Choice experiment assessment of public preferences for forest structural attributes

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Abstract

The objectives of forest policy have been broadened from tangible products, such as wood and fiber, to ecosystem services. This broadening emphasizes the need to also estimate the value of biodiversity and the social benefits of tourism and recreation. While research on the species' requirements has a long history, the issue of which habitat humans select to engage in tourism and recreation lags behind. In both cases, a major challenge is to consider the complete range of forest structure from a managed to a natural dynamic. 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.

Keywords:
forest characteristics; forest management valuation of non-market goods; choice experiment

JEL:
Q26, Q51, Q57

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 (von Carlowitz, 1713/2000; Hartig, 1791/1860). 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 industrialization has been the use value derived from timber and pulpwood (Angelstam et al., 2011). However, in 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, Lazdinis et al. (2007) and 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 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) writes: *'the general validity of most empirical studies of forest perception is limited by the consideration of limited landscapes judged by relatively 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 et al., 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 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 we obtained could be useful in defining optimal forest management plans in Poland and other European countries.

Polish forests

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%.

Methodology

2 Forest characteristics

2.1 Identification of relevant forest characteristics

Edwards at 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 at 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.

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

2.2. 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 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 270 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 choice experiment 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 is 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. 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 storey 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

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, Broad-leaved, 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 broad-leaved 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 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.

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.

Round 1 attributes

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[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.

[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.

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 1ha in area every 1km[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.

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.

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[5] The felling site was described as an area of 100 square meters.
[6] Namely, coniferous, mixed and broad-leaved.
[7] The visualization employed (fig4) can be seen at http://research.eeescience.utoledo.edu/lees/pubs/lup/

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.

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 9.

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.

3. 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. 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. Only those respondents who reported having made at least one forest visit during the 6-month period prior to the interview, the primary purpose of which was recreational, participated in the survey. 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 choice experiments, 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 figures 1 - 3. Finally, the fourth part contained debriefing questions and collected standard socio-economic data.

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

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

(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.,

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

(5)

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

5. Design and Model Specification

The choice sets employed in our study were prepared using a Bayesian d-efficient design optimized for MNL (Ferrini et al., 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. 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)[8]. The utility of the status quo alternative is given by a constant. All attributes other than *Distance* were dummy-coded.

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.

6. Results

6.1. Preference estimates

The modeling results are presented in Table 11. 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 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

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[8] 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.

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 (i.e., t-statistic= 71.78), indicating that there is significant random heterogeneity in the distance sensitivity in the studied sample.

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.

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 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 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 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.

6.2. Marginal rate of substitution

In addition to the preference estimates, in Table 14, 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.

Turning to 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. The increase in the mean WTP in the MMNL model was expected given the use of a negative lognormal distribution for the *Distance* coefficient (Giergiczny et al., 2012).

To understand the extent to which the relationship between the levels and recreational value is best described as positive, negative, bell-shaped, U-shaped, or flat, we present the relationship for each attribute on a separate graph (Figure 4).

The relationship between recreational value and attribute levels is positive for the following attributes:

- *Number of tree species,* i.e., regardless of the forest type, respondents preferred forests with a larger number of tree species,
- *Stand age,*
- *Age variation,*
- *Tree spacing,*
- *Forest diversity,*
- *Tourist infrastructure*.

The relationship is negative for:

- *Management intensity,*
- *Volume of residue* (the relationship is flat between recreational value and the *Absent* and *Medium* levels).

Finally the relationship is bell-shaped for:

- *Height of ground vegetation,*
- *Forest edge,*
- *Volume of dead wood,*
- *Understory density*.

6.3 Systematic taste variation

As Table 13 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)[9]. 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 16, we list the socio-demographic 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.

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 lower distance sensitivity, and they also 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.

7. 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 m3/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 2010, 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 species. These findings indicate that individuals, on average, do not derive positive utility form seeing 'forestry at work'.

8. 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 same place and time is not optimal. In our opinion, it should be reoriented towards the multifunctional 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.

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Table 1. Structural attributes and levels included in Edwards at 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: from one 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 at al., 2012.

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 Mixed Broadleaved	Conif1 (base) Mied2, Mixed5 Broad1, Broad5
Number of tree species	1, 2, 3, 5	
Stand age (in years)	40, 70, 100	Age_40 (base) Age_70, Age_100
Age structure	Even-aged Two-aged Uneven-aged	Even-aged (base) Two-aged Uneven-aged
ROUND 1 ATTRIBUTES		
Understory	Absent Medium Dense	Under_absent (base) Under_med Under_dense
Silviculture system	None Shelterwood Seedtrees Clearcutting	None (base) Shelterwood Seedtress Clearcutting
Tourist infrastructure	None Picnic sites Picnic site & Interpretative walking trail	None (base) Picnic Picnic_edu_walk
ROUND 2 ATTRIBUTES		
Dead wood	Low Medium High	DW_low (base) DW_med DW_high
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	Diversity1 (base) Diveristy2 Diveristy3
Residue from harvesting and thinning	Absent Medium High	Residue_absent (base) Residue_med Residue_high
ROUND 3 ATTRIBUTES		
Ground vegetation height	Absent Medium High	Ground_none (base) Ground_med Ground_high
Tree spacing	Regular Quasi-regular Irregular	Tree_regular (base) Tree_quasi_irreg Tree_irreg
Forest edges	Straight edges & no ecotone Convoluted edges & no ecotone Straight edges & ecotone	Edge_reg (base) Edge_irreg Edge_irreg_ecotone

Table 3

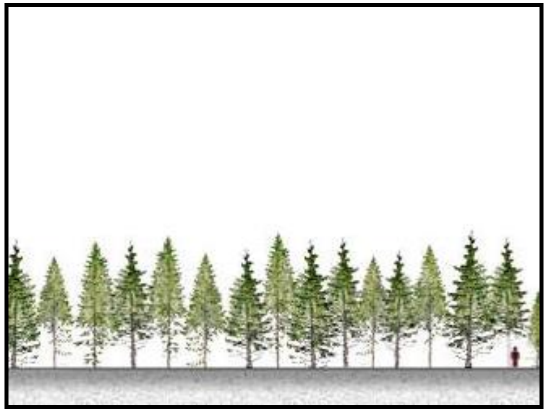
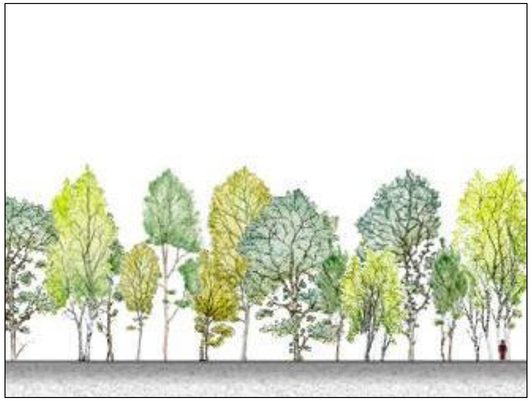
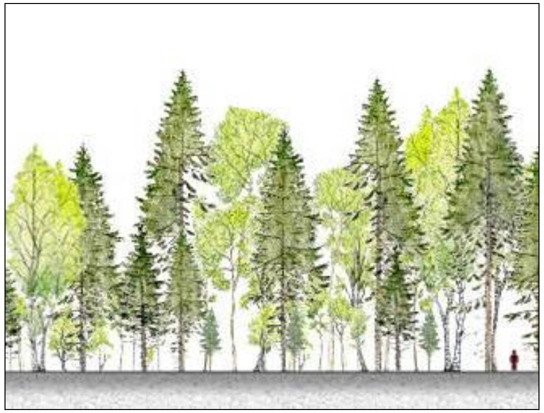
			
Forest type	Coniferous	Broad-leaved	Mixed
Number of tree species	1	4	2
Stand age	40 years	70 years	100 years
Variation in tree age	Even-aged	Two-aged	Uneven-aged

Table 4. Understory

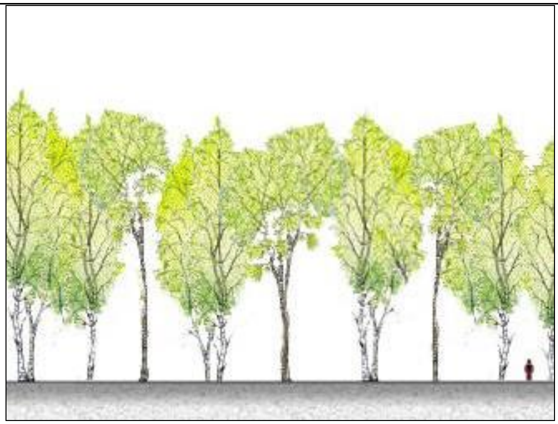
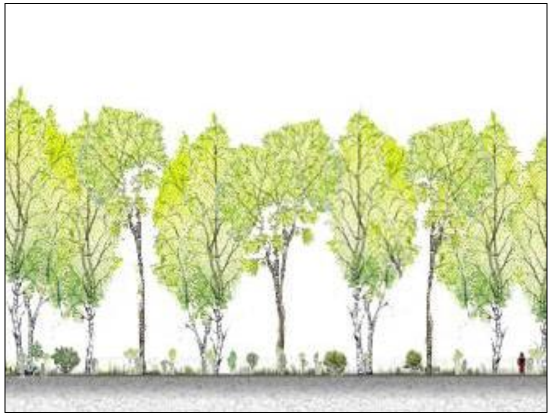
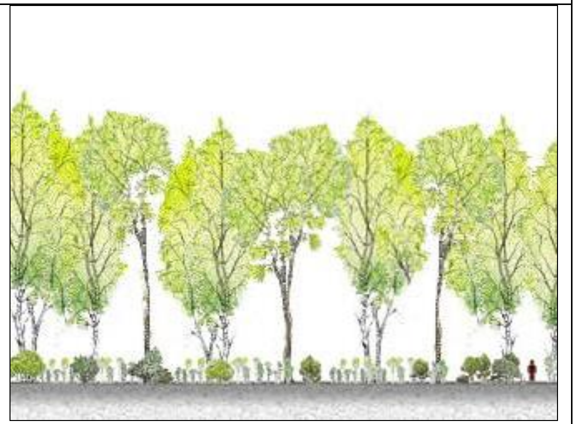
		
Absent	**Medium**	**Dense**
		

Table 5 Dead wood

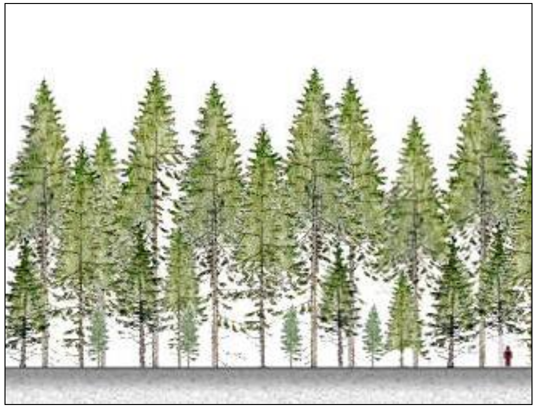
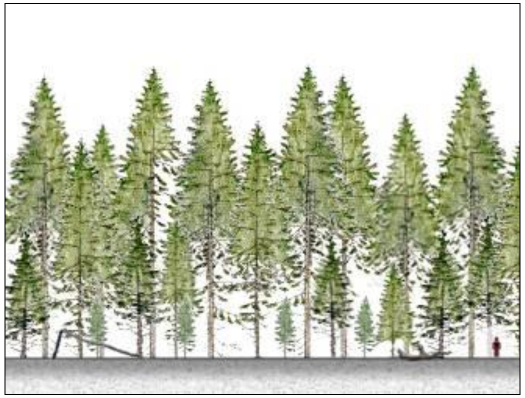
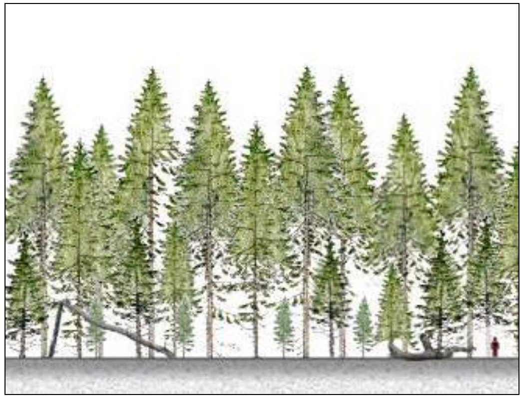
		
Low	**Medium**	**High**
		

Table 6. Ground vegetation height

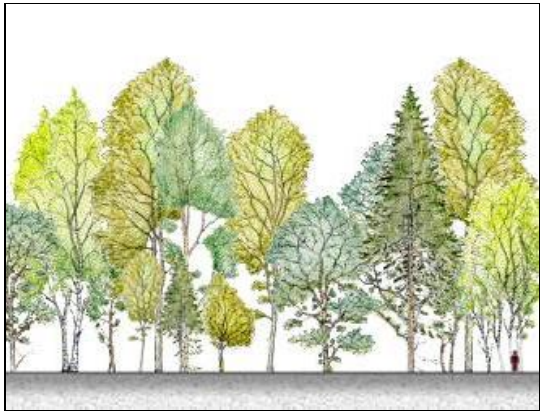
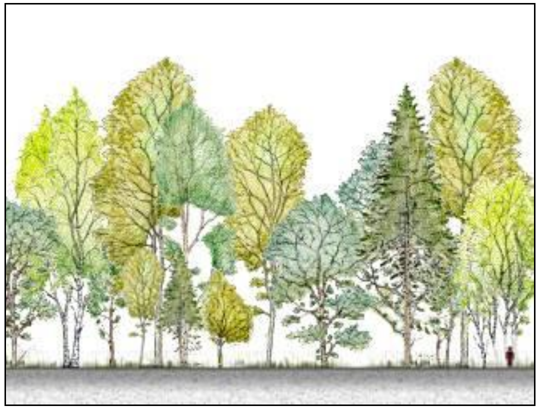
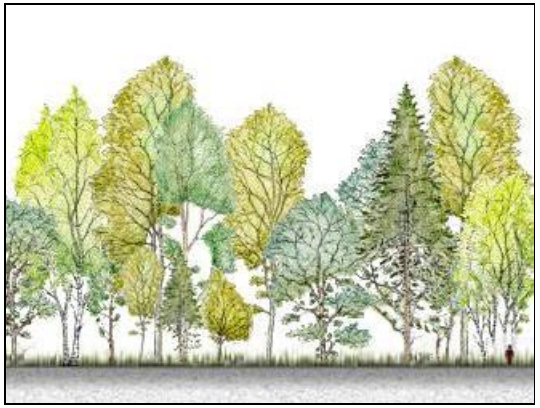
		
Absent	**Medium**	**High**
		

Table 7. Silviculture systems

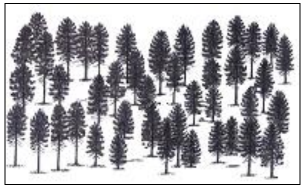
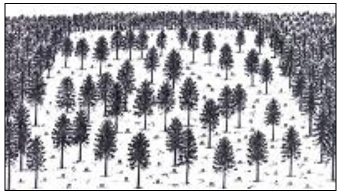
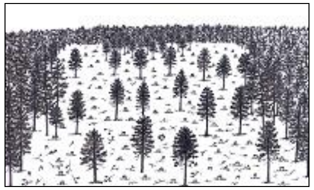
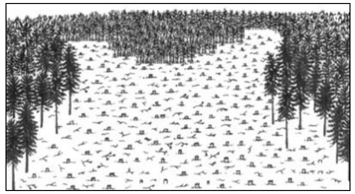
			
None	**Shelterwood**	**Seedtrees**	**Clearcutting**
			

Table 8. Tourist infrastructure.

		
None	**Picnic site**	**Picnic site & Interpretative walking trail**

Table 9. Forest diversity

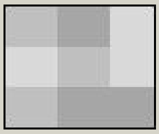
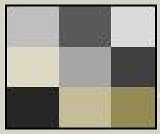
		
The same forest type and stand age	**The same forest type and variation in stand age**	**Different forest types and variation in stand age**

Table 10. Residue

		
Absent	**Medium**	**High**
		

Table 11. Tree spacing

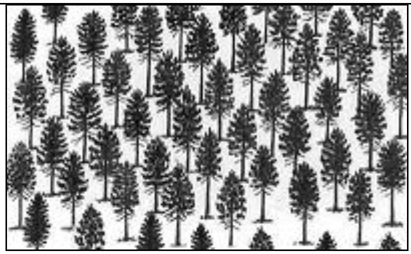
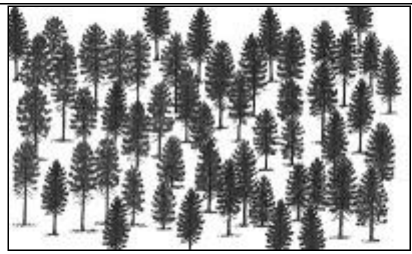
		
Regular	**Quasi-regular**	**Irregular**
		

Table 12. Forest edges

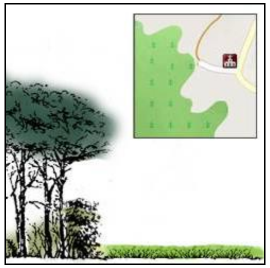
		
Straight edges & no ecotone	**Convoluted edges & no ecotone**	**Convoluted edges & ecotone**
		

Figure 1. Example of a card presented in round 1

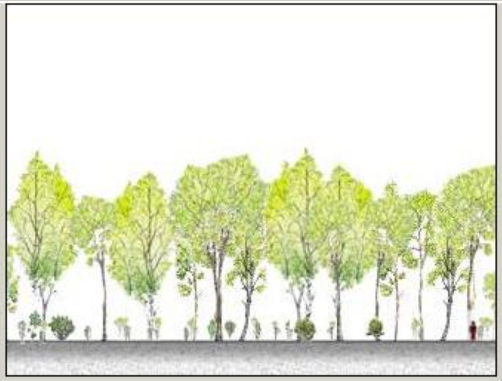
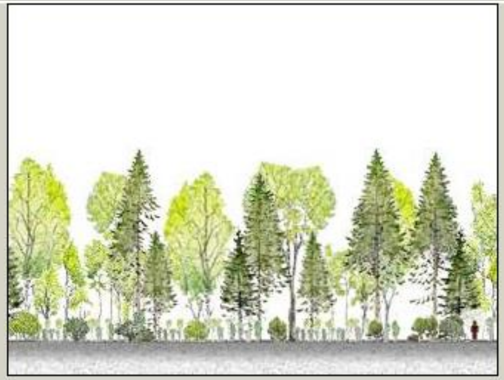
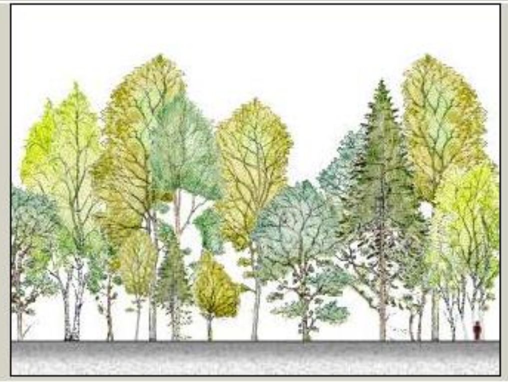
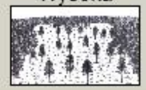
	Las 1	Las 2	Las 3	Żaden
				
Typ lasu Liczba gatunków Wiek drzew Zróżnicowanie wieku Gęstość podszytu	Lisciasty 1 gat 70 lat Jednowiekowy Średnia gęstość	Mieszany 2 gat 70 lat Dwuwiekowy Wysoka gęstość	Mieszany 5 gat 100 lat Różnowiekowy Brak	
Intensywność gospodarki leśnej	Wysoka 	Bardzo wysoka 	Wysoka 	
Infrastruktura turystyczna i rekreacyjna	Brak 	Średni 	Brak 	
Odległość	5 km	15 km	60 km	
Twój wybór	○	○	○	○

Figure 2. Example of a card presented in round 2

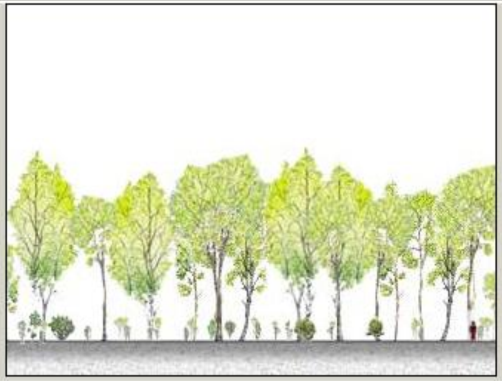
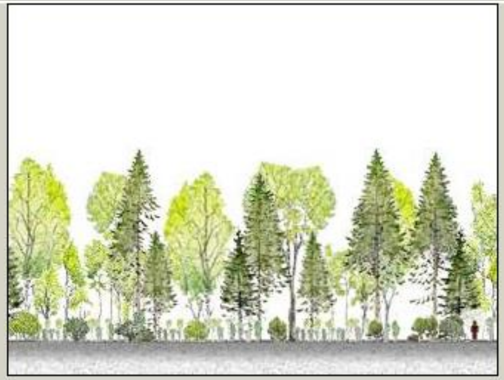
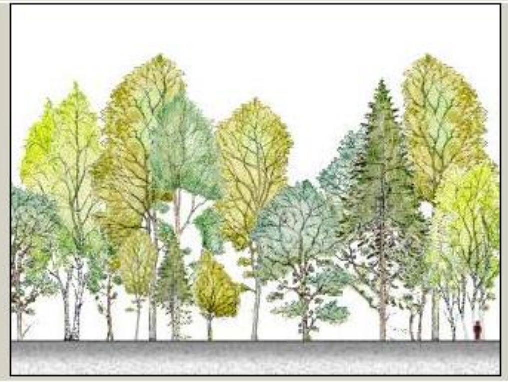
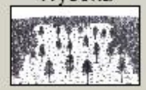
	Las 1	Las 2	Las 3	Żaden
				
Typ lasu Liczba gatunków Wiek drzew Zróżnicowanie wieku Gęstość podszytu	Lisciasty 1 gat 70 lat Jednowiekowy Średnia gęstość	Mieszany 2 gat 70 lat Dwuwiekowy Wysoka gęstość	Mieszany 5 gat 100 lat Różnowiekowy Brak	
Intensywność gospodarki leśnej	Wysoka 	Bardzo wysoka 	Wysoka 	
Infrastruktura turystyczna i rekreacyjna	Brak 	Średni 	Brak 	
Odległość	5 km	15 km	60 km	
Twój wybór				

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

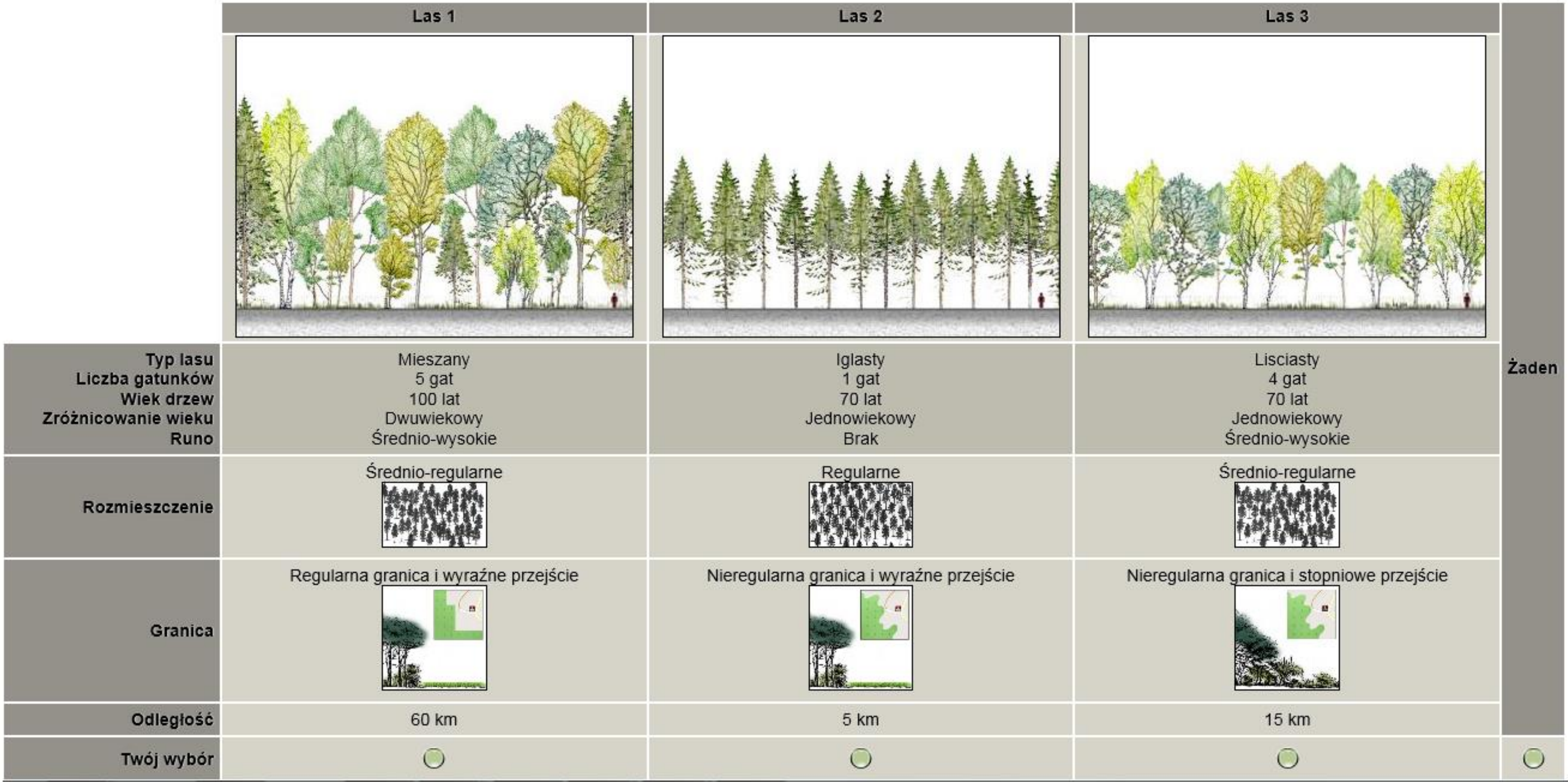


Table 13. Model estimates

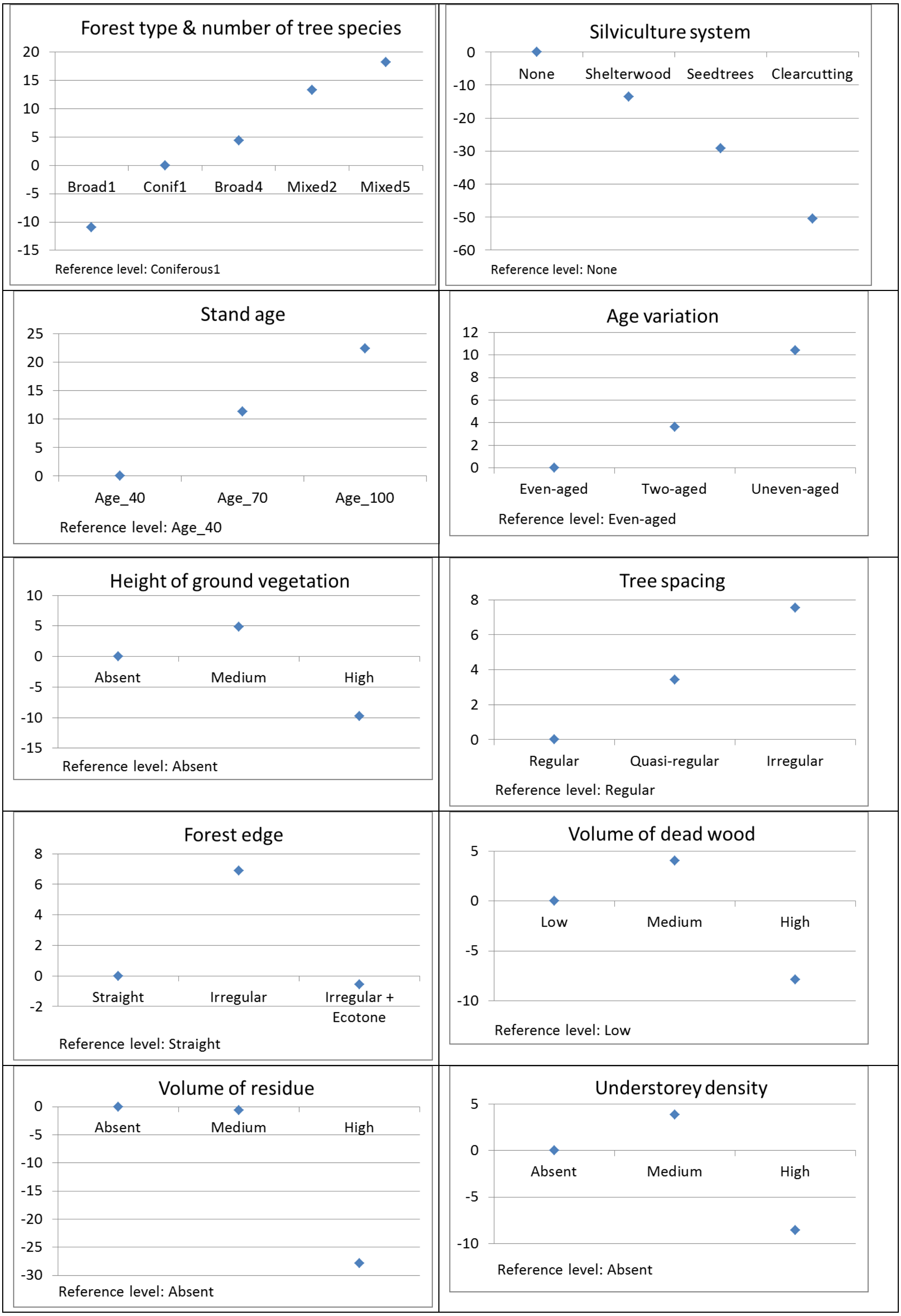
	MNL		MMNL					
			Mean		Std. dev.		CV.	Share*
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat		
Distance	-.02690***	-64.79	-3.3806***	-145.41	1.3110***	71.78	-0.39	-
Mixed2	.35723***	12.11	.38027***	12.88	.16890***	5.14	0.44	0.01
Mixed5	.49102***	14.42	.55155***	17.54	.24447***	6.31	0.44	0.01
Broadleaved1	-.29489***	-8.78	-.38139***	-11.25	.43974***	12.71	-1.15	0.19
Broadleaved4	.11898***	3.70	.17602***	6.69	.10591***	2.71	0.60	0.05
Age_70	.30482***	12.89	.41576***	16.96	.05663*	1.87	0.13	0.00
Age_100	.60139***	22.64	.71150***	24.72	.45587***	15.94	0.64	0,06
Two-aged	.09761***	3.87	.11003***	3.93	.08640**	2.53	0.79	0.10
Uneven-aged	.28010***	11.35	.34976***	12.20	.14004***	4.17	0.40	0.01
Ground_med	.12959***	3.14	.08662*	1.93	.14221***	2.70	1.64	0.27
Ground_high	-.26282***	-6.82	-.38656***	-9.39	.65762***	15.76	-1.70	0.28
Quasi-regular	.09240*	1.87	.16338***	2.90	.18352***	3.09	1.12	0.19
Irregular	.20243***	4.82	.25821***	5.43	.04059	.69	0.16	0.00
Edge_irreg	.18535***	4.80	.29839***	7.30	.20168***	4.08	0.68	0.07
Edge_irreg_ecotone	.01542	.41	.05415	1.25	.00540	.10	0.10	0.00
Dead wood_med	.10946***	2.82	.17006***	4.42	.03702*	1.66	0.22	0.00
Dead wood_high	-.21186***	-5.19	-.15178***	-3.94	.32292***	3.75	-2.13	0.32
Diversity2	.18015***	4.56	.21958***	5.08	.01913	.35	0.09	0.00
Diversity3	.49384***	13.36	.53895***	13.64	.01158	.20	0.02	0.00
Residue_med	-.01684	-.46	-.05663	-1.47	.04323	.86	-0.76	0.10
Residue_high	-.74985***	-18.06	-.88385***	-19.67	.72332***	13.86	-0.82	0.11
Understory_med	.10449***	2.92	.16677***	3.84	.47422***	9.52	2.84	0.36
Understory_high	-.23031***	-5.94	-.30173***	-6.81	.66979***	14.37	-2.22	0.33
Shelterwood	-.36288***	-8.40	-.45540***	-9.14	.00630	.08	-0.01	0.00
Seedtrees	-.78557***	-20.13	-1.01814***	-23.25	.26819***	4.86	-0.26	0.00
Clearcutting	-1.35599***	-26.56	-1.82292***	-28.17	1.10258***	15.37	-0.60	0.05
Picnic	.70408***	17.15	.90370***	19.79	.10649**	2.01	0.12	0.00
Picnic_edu-walk	.93273***	21.93	1.22440***	27.02	.41047***	8.53	0.34	0.00
SQ	-1.16314***	-27.49	-1.60855***	-37.45	-	-	-	-
LL	-29119.13		-25653.45					
Pseudo R2 adj.	.1278		.2586					
K	29		57					
N	30 000							

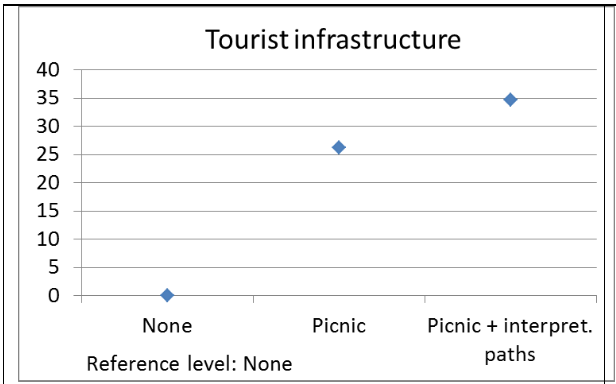
*The share of respondents for whom the sign of the coefficient was the opposite of the mean estimate.

Table 14. Marginal rate of substitution estimates

	MNL		MMNL	
	Mean	t-stat	Mean	Std. dev.
Mixed2	13.28***	12.06	25.76	52.31
Mixed5	18.25***	14.93	37.26	80.28
Broadleaved1	-10.96***	-8.62	-24.99	84.65
Broadleaved4	4.42***	3.74	11.84	27.60
Age_70	11.33***	12.88	28.75	59.65
Age_100	22.36***	22.67	49.56	124.78
Two-aged	3.63***	3.86	7.48	18.69
Uneven-aged	10.41***	11.49	24.13	49.64
Ground_med	4.82***	3.14	6.02	25.73
Ground_high	-9.77***	-6.83	-27.64	103.92
Quasi-regular	3.44*	1.87	11.08	32.95
Irregular	7.53***	4.81	17.75	34.95
Edge_irreg	6.89***	4.75	21.02	54.24
Edge_irreg_ecotone	.57	0.41	3.71	7.23
Dead wood_med	4.07***	2.82	11.75	24.09
Dead wood_high	-7.88***	-5.16	-11.08	52.17
Diversity2	6.69***	4.55	15.06	29.46
Diversity3	18.36***	13.26	36.96	71.76
Residue_med	-.62	-.46	-3.94	10.22
Residue_high	-27.88***	-17.61	-58.11	144.41
Understory_med	3.88***	2.92	11.36	75.37
Understory_high	-8.56***	-5.98	-20.79	102.90
Shelterwood	-13.49***	-8.30	-31.25	60.65
Seedtrees	-29.05***	-19.10	-69.85	143.01
Clearcutting	-50.42***	-24.27	-123.71	171.85
Picnic	26.18***	16.60	61.95	119.20
Picnic_edu-walk	34.68***	21.23	82.95	160.29

Figure 4. Relationship between recreational value and attribute levels




Tourist infrastructure
40
35
30
25
20
15
10
5
0
None
Picnic
Picnic + interpret. paths
Reference level: None

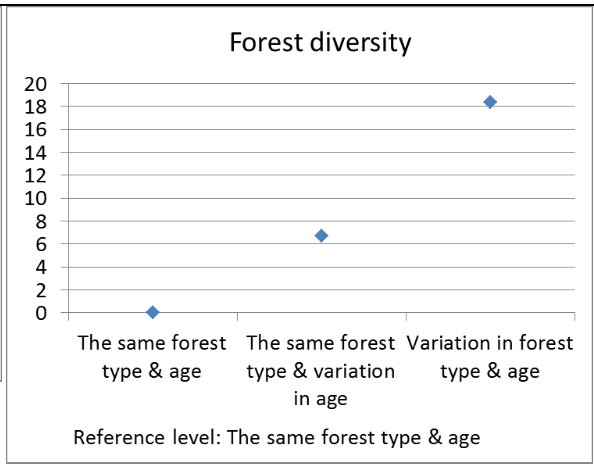

Forest diversity
20
18
16
14
12
10
8
6
4
2
0
The same forest type & age
The same forest type & variation in age
Variation in forest type & age
Reference level: The same forest type & age

Table 15. MNL with systematic taste variation

	Main effects		Male		Education		Age		Visits	
	Mean	t-stat	Mean	t-stat	Mean	t-stat	Mean	t-stat	Mean	t-stat
Distance	-.017***	-8.47	0.002	0.55	-.001***	-6.54	-.001***	-4.71	.001**	2.34
Mixed2	0.152	1.05	0.034	0.56	0.013	1.26	-0.015	-0.99	-0.001	-0.92
Mixed5	0.118	0.71	.119*	1.73	0.012	1.08	-0.008	-0.44	-0.001	-0.93
Broadleaved1	0.029	0.18	0.044	0.63	-0.007	-0.60	-.075***	-4.29	0.001	0.58
Broadleaved4	0.076	0.48	.176**	2.67	-0.001	-0.08	-.044***	-2.62	-0.001	-0.97
Age_70	0.16	1.37	.088*	1.82	-0.006	-0.72	.027**	2.21	0.002	0.03
Age_100	0.16	1.22	.160**	2.94	0.014	1.52	.035**	2.54	0.007	-0.38
Two-aged	.224*	1.79	-0.021	-0.41	0.013	1.54	-0.016	1.21	0.002	0.45
Uneven-aged	.496***	4.06	-0.003	-0.06	.019**	2.36	-.043***	3.34	0.001	0.96
Ground_med	0.011	0.05	.146*	1.73	0.01	0.69	.036*	1.66	-0.002	-1.19
Ground_high	0.175	0.91	0.059	0.74	-.033***	-2.62	0.031	1.54	0.001	0.61
Quasi-regular	0.288	1.17	-0.083	-0.81	.031*	1.82	-0.021	-0.80	.003**	2.23
Irregular	0.085	0.41	0.003	0.03	.028**	1.99	-0.026	-1.20	.002*	1.81
Edge_irr	-0.204	-1.07	-0.008	-0.11	0.017	1.28	-.039*	-1.96	0.001	0.58
Edge_irr_ecotone	-0.275	-1.49	0.006	0.08	0.016	1.38	-0.032	-1.62	0.005	-0.30
Dead wood_med	-0.107	-0.56	-0.002	-0.03	0.015	1.11	-.037*	-1.83	0.001	1.19
Dead wood_high	-0.263	-1.29	.229***	2.75	-0.003	-0.23	-0.031	-1.43	0.003	0.13
Diversity2	-0.19	-0.96	-0.09	-1.10	.031**	2.34	-0.031	-1.49	0.002	0.26
Diversity3	.524***	2.84	-0.06	-0.79	0.004	0.33	-0.013	-0.69	0.001	1.02
Residue_med	-0.023	-0.12	-0.004	-0.05	-0.003	-0.26	0.028	1.46	-0.002	-1.31
Residue_high	-.651***	-3.14	.155*	1.82	-.031**	-2.22	.045**	2.09	2.03	0.07
Understorey_med	.298*	1.68	0.105	1.42	.022*	1.82	0.013	0.70	-0.001	-0.37
Understorey_high	-0.179	-0.94	.267***	3.36	-0.016	-1.26	0.008	0.38	0.001	0.66
Shelterwood	-0.184	-0.85	-0.088	-0.99	-.024*	-1.68	0.001	0.03	-0.001	-1.01
Seedtrees	-.559***	-2.88	-0.011	-0.14	-0.002	-0.17	-0.001	-0.04	-0.001	-1.09
Clearcutting	-.467*	-1.87	0.016	0.15	-.041**	-2.43	-0.019	-0.71	-.005***	-2.67
Picnic	.483**	2.40	-153*	-1.83	0.021	1.5	-0.003	-0.12	-.004***	-2.96
Picnic_edu-walk	.474**	2.24	-0.141	-1.61	.042***	2.96	-.03855*	-1.72	-0.001	-0.75
SQ	-119***	-5.71	0.065	0.75	-0.004	-0.29	0.021	0.95	-0.001	-0.07

	Town		City		Mushroom/Berry		Nature	
	Mean	t-stat	Mean	t-stat	Mean	t-stat	Mean	t-stat
Distance	-.003**	-2.11	.005***	4.46	.004***	4.65	.001*	1.96
Mixed2	-0.008	-0.09	-0.102	-1.39	.152**	2.53	0.091	1.47
Mixed5	0.07	0.71	-0.019	-0.22	.131*	1.88	.192***	2.66
Broadleaved1	0.022	0.23	-0.061	-0.73	0.066	0.96	-0.064	-0.90
Broadleaved4	0.054	0.58	0.053	0.66	0.057	0.86	0.096	1.41
Age_70	0.105	1.54	0.046	0.78	0.063	1.30	0.028	0.57
Age_100	-0.045	-0.60	-0.062	-0.95	0.074	1.35	.128**	2.29
Two-aged	-0.077	-1.07	-.127**	-2.01	0.03	0.57	.123**	2.38
Uneven-aged	-0.058	-0.81	-0.091	-1.48	-0.047	-0.93	0.017	0.33
Ground_med	-.301**	-2.53	-0.017	-0.17	-.257***	-3.04	0.091	1.04
Ground_high	-0.138	-1.26	-0.046	-0.48	-.215***	-2.72	0.093	1.15
Quasi-regular	0.229	1.64	0.138	1.12	0.066	0.65	-0.033	-0.32
Irregular	0.126	1.06	0.063	0.61	0.017	0.20	-0.062	-0.7
Edge_irreg	0.109	0.98	0.126	1.30	.234***	2.96	0.093	1.14
Edge_irreg_ecotone	0.112	1.05	0.11	1.18	0.055	0.72	0.044	0.56
Dead wood_med	-0.123	-1.10	0.111	1.15	0.057	0.72	.176**	2.15
Dead wood_high	-0.051	-0.44	0.081	0.79	-0.077	-0.92	0.138	1.60
Diversity2	0.075	0.66	0.101	1.00	-0.054	-0.67	0.064	0.77
Diversity3	0.015	0.14	0.085	0.92	-.146*	-1.93	0.003	0.04
Residue_med	0.091	0.86	0.141	1.52	-.143*	-1.90	-0.026	-0.33
Residue_high	0.194	1.63	.224**	2.15	-.15400*	-1.81	0.039	0.44
Understorey_med	-0.160	-1.55	-0.11	-1.24	0.055	0.76	0.125	1.64
Understorey_high	-0.033	-0.30	0.005	0.06	-.144*	-1.82	0.124	1.51
Shelterwood	-0.133	-1.09	-.209*	-1.95	0.125	1.41	-0.136	-1.49
Seedtrees	-0.100	-0.9	-.167*	-1.72	-0.035	-0.44	-0.06	-0.73
Clearcutting	-0.190	-1.32	-.249**	-1.97	0.008	0.07	-0.038	-0.36
Picnic	.374***	3.24	.263***	2.61	-0.109	-1.29	-0.088	-1.02
Picnic_edu-walk	.382***	3.11	.311***	2.96	-.147*	-1.69	-0.107	-1.19
SQ	-0.026	-0.22	-.176*	-1.68	0.06	0.70	0.041	0.46
LL_full model	-28728.1							
K	261							
Pseudo R2	0.1325							

Table 16. 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