *Mixed2*, *Mixed5* and *Broadleaved4* in MNL and the means of MMNL indicate that these types of forests are preferred to *Coniferous1*, which is the base level, whereas the estimate for *Broadleaved1* is negative, which indicates that, on average, this forest type is less preferred than *Coniferous1*. The relatively large standard deviation for *Broadleaved1* in MMNL (coefficient of variation = −1.15) indicates that a substantial share of respondents (19%) prefer *Broadleaved1* to *Coniferous1*.

The estimates for the dummies coding Age (i.e., *Age70* and *Age100*) are both positive, indicating that respondents prefer older to younger stands. The relatively small coefficients of variation (CV), 0.13 and 0.64 for younger and older stands, respectively, indicate that the share of respondents who prefer younger stands to older ones is very small, 1% and 6%, respectively.

Table 13
Summary statistics of the selected sample and of the general population of Poland.

		General population	Forest visitors
Gender	Male	50	52.1
	Female	50	47.9
Age	18–29	24	26.8
	30–49	40	41.9
	50+	36	31.3
Size of municipality	Up to 20 000	52	58.2
	20 000–200 000	28	27.1
	200 000 and more	21	14.7
Education	Primary and vocational	45	41.9
	Secondary	34	35.3
	Higher	19	22.8

The positive and statistically significant estimates for *Two-aged* and *Uneven-aged* in both models indicate that these forest types, ceteris paribus, are preferred to *Even-aged*, which was the base level. In both models, the estimate for *Uneven-aged* is approximately three times as large as the estimate for *Two-aged*, indicating strong preferences for stands with trees of three or more distinct age classes. The relatively large CV for *Two-aged* (i.e., 0,79) indicates that approximately 10% of respondents prefer *Even-aged* forests to *Two-aged* ones, whereas the share of those who prefer *Even-aged* to *Uneven-aged* is close to zero (i.e., 1%).

There is an inverted U-shaped relationship between *Ground vegetation height* and recreational value. The most preferred level is *Medium*, whereas the least preferred level is *High*, with *No ground vegetation* being the base level. The CV coefficients for both levels are relatively high, indicating that there is a substantial share of respondents with opposite signs; 27% of respondents consider *Medium* to be less preferred than *Absent*, and 28% consider the *High* level to be more attractive than *Absent*.

The relationship between different levels of *Trees spacing* and utility is nearly linear, with trees planted in rows (i.e., *Regular*) being the least preferred level and the *Irregular* level (i.e., *Different sized groups of trees and openings*) being the most preferred level. In the MNL model, the estimate for *Quasi-regular* is positive; however it is not significantly different from *Regular*, whereas for the MMNL model, the means associated with *Quasi-regular* and *Irregular* are both significant at the 0.01 level. The CV measure for the *Quasi-regular* level equals 1.12, indicating that 19% of respondents prefer *Regular* to *Quasi-regular*.

For *Forest edge*, the most preferred level is *Convoluted edges and no ecotone*; the estimate associated with this level is positive and statistically significant at the 0.01 level, with the base level being *Straight edges and no ecotone*. The coefficient for *Convoluted edges and ecotone* is not significantly different from the base level in either model. The standard deviation of the *Convoluted edges & no ecotone* level is significant at the 0.01 level, indicating substantial preference heterogeneity in

Table 14
Model estimates.

z	MNL			MMNL – Mean			MMNL – Standard deviations				
	Coefficient	Std. error	p-value	Coefficient	Std. error	p-value	Coefficient	Std. error	p-value	CV	Share
Distance	−.02690***	0.0004	0.0000	−3.3806***	0.0232	0.000	1.3110***	0.0183	0.000	−0.39	–
Mixed2	.35723***	0.0295	0.0000	.38027***	0.0295	0.000	.16890***	0.0329	0.000	0.44	0.01
Mixed5	.49102***	0.0341	0.0000	.55155***	0.0314	0.000	.24447***	0.0387	0.000	0.44	0.01
Broadleaved1	−.29489***	0.0336	0.0000	−.38139***	0.0339	0.000	.43974***	0.0346	0.000	−1.15	0.19
Broadleaved4	.11898***	0.0322	0.0002	.17602***	0.0263	0.000	.10591***	0.0391	0.007	0.60	0.05
Age_70	.30482***	0.0236	0.0000	.41576***	0.0245	0.000	.05663*	0.0303	0.061	0.13	0.00
Age_100	.60139***	0.0266	0.0000	.71150***	0.0288	0.000	.45587***	0.0286	0.000	0.64	0.06
Two-aged	.09761***	0.0252	0.0001	.11003***	0.0280	0.000	.08640**	0.0342	0.011	0.79	0.10
Uneven-aged	.28010***	0.0247	0.0000	.34976***	0.0287	0.000	.14004***	0.0336	0.000	0.40	0.01
Ground_med	.12959***	0.0413	0.0017	.08662*	0.0449	0.054	.14221***	0.0527	0.007	1.64	0.27
Ground_high	−.26282***	0.0385	0.0000	−.38656***	0.0412	0.000	.65762***	0.0417	0.000	−1.70	0.28
Quasi-regular	.09240*	0.0494	0.0615	.16338***	0.0563	0.004	.18352***	0.0594	0.002	1.12	0.19
Irregular	.20243***	0.0420	0.0000	.25821***	0.0476	0.000	.04059	0.0588	0.490	0.16	0.00
Edge_irreg	.18535***	0.0386	0.0000	.29839***	0.0409	0.000	.20168***	0.0494	0.000	0.68	0.07
Edge_irreg_ecotone	.01542	0.0376	0.6818	.05415	0.0433	0.211	.00540	0.0540	0.920	0.10	0.00
Dead wood_med	.10946***	0.0388	0.0048	.17006***	0.0385	0.000	.03702*	0.0223	0.097	0.22	0.00
Dead wood_high	−.21186***	0.0408	0.0000	−.15178***	0.0385	0.000	.32292***	0.0861	0.000	−2.13	0.32
Diversity2	.18015***	0.0395	0.0000	.21958***	0.0432	0.000	.01913	0.0547	0.726	0.09	0.00
Diversity3	.49384***	0.0370	0.0000	.53895***	0.0395	0.000	.01158	0.0579	0.841	0.02	0.00
Residue_med	−.01684	0.0366	0.6455	−.05663	0.0385	0.142	.04323	0.0503	0.390	−0.76	0.10
Residue_high	−.74985***	0.0415	0.0000	−.88385***	0.0449	0.000	.72332***	0.0522	0.000	−0.82	0.11
Understory_med	.10449***	0.0358	0.0035	.16677***	0.0434	0.000	.47422***	0.0498	0.000	2.84	0.36
Understory_high	−.23031***	0.0388	0.0000	−.30173***	0.0443	0.000	.66979***	0.0466	0.000	−2.22	0.33
Shelterwood	−.36288***	0.0432	0.0000	−.45540***	0.0498	0.000	.00630	0.0788	0.936	−0.01	0.00
Seedtrees	−.78557***	0.0390	0.0000	−1.01814***	0.0438	0.000	.26819***	0.0552	0.000	−0.26	0.00
Clearcutting	−1.35599***	0.0511	0.0000	−1.82292***	0.0647	0.000	1.10258***	0.0717	0.000	−0.60	0.05
Picnic	.70408***	0.0411	0.0000	.90370***	0.0457	0.000	.10649**	0.0530	0.044	0.12	0.00
Picnic_edu-walk	.93273***	0.0425	0.0000	1.22440***	0.0453	0.000	.41047***	0.0481	0.000	0.34	0.00
SQ	−1.16314***	0.0423	0.0000	−1.60855***	0.0430	0.000	–	–		–	–
Log-likelihood	−29119.13			−25653.45							
Pseudo R2 adj.	0.1278			0.2586							
Parameters	29			57							
Observations	30000										

*The share of respondents for whom the sign of the coefficient was the opposite of the mean estimate.

the sample. The associated CV equals 0.68, which implies that approximately 7% of respondents have a negative estimate associated with this level, i.e., they prefer *Straight edges and no ecotone* to the *Convoluted edges & no ecotone* level. The standard deviation of *Convoluted edges and ecotone* is not significantly different from zero, indicating that there is no significant heterogeneity in preferences for this coefficient.

The *Dead wood* levels and utility have an inverted U-shaped relationship in both models. The most preferred level is *Medium*, whereas the least preferred level is *High*, with the *No dead wood* level being the base. The standard deviation of the *Medium* level is not significantly different from zero, indicating that there is no significant random heterogeneity for this level, whereas the standard deviation of the *High* level is significant at the 0.01 level and is large relative to the mean estimate, i.e., the corresponding CV equals −2.13, indicating that for 32% of respondents, the *High* level of dead wood is preferred to the *Low* level.

The positive and statistically significant estimates for *Same forest type & variation in stand age* and *Different forest types and variation in stand age* in both models indicate that these levels are preferred to the base level (i.e., *Same forest type and stand age*). The highest estimate for *Different forest types and variation in stand age* indicates that the greater the diversity in stand types and age, the more preferred the forest will be going. For both levels, the associated standard deviations are not significantly different from zero, indicating that there is no significant random heterogeneity in tastes for these attributes.

The estimates for the *Medium* and *High* levels of *Residue from harvesting and thinning* are negative, with the *High* level being significantly different from the base level (*Absent*) at the 0.01 significance level. The CVs for these levels are relatively small, indicating that only approximately 10% of respondents prefer *Medium* or *High* to the *Absent* level.

Both levels of *Understory density* (i.e., *Medium* and *High*) and utility exhibit an inverted U-shaped relationship that is significantly different from the reference level (i.e., *Understory absent*). The CVs for these two levels are relatively high (in absolute terms), indicating that there is a substantial share of respondents, 36% and 33% who prefer *Medium* or *High* Understory density levels, respectively, to the *Absent* level.

In both models, the estimates of the three silviculture levels are negative, indicating that higher management intensity is associated with higher disutility. Interestingly, the highest (in absolute terms) CV is associated with *Clearcutting*, indicating that approximately 5% of respondents prefer visiting forests with clearcut areas to forests where there are no visible traces of felled trees. For the remaining two levels, i.e., *Seedtrees* and *Shelterwood*, the CVs are very small, indicating that

Table 15
Number of respondents who systematically omitted a given attribute in all choice situations.

Omitted attribute	Number of respondents*
Ground vegetation	98
Forest type & number of species	113
Distance	120
Forest diversity	128
Understorey density	140
Tree spacing	143
Management intensity	145
Stand age	210
Age variation	215
Tourist infrastructure	218
Dead wood	249
Forest edge	360

* 1000 people in the sample.

less than 1% of respondents prefer these levels to *No visible traces of tree felling*.

As expected, both types of tourist infrastructure were positive and statistically significantly different from the base level at the 0.01 significance level.

As discussed in Section 1, to our best knowledge, this study is the first application, which explores in such detail the preference for forest characteristics relying on the general public not on experts as in previous studies. Given that, and also taking into account the complexity of the study, it's important to verify whether respondents understood the presented attributes. To do so, after completing all choice tasks, respondents were asked to list attributes they did not attend when making choices. These results are summarized in Table 15. It turns out that even the least attended attribute (i.e. *Forest edge*) was relevant for 64% of respondents. The remaining attributes were attended by at least 75% of respondents, This in our opinion highlights that the used attributes were communicated in an adequate way and the obtained CE results can be considered as reliable.[12]

However, if this was the case then one should expect trends to be present in preference estimates across choice tasks. We tested this possibility in the following way, as the three rounds and choice tasks within each round were randomized for each choice tasks we estimated independent MNL model. As can be seen from Graphs 1 to 9 there are no clear trends in preference estimates for the overlapping attributes.

7.2. Marginal Rate of Substitution

In addition to the preference estimates, in Table 16, we report marginal rate of substitution (MRS), expressed as the additional kilometers (one-way distance) that respondents would be willing to travel, on average, to visit a forest with a given attribute level. As the levels of all attributes, apart from *Distance*, are dummy coded, the trade-offs are calculated with respect to the reference level of each of the attributes. For example the calculated trade-off for Age_100 is 22.36 km (MNL model); this implies that, on average, a respondent would be willing to travel an additional 22.36 km to visit a 100-year-old stand compared to visiting a 40-year-old stand.

In the MMNL model all 'non-price' coefficients are normally distributed and the Distance coefficient follows negative log-normal distribution. These assumptions imply that WTP for all characteristics are distributed as the ratio of a normal to a log-normal. The most common practice is to estimate the moments of WTP through simulation (see Hensher and Greene (2003) for details). In the case of our study 100 000 draws were taken from the distribution of a given forest characteristic coefficient (β) and the Distance coefficient (θ), and the ratio of β to θ was calculated for each draw. The ratios are draws from the distribution of WTP, and the mean and variance of the draws of the ratios are used as estimates of the mean, median and variance of WTP in the population.

In the case of the MMNL model, we observe an increase in the mean WTP values and substantial levels of heterogeneity across respondents; however, the ordering of the MRS values remains similar for the two models. We also note that the median values from the MMNL are very similar to the MNL values. The increase in the mean WTP in the MMNL model was expected given the use of a negative log-normal distribution for the *Distance* coefficient (Giergiczny et al., 2012).

Table 16
Marginal rate of substitution estimates.

	MNL			MMNL		
	Mean	Std. error	p-value	Mean	Median	Std. dev.
Mixed2	13.28***	1.1012	0.0000	25.76	10.02	52.31
Mixed5	18.25***	1.2224	0.0000	37.26	14.69	80.28
Broadleaved1	−10.96***	1.2715	0.0000	−24.99	−7.45	84.65
Broadleaved4	4.42***	1.1818	0.0002	11.84	4.29	27.60
Age_70	11.33***	0.8797	0.0000	28.75	12.09	59.65
Age_100	22.36***	0.9863	0.0000	49.56	17.33	124.78
Two-aged	3.63***	0.9404	0.0001	7.48	2.47	18.69
Uneven-aged	10.41***	0.9060	0.0000	24.13	9.44	49.64
Ground_med	4.82***	1.5350	0.0017	6.02	1.59	25.73
Ground_high	−9.77***	1.4305	0.0000	−27.64	−6.78	103.92
Quasi-regular	3.44*	1.8396	0.0615	11.08	3.28	32.95
Irregular	7.53***	1.5655	0.0000	17.75	7.49	34.95
Edge_irreg	6.89***	1.4505	0.0000	21.02	7.07	54.24
Edge_irreg_ecotone	.57	1.3902	0.6818	3.71	1.58	7.23
Dead wood_med	4.07***	1.4433	0.0048	11.75	4.87	24.09
Dead wood_high	−7.88***	1.5271	0.0000	−11.08	−2.48	52.17
Diversity2	6.69***	1.4703	0.0000	15.06	6.35	29.46
Diversity3	18.36***	1.3846	0.0000	36.96	15.72	71.76
Residue_med	−.62	1.3478	0.6455	−3.94	−1.29	10.22
Residue_high	−27.88***	1.5832	0.0000	−58.11	−19.42	144.41
Understory_med	3.88***	1.3288	0.0035	11.36	2.63	75.37
Understory_high	−8.56***	1.4314	0.0000	−20.79	−5.08	102.90
Shelterwood	−13.49***	1.6253	0.0000	−31.25	−13.32	60.65
Seedtrees	−29.05***	1.5209	0.0000	−69.85	−28.36	143.01
Clearcutting	−50.42***	2.0775	0.0000	−123.71	−44.72	171.85
Picnic	26.18***	1.5771	0.0000	61.95	26.33	119.20
Picnic_edu-walk	34.68***	1.6335	0.0000	82.95	33.67	160.29

7.3. Systematic Taste Variation

As Table 17 indicates, shifting from the MNL model to the MMNL results in a substantial increase in McFadden's R^2, specifically, 0.128 for MNL and 0.259 for MMNL. This indicates that there is substantial preference heterogeneity in the sample. However, this provides no information on the factors that drive preference heterogeneity. In many applications, a substantial share of preference heterogeneity can be explained by adding interactions with socio-demographic characteristics to the utility function (i.e., by allowing systematic taste variation).

To understand the variation in preferences across respondents, we included into the utility function interactions of all parameters with the following socio-demographic characteristics: *Gender*, *Age*, *Education* – measured by years spent in school, *Intensity of recreational forest use* – measured by the number of forest visits in the 6 months prior to the interview, *Respondent's place of residence* – coded as a dummy, with living in the countryside being the base level, and finally, *Main reason for visiting the forest*, with the following three levels: *Nature observation*, *Picking mushrooms or berries* and *Walking* (the base level).[13] The results of the MNL model with all interactions are reported in Table 15.

The MNL model with systematic taste variation considers 232 parameters not included in the MNL model without interactions. We obtain a 391.03-unit improvement in log-likelihood (LL), which is significant at the 0.01 level. However, this change in LL is small relative to the change in LL when moving from the basic MNL model (without interactions) to the MMNL model, i.e., a 3882.4-unit improvement in LL at the cost of 28 additional parameters. This highlights that the majority of the taste variation across respondents is random in nature, and only a small portion of it can be explained by allowing systematic taste variation.

The included socio-demographic characteristics vary in their contribution to the LL. In Table 18, we list the socio-demographic

[12] In addition to the problems with non-attendance one could expect that if respondents had problems with understanding the attributes and levels we would see a high share of choice situations in which the status quo alternative was chosen. However, we do not observe this effect in our study; SQ was chosen in 3746 out of 30 000 choice situations (12%). Moreover none of the respondents chose SQ in all choice situations and only 13% of respondents chose SQ in more than 10 out of 30 choice situations. As pointed by an anonymous reviewer another problem with our study is its length. It is possible that respondents in the course of the CE part got tired or bored and changed their decision rules. In this case we would expect trends in preferences to be present. As the rounds and the choice tasks in our experiment were randomized to test this possibility for each choice situation we estimated independent MNL model. We did not find significant trends in preferences. The results are available from the authors upon request.

Table 17
MNL with systematic taste variation.

	Main effects			Male			Education			Age			Visits		
	Mean	Std. error	p-value	Mean	Std. error	p-value	Mean	Std. error	p-value	Mean	Std. error	p-value	Mean	Std. error	p-value
Distance	−.017***	0.002	0.00	0.002	0.004	0.58	−.001***	0.000	0.00	−.001***	0.000	0.00	.001**	0.000	0.02
Mixed2	0.152	0.145	0.29	0.034	0.061	0.58	0.013	0.010	0.21	−0.015	0.015	0.32	−0.001	0.001	0.36
Mixed5	0.118	0.166	0.48	.119*	0.069	0.08	0.012	0.011	0.28	−0.008	0.018	0.66	−0.001	0.001	0.35
Broadleaved1	0.029	0.161	0.86	0.044	0.070	0.53	−0.007	0.012	0.55	−.075***	0.017	0.00	0.001	0.002	0.56
Broadleaved4	0.076	0.158	0.63	.176**	0.066	0.01	−0.001	0.013	0.94	−.044***	0.017	0.01	−0.001	0.001	0.33
Age_70	0.16	0.117	0.17	.088*	0.048	0.07	−0.006	0.008	0.47	.027**	0.012	0.03	0.002	0.067	0.98
Age_100	0.16	0.131	0.22	.160**	0.054	0.00	0.014	0.009	0.13	.035**	0.014	0.01	0.007	−0.018	0.70
Two-aged	.224*	0.125	0.07	−0.021	0.051	0.68	0.013	0.008	0.12	−0.016	−0.013	0.23	0.002	0.004	0.65
Uneven-aged	.496***	0.122	0.00	−0.003	0.050	0.95	.019**	0.008	0.02	−.043***	−0.013	0.00	0.001	0.001	0.34
Ground_med	0.011	0.220	0.96	.146*	0.084	0.08	0.01	0.014	0.49	.036*	0.022	0.10	−0.002	0.002	0.23
Ground_high	0.175	0.192	0.36	0.059	0.080	0.46	−.033***	0.013	0.01	0.031	0.020	0.12	0.001	0.002	0.54
Quasi-regular	0.288	0.246	0.24	−0.083	0.102	0.42	.031*	0.017	0.07	−0.021	0.026	0.42	.003**	0.001	0.03
Irregular	0.085	0.207	0.68	0.003	0.100	0.98	.028**	0.014	0.05	−0.026	0.022	0.23	.002*	0.001	0.07
Edge_irr	−0.204	0.191	0.28	−0.008	0.073	0.91	0.017	0.013	0.20	−.039*	0.020	0.05	0.001	0.002	0.56
Edge_irr_ecotone	−0.275	0.185	0.14	0.006	0.075	0.94	0.016	0.012	0.17	−0.032	0.020	0.11	0.005	−0.017	0.76
Dead wood_med	−0.107	0.191	0.58	−0.002	0.067	0.98	0.015	0.014	0.27	−.037*	0.020	0.07	0.001	0.001	0.23
Dead wood_high	−0.263	0.204	0.20	.229***	0.083	0.01	−0.003	0.013	0.82	−0.031	0.022	0.15	0.003	0.023	0.90
Diversity2	−0.19	0.198	0.34	−0.09	0.082	0.27	.031**	0.013	0.02	−0.031	0.021	0.14	0.002	0.008	0.79
Diversity3	.524***	0.185	0.00	−0.06	0.076	0.43	0.004	0.012	0.74	−0.013	0.019	0.49	0.001	0.001	0.31
Residue_med	−0.023	0.192	0.90	−0.004	0.080	0.96	−0.003	0.012	0.79	0.028	0.019	0.14	−0.002	0.002	0.19
Residue_high	−.651***	0.207	0.00	.155*	0.085	0.07	−.031**	0.014	0.03	.045**	0.022	0.04	0.0203	0.290	0.94
Understorey_med	.298*	0.177	0.09	0.105	0.074	0.16	.022*	0.012	0.07	0.013	0.019	0.48	−0.001	0.003	0.71
Understorey_high	−0.179	0.190	0.35	.267***	0.079	0.00	−0.016	0.013	0.21	0.008	0.021	0.70	0.001	0.002	0.51
Shelterwood	−0.184	0.216	0.40	−0.088	0.089	0.32	−.024*	0.014	0.09	0.001	0.033	0.98	−0.001	0.001	0.31
Seedtrees	−.559***	0.194	0.00	−0.011	0.079	0.89	−0.002	0.012	0.87	−0.001	0.025	0.97	−0.001	0.001	0.28
Clearcutting	−.467*	0.250	0.06	0.016	0.107	0.88	−.041**	0.017	0.02	−0.019	0.027	0.48	−.005***	0.002	0.01
Picnic	.483**	0.201	0.02	−0.153*	0.083	0.07	0.021	0.014	0.13	−0.003	0.025	0.90	−.004***	0.001	0.00
Picnic_edu-walk	.474**	0.212	0.03	−0.141	0.088	0.11	.042***	0.014	0.00	−.03855*	0.022	0.09	−0.001	0.001	0.45
SQ	−1.19***	0.208	0.00	0.065	0.087	0.45	−0.004	0.014	0.77	0.021	0.022	0.34	−0.001	0.014	0.94

	Town			City			Mushroom/berry			Nature		
	Mean	Std. error	p-value	Mean	Std. error	p-value	Mean	Std. error	p-value	Mean	Std. error	p-value
Distance	−.003**	0.001	0.03	.005***	0.001	0.00	.004***	0.001	0.00	.001*	0.001	0.05
Mixed2	−0.008	0.089	0.93	−0.102	0.073	0.16	.152**	0.060	0.01	0.091	0.062	0.14
Mixed5	0.07	0.099	0.48	−0.019	0.086	0.83	.131*	0.070	0.06	.192***	0.072	0.01
Broadleaved1	0.022	0.096	0.82	−0.061	0.084	0.47	0.066	0.069	0.34	−0.064	0.071	0.37
Broadleaved4	0.054	0.093	0.56	0.053	0.080	0.51	0.057	0.066	0.39	0.096	0.068	0.16
Age_70	0.105	0.068	0.12	0.046	0.059	0.44	0.063	0.048	0.19	0.028	0.049	0.57
Age_100	−0.045	0.075	0.55	−0.062	0.065	0.34	0.074	0.055	0.18	.128**	0.056	0.02
Two-aged	−0.077	0.072	0.28	−.127**	0.063	0.04	0.03	0.053	0.57	.123**	0.052	0.02
Uneven-aged	−0.058	0.072	0.42	−0.091	0.061	0.14	−0.047	0.051	0.35	0.017	0.052	0.74
Ground_med	−.301**	0.119	0.01	−0.017	0.100	0.87	−.257***	0.085	0.00	0.091	0.088	0.30
Ground_high	−0.138	0.110	0.21	−0.046	0.096	0.63	−.215***	0.079	0.01	0.093	0.081	0.25
Quasi-regular	0.229	0.140	0.10	0.138	0.123	0.26	0.066	0.102	0.52	−0.033	0.103	0.75
Irregular	0.126	0.119	0.29	0.063	0.103	0.54	0.017	0.085	0.84	−0.062	0.089	0.48
Edge_irreg	0.109	0.111	0.33	0.126	0.097	0.19	.234***	0.079	0.00	0.093	0.082	0.25
Edge_irreg_ecotone	0.112	0.107	0.29	0.11	0.093	0.24	0.055	0.076	0.47	0.044	0.079	0.58
Dead wood_med	−0.123	0.112	0.27	0.111	0.097	0.25	0.057	0.079	0.47	.176**	0.082	0.03
Dead wood_high	−0.051	0.116	0.66	0.081	0.103	0.43	−0.077	0.084	0.36	0.138	0.086	0.11
Diversity2	0.075	0.114	0.51	0.101	0.101	0.32	−0.054	0.081	0.50	0.064	0.083	0.44
Diversity3	0.015	0.107	0.89	0.085	0.092	0.36	−.146*	0.076	0.05	0.003	0.075	0.97
Residue_med	0.091	0.106	0.39	0.141	0.093	0.13	−.143*	0.075	0.06	−0.026	0.079	0.74
Residue_high	0.194	0.119	0.10	.224**	0.104	0.03	−.1540*	0.085	0.07	0.039	0.089	0.66
Understorey_med	−0.160	0.103	0.12	−0.11	0.089	0.22	0.055	0.072	0.45	0.125	0.076	0.10
Understorey_high	−0.033	0.110	0.76	0.005	0.083	0.95	−.144*	0.079	0.07	0.124	0.082	0.13
Shelterwood	−0.133	0.122	0.28	−.209*	0.107	0.05	0.125	0.089	0.16	−0.136	0.091	0.14
Seedtrees	−0.100	0.111	0.37	−.167*	0.097	0.09	−0.035	0.080	0.66	−0.06	0.082	0.47
Clearcutting	−0.190	0.144	0.19	−.249**	0.126	0.05	0.008	0.114	0.94	−0.038	0.106	0.72
Picnic	0.374***	0.115	0.00	.263***	0.101	0.01	−0.109	0.084	0.20	−0.088	0.086	0.31
Picnic_edu-walk	0.382***	0.123	0.00	.311***	0.105	0.00	−.147*	0.087	0.09	−0.107	0.090	0.23
SQ	−0.026	0.118	0.83	−.176*	0.105	0.09	0.06	0.086	0.48	0.041	0.089	0.65
Log-likelihood	−28 728.1											
Pseudo R2 adj.	1325											
Parameters	261											
Observations	30 000											

characteristics and their contribution to the LL. In each case, the model with an omitted set of interactions was tested against the full model. The likelihood ratio test (LR) results indicate that for all socio-demographic variables, apart from *Town*, the associated change in the LL is significant at the 0.01 level. In the case of the interactions with *Town*, the change in the LL is significant at the 0.05 level.

Table 18
Contribution of socio-demographic characteristics to LL.

Omitted interactions	LL	LR*	K**	p-value
City	−28796.3	136.4	29	0.00
Education	−28793.3	130.4	29	0.00
Age	−28791.7	127.2	29	0.00
Mushroom	−28775.8	95.4	29	0.00
Nature	−28772.4	88.6	29	0.00
Gender	−28770.9	85.6	29	0.00
Forests visits	−28763.7	71.2	29	0.00
Town	−28752.5	48.8	29	0.012

LR — log-likelihood ratio test statistic.
K* — number of omitted variables.

The largest contribution to the LL comes from including interactions with: *City* (i.e., a dummy variable coding respondents living in cities larger than 100 000 inhabitants), *Education* and *Age*. The smallest contribution is attributable to including the interactions with *Town*, i.e., the preferences of respondents living in towns (5000–100 000 inhabitants) do not vary substantially from the preferences of respondents living in the countryside.

Regarding the model estimates, we observe that males derive higher marginal utility than females from forests with: a larger number of tree species (i.e., *Mixed5* and *Broadleved4*), older stands, high volume of dead wood and high understory density.

Better-educated respondents have higher distance sensitivity (the coefficient of Distance * Edu is negative and statistically significant). This is reasonable as we expect better educated respondents to have higher income levels[13] (higher value of time). We also see that better-educated respondents exhibit greater disutility from *High level of ground vegetation*, *High level of residue* and *Clearcutting*. However, better-educated respondents derive greater marginal utility from *Uneven-aged* forests, *Irregular tree spacing*, *The same forest type and variation in stand age* and *Picnic sites & interpretative paths*.

Older respondents derive lower marginal utility from both broadleaved forests (i.e., 1 and 4 tree species) and *Uneven-aged* forests. However, they experience less marginal disutility from a *High level of Residue*.

We note that, on average, the more visits the respondent makes, the greater her marginal utility from irregular tree spacing and the greater her disutility from encountering clear-cutting sites in the forest. Moreover, respondents who visit forests more frequently tend to derive less utility from visiting forests where picnic sites are present.

Respondents living in towns and cities have higher marginal utility values for both levels of tourist infrastructure than respondents living in the countryside. We also note that respondents living in cities experience greater disutility from a high level of residue and siliviculture attributes (i.e., clear-cutting and shelterwood) than those living in the countryside.

Finally, we observe that respondents whose main reason for visiting a forest was picking mushrooms and berries derive greater utility from visiting mixed forests and forests with irregular edges than those whose main reason for visiting a forest was walking. Whereas those whose main reason for visiting forests was observing nature, derive, on average, greater marginal utility from visiting forests with a larger number of tree species, older stands and forests with high levels of dead wood than those whose the main reason for visiting forests was walking.

8. Policy Implications

In the 1980s, the area of clear-felled forests in Poland reached nearly 43 thousand hectares annually. In contrast, the average for the last decade was just over 26.9 thousand hectares. This reduction of the clear-felling area is frequently presented as an example of the progress in the 'ecologization' of forest management. Similarly, a tree species composition that matches the site type is encouraged. However, Polish forests perform poorly on other aspects of forest structure. Polish forests have one of the lowest dead wood volumes among all European countries (5.6 m^3/ha). Lower volumes have been only reported in Denmark, the UK and Belarus. Poland also has one of the lowest shares of naturally regenerated forests, i.e., the mean for the EU27 is 64% (Forest Europe, 2011), whereas in Poland it is 11.2% (Polish State Forests, 2013).

Polish forestry developed under strong German influence focusing on sustained yield wood production (Lawrence, 2009). During the communist period, a raw-material model of forest management predominated. However, this has changed over the past 20 years through the reorientation of forest management away from the previously dominant raw-material model towards a more pro-ecological and economically balanced model of multifunctional forest management. For example the forest act (from 1991) was the first legal regulation that articulated the importance of the ecological, economic (timber production) and social functions of forests and explicitly stated that these three functions should be considered equally. The National Policy on Forests, adopted by the Council of Ministers in 1997, currently directs forest policy. According to this document, a primary goal is safeguarding the permanent multifunctional character of forests. However, a precise definition of this concept is not provided; hence policy makers understand it differently.

According to Rykowski (2008), Polish forestry currently pursues the concept of a multifunctional forest according to which forests at the district level (or even at a lower level) should simultaneously satisfy all primary functions (i.e., provide timber, protect biodiversity, and provide social functions such as recreation). However, such an approach is unlikely to be optimal and clearly leads to conflict. The most obvious conflict is that between commercial use and providing environmental or social functions, but conflicts may also arise between the use of forests for tourism and environmental functions. The most prominent example of a conflict between different functions is the Bialowieza Forest – one of the last large remnants of near-natural lowland temperate forest in Europe, where despite its high ecological and social value, a large share of the forest is subject to a timber-oriented form of management (e.g., Giergiczny, 2009; Czajkowski et al., 2014; Czajkowski et al., 2009). Further potential examples are forests bordering large agglomerations (e.g., Trojmiejski Landscape Park), the citizens of which protest the current management system, which they believe is excessively timber oriented.

An alternative approach to the concept of a multifunctional forest is multifunctional forestry proposed by Rykowski (2008), i.e., a more specialized forest management model. In his work, Rykowski states:

> "*By multifunctional forest we mean a forest that would fulfil all of these requirements* (i.e., provide timber, protect biodiversity, provide social functions) *at the same time and place. Is it possible? Shouldn't we rather separate more clearly forest functions in time and space (because preferred or dominant functions undergo changes) and carry out in practice multifunctional forestry? We mean here a more specialized forest management, dealing both with nature protection – including strict reserves, and wood production – including intensive production. Wouldn't it then be easier to balance the frequently conflicting social expectations?*"

In our work, we focused on the relationship between forest characteristics that represented a management intensity gradient from more to less natural on the one hand and recreational value on the other. Our results indicate that there is a clear conflict between intensive timber production and recreational use, i.e., the forest attribute levels associated with timber-oriented management result in decreased recreational value. Thus, the greater the management intensity, the lower the recreational value. Respondents also dislike the high level of residue that results from thinning and felling. They prefer to visit older stands, ones that are more diverse in terms of tree spacing and variation in tree size, and finally, those with a larger number of tree

[13] We do not include interactions with income as 30% respondents refused to answer to this question.

species. These findings indicate that individuals, on average, do not derive positive utility from seeing 'forestry at work'.

9. Conclusions

The results of our study indicate that respondents prefer older stands with vertical layering and irregularly spaced trees. The results also provide strong evidence that an increasing number of tree species is positively related to recreational value. We also observe that, on average, respondents prefer to visit forests containing different stand types with age variation between stands. We also observe that the respondents tend to appreciate the presence of tourist infrastructure in the forest. By contrast, our results indicate that of all attributes considered, the management intensity attribute had the greatest (negative) impact on respondents' choices. Our results indicate that, regardless of the model used, greater management intensity is associated with higher disutility. The same relationship holds for residue from harvesting and thinning. For the remaining attributes, i.e., *Height of ground vegetation*, *Forest edge*, *Volume of dead wood* and *Understory density*, we find that the relationship with recreational value is bell-shaped, indicating that there is an intermediate optimal level for these attributes.

To conclude, while regardless of the model used, greater management intensity is associated with greater disutility, we do not perceive a risk of conflict between forests managed to protect biodiversity and those managed to ensure recreational value. Obviously, intensive recreational use may have negative impacts on biodiversity, but the CE results indicate that, on average, respondents tend to prefer characteristics associated with more natural forests. In other words, our study indicates that forests that are managed (or left unmanaged) for biodiversity purposes are also likely to be attractive to humans. This is an important finding, as the area of unmanaged forests in Poland is expected to increase (due to FSC certification, which requires setting aside at least 5% of forests for biodiversity purposes).

The demand for timber is likely to increase in the future due to increases in global population growth and wealth. Moreover, the other non-timber functions provided by forests (i.e., recreation, non-use values related to biodiversity) will also become important. The results of our study indicate that there is a clear conflict between intensive timber production and recreational use, i.e., the attributes associated with timber-oriented management result in decreasing forest recreational value. As we do not perceive a conflict between forests that are managed to protect biodiversity and those managed to ensure recreational value, our results indicate that the current management model adopted by Polish State Forests, which implies fulfilling all functions at the same place and time is not optimal. In our opinion, it should be reoriented towards the multi-functional forestry model proposed by Rykowski (2008), which implies spatially differentiated forest management that segregates among different functions. Compared to countries with diverse and fragmented land ownership structures, the state ownership of all larger Polish forest massifs makes this zoning approach feasible.

Acknowledgments

The conducted work was supported by the Polish Forest State Holding grant 'Wycena pozaprodukcyjnych funkcji lasu'. The second author gratefully acknowledges the support of the Polish Ministry of Science and Higher Education and the Foundation for Polish Science.

References

Angelstam, P., Axelsson, R., Elbakidze, M., Laestadius, L., Lazdinis, M., Nordberg, M., Pătru-Stupariu, I., Smith, M., 2011. Knowledge production and learning for sustainable forest management: European regions as a time machine. Forestry 84 (5), 581–596.

Blicharska, M., Angelstam, P., Antonson, H., Elbakidze, M., Axelsson, R., 2011. Road, forestry and regional planners' work for biodiversity conservation and public participation: a case study in Poland's hotspot regions. J. Environ. Plan. Manag. 54 (10), 1373–1395.

Bliemer, M.C.J., Rose, J.M., Hess, S., 2008. Approximation of Bayesian efficiency in experimental choice designs. J. Choice Model. 1, 98–127.

Boxall, P.C., Macnab, B., 2000. Exploring the preferences of wildlife recreationists for features of boreal forest management: a choice experiment approach. Can. J. For. Resour. 30, 1931–1941.

Carlowitz, H.C., 1713/2000. Sylvicultura oeconomica (economic forest management) oder Hausswirthliche Nachricht und naturmässige Anweisung zur wilden Baumzucht reprint edited by K. Irmer, Technische Universität Bergakademie Freiberg, Freiburg (In German).

Czajkowski, M., Buszko-Briggs, M., Hanley, N., 2009. Valuing changes in forest biodiversity. Ecol. Econ. 68 (2), 2910–2917.

Czajkowski, M., Bartczak, A., Giergiczny, M., Navrud, S., Żylicz, T., 2014. Providing preference based support for forest ecosystem service management. For. Policy Econ. 39, 1–12.

Daly, A.J., Hess, S., Train, K.E., 2012. Assuring finite moments for willingness to pay in random coefficients models. Transportation 39 (1), 19–31.

Dumont, J., Giergiczny, M., Hess, S., 2015. Individual-level models vs. sample-level models: contrasts and mutual benefits. Trans. A Transp. Sci. 11 (6), 465–483.

Edwards, D., Jay, M., Jensen, F.S., Lucas, B., Marzano, M., Montagné, C., Peace, A., Weiss, G., 2012. Public preferences for structural attributes of forests: towards a pan-European perspective. For. Policy Econ. 19 (0), 12–19.

Elbakidze, M., Angelstam, P., 2007. Implementing sustainable forest management in Ukraine's Carpathian Mountains: the role of traditional village systems. For. Ecol. Manag. 249, 28–38.

European Commission, 2013. Green infrastructure (GI) — enhancing Europe's natural capital. COM 249, Brussels.

Ferrini, S., Scarpa, R., 2007. Designs with a priori information for nonmarket valuation with choice experiments: a Monte Carlo study. J. Environ. Econ. Manag. 53, 342–363.

Forest Europe, 2011. State of Europe's Forests 2011: Status and Trends in Sustainable Forest Management in Europe. Ministerial Conference on the Protection of Forests in Europe, Oslo.

Giergiczny, M., 2009. Rekreacyjna wartość Białowieskiego Parku Narodowego (Recreational value of the Białowieża National Park). Ekonomia i Środowisko 2 (36), 117–127.

Giergiczny, M., Valasiuk, S., Czajkowski, M., De Salvo, M., Signorello, G., 2012. Including cost income ratio into utility function as a way of dealing with "exploding" implicit prices in mixed logit models. J. For. Econ. 18, 370–380.

Giergiczny, M., Hess, S., Dekker, T., Chintakayala, P.K., 2013. Testing the consistency (or lack thereof) between choices in best-worst surveys. paper presented at the Third International Choice Modelling Conference, Sydney.

Hanley, N., Wright, R.E., Koop, G., 2002. Modelling recreational demand using choice experiments: climbing in Scotland. Environ. Resour. Econ. 22, 449–466.

Hartig, G.L., 1860. Kort undervisning om skogens behandling och kultur (original title: Kurze Behlerung über die Behandlung und Kultur des Waldes, published 1791) (Bonniers, Stockholm. (In Swedish.)).

Hensher, D., Greene, W., 2003. The mixed logit model: the state of practice. Transportation 30 (2), 133–176.

Horne, P., Boxall, P.C., Adamowicz, W.L., 2005. Multiple-use management of forest recreation sites: a spatially explicit choice experiment. For. Ecol. Manag. 207, 189–199.

Larsen, J.B., Nielsen, A.B., 2007. Nature-based forest management — where are we going? Elaborating forest development types in and with practice. For. Ecol. Manag. 238, 107–117.

Lawrence, A., 2009. Forestry in transition: imperial legacy and negotiated expertise in Romania and Poland. For. Policy Econ. 11 (5-6), 429–436.

Lee, T.R., 2001. Perceptions, Attitudes And Preferences In Forests And Woodlands. *Technical Paper 18*, Forestry Commission, Edinburgh.

Lehtinen, A.A., Donner-Amnell, J., Saether, B., 2004. Politics of Forests. Ashgate, Farnham, UK.

Mattsson, L., Li, C.Z., 1994. How do different forest management practices affect the non-timber value of forests? — An economic analysis. J. Environ. Manag. 41, 79–88.

Merlo, M., Croitoru, L., 2005. Concepts and methodology: a first attempt towards quantification. In: Merlo, M., Croitoru, L. (Eds.), Valuing Mediterranean Forests. Towards Total Economic Value. CABI Publishing, Wallingford, pp. 17–36.

Mill, G.A., Van Rensburg, T.M., Hynes, S.D., C, 2007. Preferences for multiple use forest management in Ireland: citizen and consumer perspectives. Ecol. Econ. 60, 642–653.

Nielsen, A.B., Olsen, S.B., Lundhede, T., 2007. An economic valuation of the recreational benefits associated with nature-based forest management practices. Landsc. Urban Plan. 80, 63–71.

Peterken, G., 1996. Natural Woodland: Ecology and Conservation in Northern Temperate Regions. Cambridge University Press.

Polish State Forests, 2013. Raport o stanie lasów.

Revelt, D., Train, K., 1998. Mixed logit with repeated choices: households' choices of appliance efficiency level. Rev. Econ. Stat. 80 (4), 647–657.

Ribe, R.G., 1989. The aesthetics of forestry: what has empirical preference research taught us? Environ. Manag. 13, 55–74.

Riera, P., Signorello, G., Thiene, M., Mahieu, P.A., Navrud, S., Kaval, P., Rulleau, B., Mavsar, R., Madureira, L., Meyerhoff, J., Elsasser, P., Notaro, S., De Salvo, M., Giergiczny, M., Dragoi, S., 2012. Non-market valuation of forest goods and services: good practice guidelines. J. For. Econ. 18, 259–270.

Rykowski, K., 2008. Forest for Quality of Life, or The Paneuropean Process of Counteracting Climate Change. Forestry Research Institute, Warsaw, Poland.

Sheppard, S.R.J., Harshaw, H.W., 2001. Forest and Landscapes: Linking Ecology, Sustainability and Aesthetics. CABI Publishing, New York.

Train, K., 2003. Discrete Choice Methods with Simulation. Cambridge University Press, New York.

Zylicz, T., Giergiczny, M., 2012. Wycena pozaprodukcyjnych funkcji lasu [Valuation of non-timber forest functions]. Report for the Polish Forest State Holding.