frontiers | Frontiers in Forests and Global Change

TYPE Original Research
PUBLISHED 16 July 2025
DOI 10.3389/ffgc.2025.1486532

OPEN ACCESS

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RECEIVED 26 August 2024
ACCEPTED 23 June 2025
PUBLISHED 16 July 2025

CITATION
Purwestri RC, Hájek M, Palátová P, Tahri M, Huertas-Bernal DC , Awuni S, Letsoin SMA, Rahmawan F, Hochmalová M, Jarský V, Riedl M and Dudík R (2025) Investigating Czech society's expectations for forest recreation.
Front. For. Glob. Change 8:1486532.
doi: 10.3389/ffgc.2025.1486532

Investigating Czech society's expectations for forest recreation

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Forests provide numerous advantages for human wellbeing, i.e., provisioning, regulation, and cultural services. As part of the cultural services, recreational functions contribute aesthetic value and opportunities for various sports and leisure activities. Our research aims to address four main objectives: exploring respondents' expectations regarding the naturalness of forest visuals and descriptions, investigating the relationship between forest visuals and public expectations of naturalness and facilities, and examining the independent predictors of high preferences in forest visuals (stand type, level of visual penetration, and occurrence of natural deadwood). Data regarding public expectations for forest recreation were collected through a representative online survey in the Czech Republic in 2022 among respondents aged 18 to 65 years. Vegetation density, derived from the Normalized Difference Vegetation Index for the forest area in 2018, was developed using CORINE Land Cover data. Societal expectations regarding naturalness in visuals, descriptions, presence of recreation facilities, and their interconnection were analyzed and presented. Binary regression analysis identified potential predictors of visual preferences. Results showed a high preference for mixed forests with a medium level of visual penetration and a moderate amount of natural deadwood. The results of the association between forest visuals and naturalness descriptions revealed societal expectations for closer-to-nature forests while still valuing the ability to explore and walk within them. Educational, visible signs and accessible paths were generally considered essential recreational facilities by the respondents, whereas sports amenities, kiosks, and parking areas were not. Frequent forest attendance and an age range from 18 to 45 years were primary indicators for visual preferences. Additionally, respondents residing in municipalities with over 20,000 inhabitants and those in Prague-Central Bohemia showed strong preferences for mixed stands and moderate natural deadwood occurrence, respectively. Understanding how socio-demographic attributes influence visual preferences can help tailor forest recreational services to specific target groups within Czech society.

KEYWORDS

recreation, ecosystem service, forest visual, stand type, visual penetration, natural deadwood, visitor facilities

1 Introduction

Forest ecosystems provide numerous advantages for human wellbeing, i.e., provisioning, regulation, and cultural services. Recreation is one of the essential cultural ecosystem services, offering aesthetic value of the land cover, non-wood commodity collection, and game hunting. Additionally, forests serve as spaces for sports and relaxation activities for human wellbeing (Felipe-Lucia et al., 2018; Haines-Young and Potschin, 2018), which gives a person time away from business, work, and household tasks (Clough, 2013). In contrast to wood forest products, which are widely acknowledged to be intricately linked with local communities and serve as a dynamic interface between environmental conservation, public livelihoods, and forest management practices (Arabatzis et al., 2012; Yang et al., 2018), the recreational value has received comparatively less attention unless it is connected with the economic valuation, such as travel expenses, entrance fees, etc. (Scarpa et al., 2000; Zandersen and Tol, 2009).

Societal preference for forests has contributed to influencing management by providing insight into the visual and recreational value appreciation. For instance, Edwards et al. (2012) investigated public expectations regarding various management objectives (forest nature reserves, closer-to-nature forestry, multi-purpose forestry, intensive, even-aged forest management, and provision of woody biomass) in Great Britain, the Iberian Peninsula, as well as Scandinavia and Central Europe, which revealed the preferred management plan, stand type, and development phase of trees from each region. Furthermore, Scarpa et al. (2000) found that nature reserves and the natural environment in Irish forests are principal attractors for visitors. These investigations of societal preferences and expectations rooted in human perception (Tyrväinen et al., 2007; Kumar and Kumar, 2008; Chan et al., 2012), primarily employed qualitative approaches, allowing for a deeper exploration and interpretation of societal perspectives. This, in turn, facilitated the development of strategic recommendations (Martín-López et al., 2012; Gebrehiwot et al., 2014; Muhamad et al., 2014; de Oliveira and Berkes, 2014; Asah et al., 2014), which can be further verified by complementary findings, such as changes in land use or production services (Delphin et al., 2016; Huertas Bernal et al., 2021).

The preference for forest naturalness has been gaining more attention recently because of the ecological benefits. For instance, the presence of deadwood is associated with the richness of biodiversity, soil fertilization, and carbon stock supply (Sandström et al., 2019; Mansuy et al., 2024; Zumr et al., 2024a), while mixed stands improve forest resilience (Kunert and Cárdenas, 2015; Jactel et al., 2017) and improve the productivity of provisioning services (Zhang et al., 2012). Moreover, ground layers and understory of forests provide food and shelter for various species (Nielsen et al., 2018; Toivonen et al., 2023). Unfortunately, the ecological contributions of natural forests can conflict with recreational values. For example, the presence of standing and lying natural deadwood can be an obstacle to aesthetics, as perceived by Italian visitors (Paletto et al., 2017) and Turkish students (Bayraktar et al., 2024), despite their preferences for closer-to-nature forests. A recent study in Poland revealed that deadwood in forest environments induced sadness and decreased positive emotions in young adults, particularly when individuals are not informed about the ecological functions of deadwood (Janeczko et al., 2021). A significant negative relationship was observed between the road density and deadwood amounts in Swiss forests (Sauvain, 2003), while in Poland, more deadwood was detected at locations farther from housing areas (Pasierbek et al., 2007), linking the presence of deadwood with limited accessibility. Regarding visual penetration levels, respondents from four European regions (Great Britain, the Nordic countries, Central Europe, and Iberia) rated areas with high field cover density as the lowest and preferred moderate visual permeability (Edwards et al., 2012). These challenges can result in a reduction of the recreational values that the area offers.

In Central and Eastern Europe, public access to the vast majority of forests in Europe for cultural and recreational purposes is legally guaranteed by Forest Acts (Hochmalová et al., 2021). Consequently, monetizing these services is challenging, as it would require significant policy changes to long-established Forest Acts, which are deeply rooted in cultural traditions and history (Hochmalová et al., 2021; Purwestri et al., 2023a). Non-market forest ecosystem services, including recreational services, emerge spontaneously alongside wood production (Filyushkina et al., 2016). Their primary advantage lies in being incidental outputs of forest management, requiring no direct effort or investment from forest owners (Costanza et al., 1997; Baciu et al., 2021). Following wood production, forest recreation together with non-wood commodity collection, including game and mushroom/berry picking, are integral recreational activities deeply rooted in Czech culture and history and continue to be practiced today (Svoboda et al., 2011; Šiftová, 2020; Jarský et al., 2022; Purwestri et al., 2023a). Situated in Central Europe, forests in the Czech Republic cover approximately one-third of the land area (Ministry of Agriculture of the Czech Republic (MoA), 2022). Nowadays, forest recreation is expected to include areas for engaging in socio-cultural, nature environment, and health/sports-related activities, thereby providing opportunities for relaxation and tourism to improve people's physical and mental health (Kalábová, 2018; Šodková et al., 2020; Rinn et al., 2023). A study by Jůza et al. (2020) addressed the public's needs and expectations of the municipal forests close to an agglomeration, including the cost evaluation needed for recreational infrastructure. The importance of municipal forests and the increased number of visitors, which can be challenging for forest management, have been studied over the past years, particularly during COVID-19 (Derks et al., 2020; Jarský et al., 2022). Additionally, based on the analysis results of the Swiss National Forest Inventories, variations in forest visual attractiveness were mainly determined (84%) by individual visitor characteristics (Hegetschweiler et al., 2022). The reports mentioned above underscore the pivotal role of public expectation in forest recreation, as they are the chief users of the service. Therefore, their evaluations and preferences can enhance forest recreational management and increase the potential economic and ecological value.

Climate change causes extreme events and ecosystem disturbances, visibly transforming forests with an increase in dying trees and young stands, primarily due to intensified insect damage, storms, and fires, as well as massive logging activities (Ciscar et al., 2009; Bernetti et al., 2011; Tudoran et al., 2016; Hlásny et al., 2021a,c). This destruction significantly impacts forest growth and stability globally, including Europe (Charru et al., 2017; Ala-Hulkko et al., 2019), while degrading forest views (Arnberger et al.,

2018). The rising demand for wood and non-wood ecosystems, potentially adds additional pressure on forest health and resilience, particularly in recreational services (Font and Tribe, 2000; Orellana et al., 2012; Marzano and Dandy, 2012). Evaluating ecosystem services provided valuable information for decision-making. In this case, it is essential for improving forest recreation attractiveness and resilience and ultimately mitigating climate change. Attention is increasing on incorporating assessments based on human perceptions (Tyrväinen et al., 2007; Kumar and Kumar, 2008; Chan et al., 2012; de Groot et al., 2010). In the Czech Republic, Mohammadi et al. (2024) reported the society's willingness to be engaged in forest management planning. However, to date, there are still limited studies revealing the public preferences of forest recreational aspects, which incorporate, e.g., the views, activities, facilities, and the associations within them.

The first objective of this paper was to explore the respondents' expectations regarding forest naturalness from visuals and descriptions. Our first hypothesis was that the survey respondents expected closer-to-nature forest visuals, indicated by their selection of preferred stand types, densities of natural deadwood, and levels of visual penetration of forests, following the characteristics of naturalness described by Larsen et al. (2022). The bark beetle outbreak significantly altered forest environments, resulting in an increase of standing dying trees and disturbances caused by extensive logging activities (Arnberger et al., 2018; Hlásny et al., 2021a,c). In this paper, we only investigated the presence of natural deadwood. The second objective was to examine the relationship between the visually presented forests and their descriptions, based on our hypothesis that forest descriptions can confirm which types of management are expected (Hahn et al., 2007; Bauhus et al., 2013; Jactel et al., 2017; Larsen et al., 2022), levels of visual penetration (Nelson et al., 2001; Verheyen et al., 2024), and deadwood densities (Sauvain, 2003; Bujoczek et al., 2021). The third objective was to explore the intricate relationship between the forest visuals and public expectations of recreational facilities, which was based on the hypothesis that the preferred forest visuals are associated with the presence of amenities (Sauvain, 2003; Hochmalová et al., 2022). Lastly, the paper aims to examine the independent predictors of a high score for forest visuals, as certain factors, such as demographic characteristics and vegetation types, are significant predictors of this preferences (Paletto et al., 2017; Hegetschweiler et al., 2022). Through this exploration, we aimed to contribute to the broader discussion on sustainable forest management, its connection to public expectations, the ecological implications, and the potentiality incorporating the findings for developing forest recreation services. We also addressed how to maintain the natural integrity of forests while ensuring their resilience to climate change, using the Czech Republic as a case study.

2 Materials and methods

Forested landscapes of the Czech Republic cover 34.2% of the country's total area (Figure 1). The Czech forests are predominantly managed by the state (about 54%). More than 74% of the Czech forests are production forests, mainly (about 72%) consisting of coniferous trees—the result of the mandatory extensive cultivation of monocultures from more than 100 years ago. The implementation resulted in substituting natural broadleaved and mixed forests in the Czech lands to enhance wood production (Ardö, 1998; Ministry of Agriculture of the Czech Republic (MoA), 2022; Janová et al., 2022). To date, Norway spruce has been the primary coniferous tree that produces wood in the Czech Republic, followed by pine and larch (Ministry of Agriculture of the Czech Republic (MoA), 2022). In the Czech Republic, public free access is given to 92% of the forests (except for military forests and areas dedicated for national parks and strongly nature conservation)— is legally guaranteed by Forest Acts (Ministry of Agriculture of the Czech Republic (MoA), 2016; Hochmalová et al., 2021). Consequently, monetizing these services is challenging, as it would require significant policy changes to long-established Forest Acts, which are deeply rooted in cultural traditions and history (Hochmalová et al., 2021; Purwestri et al., 2023a).

2.1 Framework for data collection in understanding societal preferences for forest recreation

This paper's data collection framework was developed according to the objectives and hypotheses of this study. Our paper intends to examine public expectations regarding the naturalness of forests, focusing on visual aesthetics, natural appeal descriptions, the availability of essential facilities and how they are connected (Nelson et al., 2001; Sauvain, 2003; Bauhus et al., 2013; Larsen et al., 2022). The objective is to support the development of ecosystem services linked to forest recreation. The expectations of naturalness in forest visuals are assessed by the selection of stand type, presence and densities of natural deadwood, and level of visual penetration of forests. In our study, closer-to-nature forests are also characterized as quiet and undisturbed environments with minimal human intervention and partially obscured paths (Larsen et al., 2022). Furthermore, socio-demographic characteristics and vegetation density are considered underlying factors that influenced the perception of investigated forest recreation elements (Paletto et al., 2017; Hegetschweiler et al., 2022; Figure 2).

This paper focuses on public perceptions of near-natural forests and does not directly explore the numerous ecological and economic benefits they provide to society and wildlife (Kunert and Cárdenas, 2015; Jactel et al., 2017; Sandström et al., 2019; Toivonen et al., 2023; Mansuy et al., 2024). Moreover, external factors such as global warming and changes in land use and management can significantly impact forest ecosystem services and vegetation density (Ciais et al., 2008; Gamfeldt et al., 2013; Hlásny et al., 2021c). Forest vegetation changes and societal preference in the Czech Republic are also influenced by sociocultural, economic, and political factors (Hájek et al., 2020; Dudík et al., 2021; Hochmalová et al., 2021; Palatova et al., 2022; Purwestri et al., 2023b). Although these factors were not directly analyzed in our study, their relevance is still acknowledged.

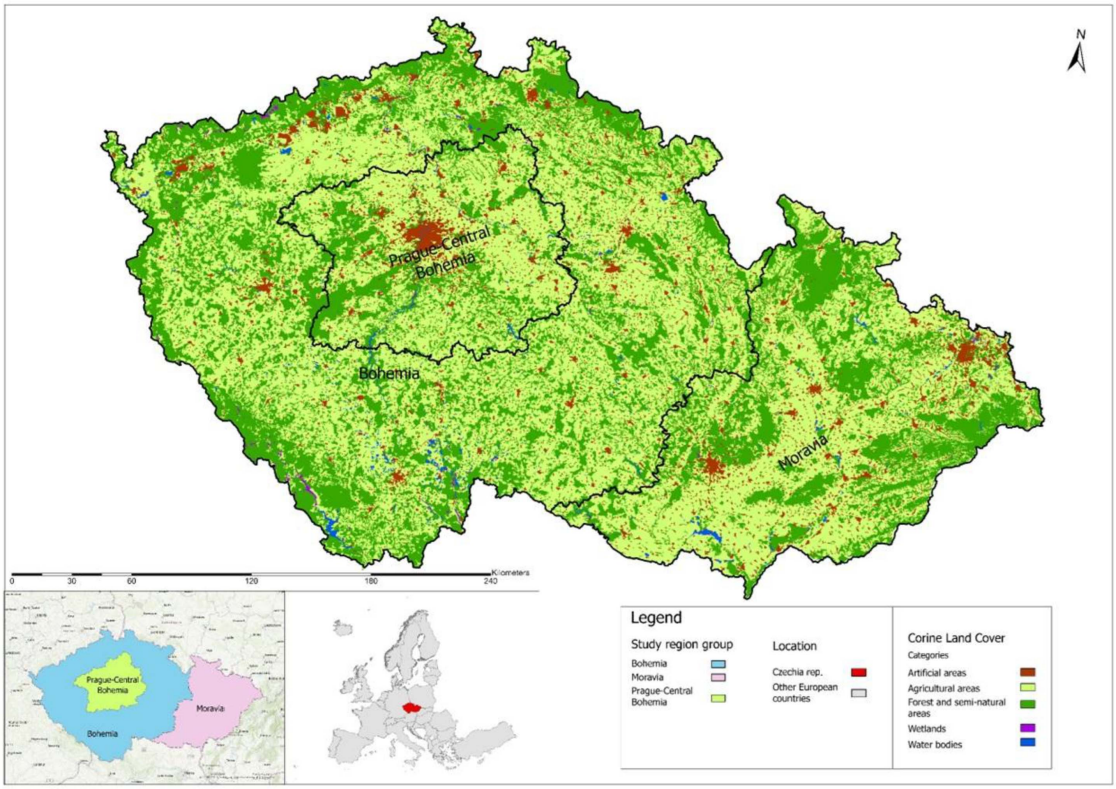

FIGURE 1
Map of the study location.

2.2 Survey on the societal expectations for recreational services and forest facilities

The survey was part of the "Advanced research supporting the forestry and wood-processing sector's adaptation to global change and the 4th industrial revolution (EVA 4.0)" research project at the Faculty of Forestry and Wood Sciences (Fakulta Lesnická a Dřevařská/FLD), Czech University of Life Sciences Prague (Česká Zemědělská Univerzita v Praze/CZU). The study was performed from November 2022 to January 2023—in cooperation with a third-party company, STEAM/MARK, Inc., specializing in marketing research activities. The minimum national representative sample size was estimated using a population survey formula (Cochran, 1977), with a 95% confidence level, a 50% estimated proportion for the preference of forest naturalness description, a total population size of 10,500,850 people in 2021 (Czech Statistical Office [CZSO], 2022), and a 5% margin of error. This resulted in a minimum sample size of 768 respondents. Additionally, the minimum required sample size for the subgroup of forest owners and managers (n = 38) was determined using a formula based on a defined proportion of mean differences, with a power index of 3.24, a standard deviation of 0.8 (calculated based on data from Purwestri et al., 2023b), and a 75% defined mean difference (Hassard, 1991), yielding a minimum of 38 respondents. Detailed information on the sample size calculation is presented in Supplementary Appendix 1A.

A nationwide survey was carried out using the Computer Assisted Web Interview (CAWI) method. The online panel was recruited proportionally based on population size per region (NUTS 3 level), as determined by the Czech Statistical Office [CZSO] (2022).[1] Supplementary Figure A1 depicts the proportions of the survey participants by region. Equal representation of both genders was ensured among the respondents. Participants were required to be at least 18 years old to ensure self-representation and needed internet access, as the questionnaire was distributed via online platforms using an algorithm that generated and sent invitations to potential participants. Respondents completed the survey independently, with no private information stored, guaranteeing anonymity. The questionnaire was designed to capture public opinions on forest ecosystem services, which was pretested and modified to enhance the clarity of the questions at the FLD-CZU before the survey implementation. A preliminary study using the same questionnaire was done in 2021 employed to selected societal groups (tourists, students, and urban dwellers) in specific areas in the Czech Republic and China (Hochmalová et al., 2022), indicating the questionnaire's reliability for nationwide implementation.

The respondents were asked to answer a closed-ended questionnaire of socio-demographic characteristics and then score their expectations about forest recreation. The Likert scale scoring system involves five degrees of values, from 1 (one), defined as

1 https://csu.gov.cz/

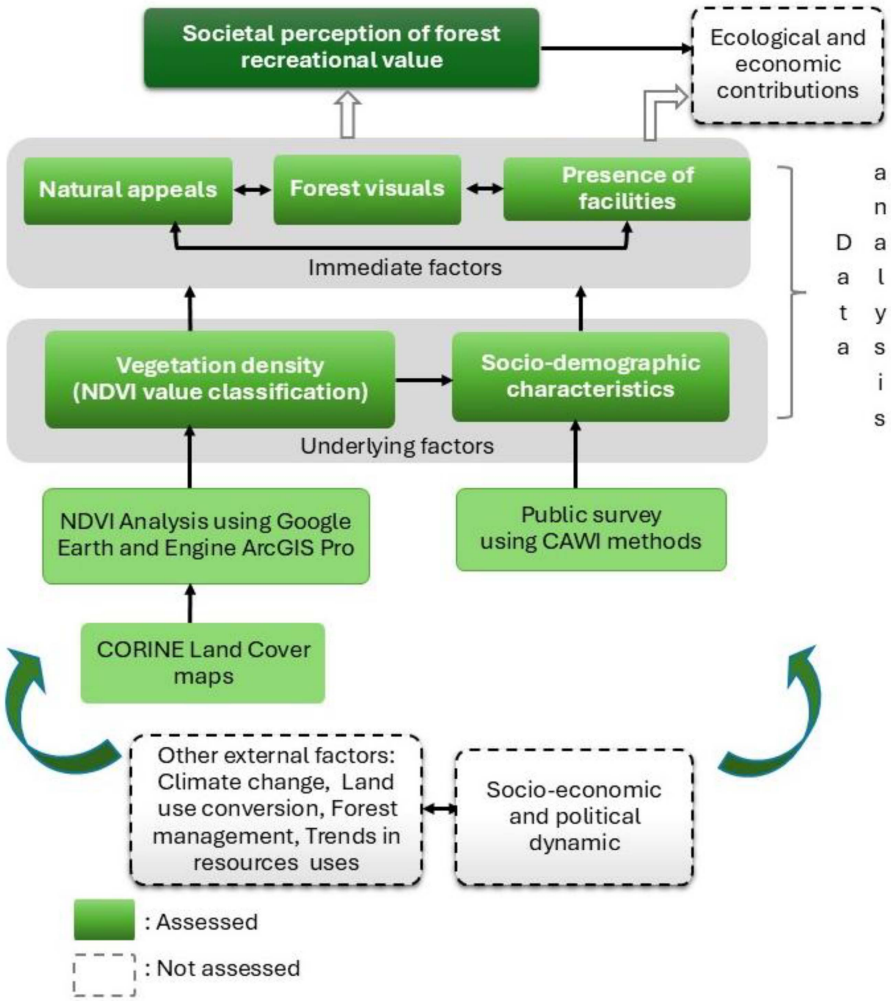

FIGURE 2
Framework of data collection.

very unimportant, to 5 (five), very important (Suárez-García et al., 2024). Additional impressions could be written/typed to explain the answer option: "others," which were later grouped and coded for further analysis. This scoring system was applied in all questions for preferences in forest naturalness descriptions and recreational facilities, resulting to Cronbach's alpha = 0.88 (good) for the internal consistency of the questions. The questions concerning preferences of forest stand types and naturalness (visual penetration of forests and presence of natural decaying wood) that indicate the closer-to-nature management (Larsen et al., 2022), were confirmed using pictures to ensure the validity of the questions (see Supplementary Figures A2a–c, from Hochmalová et al., 2022).

The level of visual penetration (Supplementary Figure A2b) was characterized by absent, medium, and high density of ground layers. The ground layer refers to the vegetation on the forest floor, including grasses, herbs, and small plants. Above this, the understory is the vegetation layer located beneath the dominant canopy. It consists of suppressed trees, shrubs, and other plant types and occupies an intermediate position between the ground layer and the overstorey (Toivonen et al., 2023). Natural deadwood is defined as decaying wood, usually lying on the forest floor or standing (in Czech: "mrtvé tlející dřevo"), and did not include standing dead trees ("souše") caused by bark beetle infestation (Hlásny et al., 2021c). Detailed questions on expected services of forest recreation were categorized into the availability of facilities, expected activities, and forest conditions (Supplementary Table A1).

In total, 1500 respondents were recruited (Table 1), with a similar proportion of males and females. As many as 57.7% of them resided in rural areas with less than 20,000 inhabitants. About 32% of the respondents belonged to the oldest age group (60 years and above), followed by those aged 30 to less than 45 years old. Of all respondents, 53 of them were forest owners or managers. Furthermore, only 18.4% of respondents from Prague-Central Bohemia lived in municipalities with less than 20,000 inhabitants, lower than from Bohemia (48.7) and Moravia (32.9%) ($p < 0.001$)

In this paper, classification of the respondents' residential characteristics was defined according to three factors: population size, group of regions, and classification of vegetation index values. Concerning group of regions, the Czech lands were formed by two ancient regions of Bohemia and Moravia (Marek, 2020).

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TABLE 1 General characteristics of the respondents in the studied areas, % (n).

Characteristics	Czech Republic N = 1,500
Population size	
- < 20,000 inhabitants	57.7 (866)
- ≥ 20,000 inhabitants	42.3 (634)
Study region	
- Prague-Central Bohemia	24.7 (371)
- Bohemia	41.2 (618)
- Moravia	40.7 (611)
Gender (female)	50.9 (764)
Age group	
- 18 to < 30 years	16.1 (242)
- 30 to < 45 years	28.4 (426)
- 45 to < 60 years	23.8 (357)
- 60 years and above	31.7 (475)
Education level	
- High school graduate without the state certificate (*maturita*) and below	49.9 (748)
- High school graduate with the state certificate (*maturita*) and higher education	50.1 (752)
Frequency of forest visits	
- Rarely, less than 1 × month	36.9 (554)
- Frequently, at least 1 × month	63.1 (946)

Based on recent studies, the Moravian society (South Moravia, Olomouc, Zlín, and Moravia-Silesia) demonstrated a distinctive preference for forest recreational activities, such as collecting non-wood forest products, compared to the Bohemians. In addition, Prague, as the capital city, and its outskirts (Central Bohemian region) exhibited typical urban development and lifestyle (Riedl et al., 2020; Purwestri et al., 2023a). Therefore, a comparison of the Czech regional groups (NUTS level 3) in the country, i.e., Prague-Central Bohemia, Bohemia, and Moravia, is also presented in this paper. A municipality with a population lower than 15,000 inhabitants in the Czech Republic is categorized as a small town (Pechrová and Šimpach, 2013; Vaishar et al., 2016). In this paper, the cut-off population size was increased to 20,000 people to avoid the overlapping of socio-demographic (age structure and education level), economic (employment rate), as well as environmental (infrastructure and facilities) factors (Pechrová and Šimpach, 2013; Vaishar et al., 2016). Hence, respondents living in areas with a density of ≥ 20,000 residents were categorized as from cities (urban or peri-urban), while their counterparts were from rural regions with less than 20,000 inhabitants. After applying the new categorization based on these two residential characteristics, the main indicators for sampling procedure (age and gender), remained consistent and comparable statistically to the total sample. The classification of vegetation index values is explained in section 2.3.

2.3 Data acquisition, preprocessing, and analysis of the Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is a key parameter for measuring vegetation vitality by recognizing changes in forest cover or land degradation (Meneses-Tovar, 2011; Huang et al., 2021; Xue et al., 2023). In this section, we explained the classification of vegetation index values based on the groups of the study region (Prague-Central Bohemia, Bohemia, and Moravia). The forest areas (in hectares) were extracted from the CORINE Land Cover (European Environment Agency, 2021) maps in homogeneous landscape arrays using ArcGIS Desktop 10.8.2 (Tom Sawyer Software, Berkeley, California). The forest area is defined as land covered with trees and woodlands where the height of trees exceeds 5 m, with a minimum of 30% canopy closure and a minimum threshold of 500 subjects per hectare of young shoots (Büttner et al., 2021). Then, the NDVI was developed from the forest area information for the selected year (2018) using CORINE Land Cover. The NDVI is constructed from red (R) and near-infrared (NIR) bands (Rouse et al., 1974; Pettorelli, 2013). The normalized vegetation index measures the health status of plants based on the reflectance and absorption of wavelengths, which highlights the difference between the visible band of red and the near-infrared (Pettorelli, 2013). The expression is as follows:

$$NDVI = (NIR - R) / (NIR + R)$$

A layer was built using the previous formula to derive the vegetation cover map. The LANDSAT 8 OLI image was provided by NASA's Earth Science Data Systems (ESDS) archives. The satellite image was acquired during the spring (April) of 2018 when the green leaves were sufficiently displayed. Then, atmospheric and radiometric methods were required to filter the cloud effects from a satellite image. Satellite MODIS with MOD09GA version and Google Earth Engine were used for satellite data acquisition.

Plants contain chlorophyll, which governs the greenness of their leaves (Gitelson and Merzlyak, 1997; Xu et al., 2000). In this context, remote sensing-derived NDVI was employed to evaluate an area's level of greenness with the values ranging between –1 and +1, with negative values corresponding to surfaces other than vegetation covers, such as water, for which the reflectance in the red is greater than that of the near-infrared (Rouse et al., 1973; Pettorelli, 2013). The NDVI values were initially calculated and classified on the NDVI map using the Natural Breaks (Jenks) method provided in the ArcGIS Pro based on the univariate classification scheme (De Smith et al., 2007), as follows:

- less than 0 : Bare soil and/or water
- 0 to < 0.2 : Very low/sparse vegetation
- 0.2 to < 0.4 : Low/sparse vegetation
- 0.4 to < 0.6 : Moderately low vegetation (more coverage, but still low-density vegetation)
- 0.6 to < 0.8 : Moderately high/dense vegetation
- 0.8 and more : High/very dense vegetation.

Afterward, the data were exported to Microsoft Excel, Microsoft 365 MSO version 2210 (Microsoft Corp, Redmond, WA, United States) for further analysis. The NDVI groups in this paper primarily followed the classification system developed

TABLE 2 Classifications of NDVI values in the studied regions.

NDVI values	Bare soil and/or water	Very low vegetation	Low vegetation	Moderately low vegetation	Moderately high vegetation	High vegetation
	Less than 0	0 to < 0.2	0.2 to < 0.4	0.4 to < 0.6	0.6 to < 0.8	0.8 and above
Studied region (in ha)[1]						
- Prague-Central Bohemia	7,865.4	1,593.8	68,410.2	252,027.4	766,309.7	54,392.6
- Bohemia	78,108.1	12,911.7	204,333.0	715,822.7	3,419,847.4	201,695.7
- Moravia	44,263.0	4,780.1	107,617.6	345,425.1	1,396,921.0	316,013.2
Proportion of the areas (in %)						
- Prague-Central Bohemia	0.7	0.1	5.9	21.9	66.6	4.7
- Bohemia	1.7	0.3	4.4	15.5	73.8	4.4
- Moravia	2.0	0.2	4.9	15.6	63.1	14.3

[1] Data are presented in sum.

by Aburas et al. (2015), except in this study, one group, "high vegetation," was introduced to account for areas within the Moravia study region. These were shown to have the highest proportion (14.3%) in high vegetation index (above 0.8) compared to the other locations (Table 2). The areas with very high vegetation in Moravia appear to be associated with the White Carpathian Forest along the Czech border with Slovakia. The mixed and dense nature of the protected forest areas is recognized for its rich biodiversity (Wilson et al., 2012). Although Prague-Central Bohemia had the smallest absolute acreages of moderately high and high vegetation, both classifications combined still showed a considerable proportion (71.3%) in these categories within Prague-Central Bohemia. Moreover, significant alterations in forest vegetation locations in Bohemia have been evident, aligning with the Czech Forest Act's objective to augment the share of mixed forests in the country. Contrastingly, a decline in the coniferous forest region in Moravia was identified and attributed to salvage logging caused by the bark beetle infestation (Hlásny et al., 2021c; Purwestri et al., 2023b).

Furthermore, for future analysis, the NDVI classifications (Table 2) for moderately high and high vegetation were combined and categorized as high vegetation index values, while the remaining classifications were grouped as low vegetation. For future analysis (especially the predictor analysis), these new combined groups and their cumulative proportions and areas were used.

2.4 Data analysis

Comparison between categorical data groups, such as general characteristics information, population size, and preferences of forest visuals, was analyzed using a chi-square test. Continuous data were initially assessed for normality using the Kolmogorov-Smirnov normality test (Hassard, 1991). For comparing groups of non-categorical and not-normally distributed data, such as areas of vegetation index across the study regions, a non-parametric test, i.e., Mann-Whitney test (for two groups) and Friedman test (for three or more groups) followed by the Bonferroni test for pairwise comparisons, was employed. The Spearman's rank non-parametric correlation tests analyzed the association between two non-normally distributed data (Ott and Longnecker, 2001), i.e., scores of public expectations and vegetation index values.

Detailed results of association between forest visuals and scores of naturalness descriptions and recreational facilities are presented in Supplementary Tables A2, A3. Scores 1 (one) to 3 (three) were combined into a low-score group, while 4 (four) and 5 (five) were classified as a high-score group to address the issue of small values in individual cells. The association between the investigated forest visuals and the scoring group (high and low-score) was analyzed using the chi-square test.

Binary regression analysis with the forward conditional approach was used to identify the potential predictors of the questioned visual preferences from the forests (Ott and Longnecker, 2001). The reference (one = 1) for the dependent variable was the investigated visual preference. Independent parameters of residential characteristics included in the analysis were population size (1 = population less than 20,000 inhabitants), group of study region (1 = investigated study area, Prague-Central Bohemia, Bohemia, and Moravia), vegetation index value percentages (1 = investigated classification), categorized as low (bare soil/water until moderately low), or high vegetation (moderately high and high). Other attributes of the respondents were also included: age (1 = 18–45 years), gender (1 = female), education level (1 = high education level, defined as high school graduates with the state certificate and above), and frequency of forest visits (1 = frequently, described as a visit to forests more than once a month). In line with the regression results, only parameters with a significant association with the dependent variables were presented. A p-value of less than 0.05 was the designated statistical significance in all analyses. Statistical analysis was completed using IBM SPSS version 26 (IBM Corp., Armonk, NY, United States).

3 Results

The results addressing the first research objective indicated that forest views featuring mixed tree species, medium visual

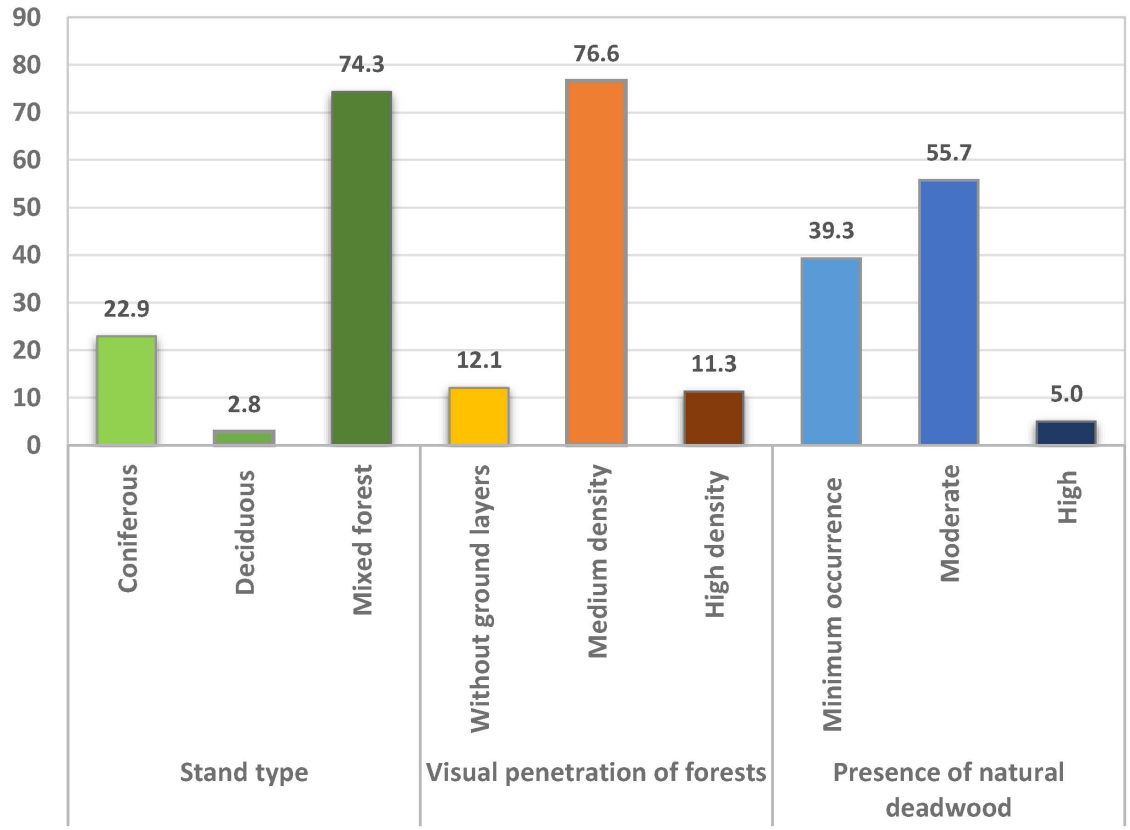

FIGURE 3
Forest visual preferences (N = 1,500).

permeability, and a moderate presence of natural deadwood were the most preferred (Figure 3). The chi-square test did not show a statistically significant association between forest visuals and the combined groups of vegetation index values (low and high vegetation areas). Using the same test, no statistically significant differences were found in the expectation of visual appearance of forests by population size categories (below 20,000 and with 20,000 or more people) and the studied regions (Prague-Central Bohemia, Bohemia, and Moravia).

Despite considerable differences in the population sizes of the two respondent groups and three studied regions, their expectations regarding forest conditions did not result in statistical significant difference, as indicated by chi-square test results. Therefore, the results were pooled, and the total values are presented in Table 3. Most respondents rated the highest or second highest for silent and unoccupied forests with no disturbances from human activities (55.2 and 33.2%, respectively), with an average score of 4.4 out of 5 points, followed by forest floor without harvest residue. Meanwhile, forests without human intervention and non-overgrown paths scored the least (3.8 ± 1.0).

Concerning forest recreational facilities, the presence of education trails and visible signs were the most preferred, while the availability of kiosks was considered the least important (Table 3). Education trails and visible signs were considered important facilities in all varieties of stand types, together with forest accessibility and nearby parking areas. Additionally, using chi-square test, no statistically significant differences were observed in forest naturalness conditions and recreational facility preferences between all respondents and forest owners/managers.

Table 4 presents the associations between forest visuals and naturalness descriptions, addressing the second research objective of exploring the links between the investigated forest visuals and perceptions of naturalness. Overall, the preference for all forest stands, levels of visual penetration, and various densities of natural deadwood were linked to a high proportion (above 51.1%) of top-rated natural forest descriptions, such as silence, absence of disturbances, and lack of human activities. At the same time, the respondents gave high scores for forests with clear paths free from harvest residue and overgrown bushes/weeds, which were particularly evident among those who preferred forests with minimal or medium ground layers and natural deadwood ($p < 0.05$ and $p < 0.001$, respectively, chi-square test). Forests with a medium density of ground layers were chosen as the most preferred by 76.6% of the Czech respondents (Figure 3), which linked to the highest prevalence of high-rated undisturbed forests (89.7%, $p < 0.05$) compared to other levels of visual penetration. The proportion of respondents who preferred forests with minimal ground layers and gave high ratings for clear paths free from harvest residues, as well as overgrown bushes and weeds, was significantly higher (79.1 and 72.0%, respectively) compared to those who favored forests with medium or high density of ground layers.

More than 50% of respondents who favored a high density of deadwood in forests did not expect clear paths ($p < 0.001$) compared to those who preferred minimal and medium densities.

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TABLE 3 Expectations of conditions and facilities of forest recreation services (N = 1500)[1].

Expectation	Score					Mean ± SD
	1	2	3	4	5	
Forest condition						
Silent and unoccupied forests with no disturbances from human activities	0.9 (14)	1.3 (19)	9.3 (140)	33.3 (499)	55.2 (828)	4.4 ± 0.8
Forests without harvest residues and clear forest floor among the trees	2.6 (39)	4.7 (70)	19.7 (296)	38.1 (571)	34.9 (524)	4.0 ± 1.0
Trails and paths not overgrown by shrubs and weeds	4.1 (61)	6.2 (93)	25.7 (385)	37.9 (568)	26.2 (393)	3.8 ± 1.0
Natural forests without any human intervention with impenetrable places	3.0 (45)	6.5 (97)	28.6 (429)	35.0 (525)	26.9 (404)	3.8 ± 1.0
Facilities						
Education trails (shelters, springs, lookout towers, etc.)	1.7 (26)	4.3 (64)	18.4 (276)	42.9 (644)	32.7 (490)	4.0 ± 1.0
Visible signs	2.1 (13)	4.1 (26)	17.7 (112)	41.9 (271)	32.1 (482)	4.0 ± 1.0
Easy access for strollers and people with disabilities	6.9 (104)	11.0 (165)	31.0 (465)	30.9 (464)	20.1 (302)	3.5 ± 1.2
Bike trail networks	13.1 (197)	17.4 (261)	30.7 (460)	26.3 (394)	12.5 (188)	3.1 ± 1.2
Sports facilities for active leisure time (tree climbing, forest gym, etc.)	15.9 (239)	20.8 (312)	30.7 (460)	21.5 (323)	11.1 (166)	2.9 ± 1.2
Parking places nearby	15.7 (235)	17.7 (266)	32.3 (484)	22.9 (343)	11.5 (172)	2.9 ± 1.2
Kiosks with refreshments at the main entrance and the edges	29.7 (446)	22.7 (340)	24.1 (362)	14.1 (212)	9.3 (140)	2.5 ± 1.3

[1] Data are presented as % (n) or mean ± standard deviation; Scoring system: 1 (very unimportant) to 5 (very important).

They preferred forests characterized by silence (82.7%) and an absence of human activity with impenetrable areas (68.0%, $p < 0.01$).

Table 5 depicts the relationship between the investigated forest visuals and the expectations regarding the availability of recreational facilities. Approximately 50 to 83% of respondents classified in all categories of the evaluated forest visuals, assigned high scores for the availability of education trails, visible signs, and paved paths; however, participants who favored forests with a high density of ground layers, as well as medium and high densities of deadwood, did not expect forests with easy access ($p < 0.001$). Additionally, approximately 50–79% of participants in all categories of forest visuals were less interested in parking areas, kiosks, and sports amenities, like tree climbing sites. In particular, a high proportion of the low-score group for sports facilities and kiosks was found among those who favored mixed forest stands (69.7%, $p < 0.01$ and 78.7%, $p < 0.001$, respectively). The low-rating group for nearby parking and kiosks was especially prevalent among respondents who preferred forests with a medium density of ground layers (67.7%, $p < 0.001$ and 78.5%, $p < 0.01$, respectively). Conversely, respondents who preferred forests with a high density of natural deadwood were associated with a lower ranking for sports networks and nearby parking (72.0 and 73.3%, respectively, $p < 0.01$).

Table 6 presents the findings of binary logistic regression analysis using the forward approach, addressing the fourth research objective, which examines the independent variables associated with the high-score group of the preferred forest visuals. Only parameters with a significant association with the dependent variables were presented. The results showed that frequent forest attendance and being in the active age group (18–45 years old) were the primary predictors associated with high-rated forest appearances. Other significant factors associated with a high score of forest visuals were residential characteristics, higher level of education, and gender.

Respondents who visited forests frequently (more than once a month) were approximately 1.3–1.4 times more likely to favor moderate levels of deadwood and mixed forest, respectively. Conversely, they were less likely to prefer coniferous stands, forests without ground layers, and those with minimal natural deadwood. Respondents (aged 18–45 years) were about 1.83 and 1.93 times more likely to favor high density of ground layers ($p < 0.001$) and deadwood ($p = 0.006$), respectively. They also disfavored the minimum presence of natural deadwood ($p = 0.005$). Furthermore, Czech female respondents were observed to be less inclined toward deciduous forests.

Survey respondents residing in areas with a larger population (20,000 or more) were approximately 1.3 times as likely to belong

TABLE 4 Association between visual preferences and high and low-score group of preferred forest conditions (N = 1500)[1].

Forest visuals	Naturalness descriptions							
	Silent and unoccupied forests with no disturbances from human activities		Natural forests without any human intervention with impenetrable places		Forests without harvest residues and clear forest floor among the trees		Trails and paths not overgrown by shrubs and weeds	
Stand type	Low	High	Low	High	Low	High	Low	High
Coniferous (n = 343)	12.5 (43)	87.5 (300)	36.7 (126)	63.3 (217)	24.8 (85)	75.2 (258)	34.7 (119)	65.3 (224)
Deciduous (n = 42)	19.0 (8)	81.0 (34)	28.6 (12)	71.4 (30)	28.6 (12)	71.4 (30)	28.6 (12)	71.4 (30)
Mixed forest (n = 1115)	10.9 (122)	89.1 (993)	38.8 (433)	61.2 (682)	27.6 (308)	72.4 (807)	36.6 (408)	63.4 (707)
Visual penetration								
Without ground layers (n = 182)	17.0 (31)	83.0 (151)	48.9 (89)	51.1 (93)	20.9 (38)	79.1 (144)*	28.0 (51)	72.0 (131)***
Medium density (n = 1149)	10.3 (118)	89.7 (1031)*	38.0 (437)	62.0 (712)	27.1 (311)	72.9 (838)	35.5 (408)	64.5 (741)
High density (n = 169)	14.2 (24)	85.8 (145)	26.6 (45)	73.4 (124)***	33.1 (56)	66.9 (113)	47.3 (80)	52.7 (89)
Presence of natural deadwood								
Minimum occurrence (n = 589)	11.7 (69)	88.3 (520)	43.0 (253)	57.0 (336)	19.0 (112)	81.0 (477)***	30.1 (177)	69.9 (412)***
Moderate (n = 836)	10.9 (91)	89.1 (745)	35.2 (294)	64.8 (542)	30.3 (253)	69.7 (583)	38.0 (318)	62.0 (518)
High (n = 75)	17.3 (13)	82.7 (62)	32.0 (24)	68.0 (51)**	53.3 (40)	46.7 (35)	58.7 (44)	41.3 (31)

[1] ata are presented as % (n); *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$; chi-square test, the p-value sign was placed on the highest proportion in each crosstabulation category.

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TABLE 5 Association between visual preferences and high and low-score group of preferred recreational facilities (N = 1500)[1].

Forest visuals	Recreational facilities													
	Education trails, shelters, springs, lookout towers etc.		Clearly visible tourist trails, signs, and information boards		Easy access to forest for strollers and people with limited mobility (paved paths)		A bike trail networks		Sports facilities for active leisure time (tree climbing sites, tree climbing, zip lines, etc.)		Parking located nearby		Kiosks with refreshments at the edges and main entrances	
Stand type	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Coniferous (n = 343)	26.2	73.8	25.9	74.1	45.8	54.2	57.4	42.6	62.1	37.9	63.0	37.0	71.4	28.6
Deciduous (n = 42)	26.2	73.8	16.7	83.3	45.2	54.8	50.0	50.0	50.0	50.0	54.8	45.2	59.5	40.5
Mixed forest (n = 1115)	23.8	76.2	26.3	73.7	50.0	50.0	62.8	37.2	69.7**	30.3	66.9	33.1	78.7***	21.3
Visual penetration														
Without ground layers (n = 182)	28.0	72.0	24.7	75.3	44.5	55.5	58.8	41.2	60.4	39.6	52.2	47.8	69.8	30.2
Medium density (n = 1149)	23.8	76.2	24.6	75.4**	48.9	51.1	61.7	38.3	68.9	31.1	67.7***	32.3	78.5**	21.5
High density (n = 169)	24.9	75.1	36.1	63.9	53.8	46.2	60.4	39.6	64.5	35.5	66.3	33.7	70.4	29.6
Presence of natural deadwood														
Minimum occurrence (n = 589)	21.9	78.1*	21.1	78.9***	43.6	56.4	59.6	40.4	62.6	37.4	61.0	39.0	74.2	25.8
Moderate (n = 836)	25.2	74.8	27.3	72.7	51.2	48.8	62.0	38.0	70.3	29.7	63.8	31.7	78.1	21.9
High (n = 75)	34.7	65.3	49.3	50.7	65.3***	34.7	65.3	34.7	72.0**	28.0	73.3**	26.7	77.3	22.7

[1] Data are presented as %; *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$, chi-square test; the p-value sign was placed on the highest proportion in each crosstabulation category.

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TABLE 6 Respondents' attributes as predictors of forest visual preferences based on binary logistic regression analysis[1].

Predictors	Beta (B)	Standard Error (SE)	Wald	Exp (B)	*p*-value
Type of forest vegetation					
Coniferous					
- Forest visit (1 = = frequent)	−0.32	0.13	6.67	0.72	0.010
Deciduous					
- Gender (1 = = female)	−0.86	0.34	6.52	0.42	0.011
Mixed Forest					
- Forest visit (1 = frequent)	0.32	0.12	6.90	1.38	0.009
- Population size (1 = ≥ 20,000)	0.26	0.12	4.54	1.27	0.048
Visual penetration					
Without ground layers					
- Forest visit (1 = frequent)	−0.33	0.16	4.36	0.72	0.037
High density of ground layers					
- Education level (1 = high)	−0.39	0.17	5.37	0.68	0.020
- Age (1 = 18–45 years)	0.81	0.21	13.30	1.83	< .001
Presence of natural deadwood					
Minimum presence of deadwood					
- Forest visit (1 = frequent)	−0.33	0.16	4.36	0.72	0.037
- Study region (1 = Prague-Central Bohemia)	−0.26	0.12	4.41	0.77	0.036
- Age (1 = 18–45 years)	−0.302	0.11	7.92	0.74	0.005
Medium presence of deadwood					
- Forest visit (1 = frequent)	0.22	0.11	4.19	1.25	0.041
- Study region (1 = Prague-Central Bohemia)	0.30	0.12	6.03	1.35	0.035
High presence of deadwood					
- Age (1 = 18–45 years)	0.66	0.24	7.41	1.93	0.006

[1]Beta (B) = regression coefficient; Standard Error (SE) = Standard Error of Beta, Wald = Wald statistics, square of the ratio of B to SE; Exp (B) = exponential value of B, estimated odds ratio.

to the category showing a high preference for mixed forests (p = 0.048). The predictor analysis also revealed that participants in the Prague-Central Bohemian study region had 1.35 times higher odds of exhibiting a strong preference for a medium presence of natural deadwood (p = 0.035). Meanwhile, they disfavored a minimal occurrence of the deadwood (p = 0.036).

4 Discussion

Given the ongoing global economic, environmental, and societal transformations, changes in recreational needs and preferences for forests, such as vegetation type, naturalness, or aesthetic values, facilities, their interconnections, and relationship with respondent's attributes, are envisioned (Panagopoulos, 2009; Paletto et al., 2017; Hochmalová et al., 2022). As discussions around conservation and sustainable forest management intensify at both national and EU levels, particularly concerning the ecological benefits of forests, it becomes evident that these issues are deeply intertwined with societal values and preferences (Sauvain, 2003; Paletto et al., 2023; Hering et al., 2023; Bayraktar et al., 2024). Hering et al. (2023) emphasized the importance of recognizing this connection and integrating it into policy-making and forest management decisions, by understanding how people relate to forests, not just as a resource for recreation but also as a crucial component of ecological health and sustainability, and how this will aid in the sustainable development of this ecosystem service.

4.1 Forest visual preferences: associations with naturalness descriptions and recreational facilities

The Czech Forest Act allows public access to 92% of the country's forests, excluding military zones, protected areas, and national parks, as long as the environment remains undisturbed (Ministry of Agriculture of the Czech Republic (MoA), 2016; Hochmalová et al., 2021). Public free access to forests supports wide range of outdoor activities for all societal groups (Bauer and Matleena Kniivilä, 2004), particularly in countries with high to medium forest cover, such as the northern regions (e.g., Finland, Norway, Sweden), as well as Central and Eastern Europe (e.g., Germany, Austria, the Czech Republic, Poland) (Bell et al., 2009; Hochmalová et al., 2021). These recreational activities

strengthen the connection between the society and environment and contributing to improved health and wellbeing (Bell et al., 2007, 2009). Furthermore, these outdoor activities are linked to the provision of recreational facilities (Hynes et al., 2006; Bell et al., 2007), which are shaped from societal preferences, as also described in the framework of the study (Figure 2). This Czech legal framework also allows our study to explore public preferences regarding different forest environments, providing valuable insights for forest management and contributing to the broader understanding of public desires in forest recreation.

Our survey found that most of Czech society favored mixed tree stands (74.3%), which was followed by coniferous monoculture (22.9%) (Figure 3). The preference of mixed trees was likely due to the aesthetic appeal of forests throughout all seasons, where changing color and leaf density enhance the visual attractiveness, unlike in coniferous monoculture vegetation, as reported by Edwards et al. (2012) and De Meo et al. (2015). Furthermore, coniferous forests were associated with the potential for more human activities, such as logging, as their management typically focuses on such objectives. When the naturalness descriptions were linked to the visuals based on stand types, over 60% of the Czech respondents in all categories gave high scores for a silent, undisturbed forest and minimal human intervention (Table 4), indicating the societal preference for closer-to-nature management, along with appreciation of enjoying and walking within them. The findings suggest the need for a balance between forest access and conservation, as well as the development of recreational facilities that align with society's preferences for enjoyment and walking in forests. In our survey, mixed forest was also the most favored visual among the forest managers/owners (n = 53). However, Janová et al. (2022) reported that despite being well-informed about the ecological advantages and the potential economic benefits of mixed tree species, forest managers favored coniferous trees over deciduous ones. Their decisions regarding stand type selection are still primarily influenced by economic considerations and adherence to the Czech Forest Act. Coniferous trees, specifically Norway spruce (*Picea abies*), dominate Czech forests, accounting for approximately 50% of the total tree population (Ministry of Agriculture of the Czech Republic (MoA), 2022). Coniferous vegetation has contributed substantially to economic benefits in the Czech Republic, as evidenced by its status as one of the top global wood exporters (FAO, 2021). Currently, due to initiatives outlined in the Czech Forest Act, which aims to reduce the dominance of Norway spruce by 28.3% in favor of promoting mixed stands, the proportion of coniferous trees is gradually decreasing (Apltauer et al., 2021). This shift intends to enhance ecological diversity (Gamfeldt et al., 2013) and resilience within forest ecosystems (Kunert and Cárdenas, 2015; Jactel et al., 2017). From the recreational perspective, changes in forest management, particularly selecting tree species, can significantly impact forest visuals (Ruddell et al., 1989; Edwards et al., 2012). Furthermore, contrasting visual effects observed in forests before and after tree harvesting can influence the views (Brown, 1987), which is more prevalent in coniferous productive forests in this country.

Forests with medium density of ground layers were the most preferred visual penetration type by 76.6% of the Czech survey participants (Figure 3), which agrees with the perceptions of respondents from four European regions. According to these respondents, forests with medium levels of ground layers were perceived as "clean forests" and enabled movement (Edwards et al., 2012). In our study, respondents associated the visual penetration levels with high scores for undisturbed forests, along with clear paths free from harvest residue, overgrown bushes, and weeds, which were particularly evident among those who preferred forests with minimal or medium ground layers ($p < 0.05$). Those who favored high-density ground layers did not expect forests with clear paths (Table 4). The results indicated societal preferences for various visual penetrations were linked to their expectation in enjoying forests. Activities like hiking and sports in forests can be comfortably accommodated in areas with open forests with minimal and medium levels of ground layers (Kaprová et al., 2014) and are more easily practiced in forests with clear paths. Since we did not ask the respondents to explain the reasons for picture selection in this category, other than linking them with the naturalness of the forest condition, the findings reported by Kaprová et al. (2014) help to highlight these recreational aspects essential in enjoying forests.

Deadwood plays a crucial role in the species diversity of forests, such as for invertebrate fauna (Andringa et al., 2019; Zuo et al., 2021; Zumr et al., 2024a,b), fungi (Abrego and Salcedo, 2013), arthropods, bats (mammals), and birds (Bouvet et al., 2016). Moreover, deadwood is considered essential in the carbon, nitrogen, and phosphorus cycles, influencing soil fertility (Köster et al., 2015; Smyth et al., 2016). However, it can affect the aesthetic view and reduce recreational value. As reported by Paletto et al. (2017), about 40% to 43% of the survey respondents in Italy perceived that standing and lying deadwood occurrence in various types of forests decreased the aesthetic value, higher than 7.5 and 23%, respectively, who considered it positively. Furthermore, a study in Germany and the US reported that visitors preferred healthy mature forest stands and disliked forests with substantial deadwood (Arnberger et al., 2018). Contrastingly, in this survey, 55.7 and 5% of the respondents preferred medium and high presence of natural deadwood in the forests (Figure 3), indicating support for the naturalness of the forests. Generally, Czech visitors reported to highly value forests that serve as a natural habitat for animals and plants (Purwestri et al., 2023b).

Another aspect from a sociological perspective is related to the history of the country. A growing interest in civic engagement has been reported in post-communist countries. This interest is characterized by a rediscovery of civic participation and activism in almost all sectors as essential components of democratic societies. The Czech Republic is among the countries where this trend is evident (Narozhna, 2004; Stachová, 2008). The societal engagement included supportive activities related to environmental issues, which were downgraded during the previous regime (Scrieciu and Stringer, 2008; Stachová, 2008; Chaisty and Whitefield, 2015). Hence, while this study did not explore the underlying reasons for the preference for forest naturalness, the Czech society's historical reconnection and growing civic engagement contribute to explanations of expectations for the protection and sustainability of future forest ecosystems.

Facilities for educational purposes and accessibility (visible signs, easy access for strollers and wheelchairs, and nearby parking areas) were preferred in all stand types.

However, participants who favored forests with a high density of ground layers, as well as medium and high densities of deadwood, did not expect forests with easy access ($p < 0.001$).

Participants across all categories of forest visuals showed less interest in secondary recreational facilities, i.e., sports amenities, parking areas, and kiosks. This was particularly evident among those who favored mixed forest and medium density (Table 5), the top-ranked choices for forest stands and visual penetration. Additionally, the low-score group for sports networks and nearby parking was observed among respondents who favored forests with a high density of natural deadwood. The findings suggest a stronger preference for preserving the natural aesthetic and ecological integrity of forests, with the exception of amenities that support education and accessibility. It highlights the societal preference for forest experiences focused on peace and connection with nature rather than those centered on fabricated secondary facilities.

4.2 Predictive factors of preferred forest appearances

The fourth research objective is understanding society's preferences and attributes, which can be useful in developing forest recreation management. Binary logistic regression was used to define the significant predictors of the high preference in provided forest visuals (Supplementary Figures A2a–c). In our survey, frequent forest visitors and the young age of respondents were identified as the primary predictors significantly associated with strong preferences or dislikes for different forest types based on visualization (Table 6). Respondents who visited forests more than once a month were 1.3–1.4 times more likely to prefer moderate amounts of deadwood and mixed forests, both ranked the most preferred types of forest visuals. In contrast, they were less inclined to favor coniferous stands, trees without ground layers, or those with minimal natural deadwood, indicating a preference for closer-to-nature forests (Larsen et al., 2022). In line with our findings, a study conducted in Slovakia reported that diverse tree species, natural forest scents, and uneven-aged forests were significantly associated with improved subjective wellbeing after forest visits (Výbošťok et al., 2024). Research among Irish respondents also emphasized that the presence of a nature reserve and natural environment in the forests is an important attribute for the visitors, which encourages them to enjoy the forests more frequently (Scarpa et al., 2000). Regular forest attendees were the primary beneficiaries of the ecosystem service-related recreation aspects, as they intentionally left their routine lives to experience nature and perform various recreational activities (Clough, 2013). Forest visitors even continued to look for an escape into the forest during the COVID-19 pandemic, which was evident by the increase in the number of visitors during the period of increased restrictions of movement in European forests, e.g., in Slovakia (Pichlerová et al., 2023), Germany (Derks et al., 2020), as well as in the Czech Republic (Jarský et al., 2022). Female respondents from the Czech Republic were also found to not prefer deciduous forests, possibly due to the less aesthetic view during the bare branch period (Nelson et al., 2001; Edwards et al., 2012).

Respondents (aged 18–45 years) were about 1.83 times more likely to favor a high density of ground layers, in contrast to the Czech participants categorized in the high education level group (p = 0.020). Referring to the results of Table 5, where 53.8% of respondents who desired forests with thick ground layers did not expect easy access to forests. We speculate that this type of forests was likely viewed as inaccessible and unappealing for the respondents from this category, especially if young children or elderly family members accompany the respondents. In line with our findings, Kaprová et al. (2014) presented that visitors (n = 722) in the Jizera Mountains Protected Landscape Area, Czech Republic, assigned the highest aesthetic values to forests with less dense vegetation characterized by broadleaf and immature forest stands, which enhances their visual experience and overall utility during recreation, such as hiking and biking.

Young respondents aged 18–45 years were about 1.93 times more likely to prefer a high density of deadwood. In contrast, they disfavored the minimum presence of natural deadwood, reflecting a clear preference for the naturalness of the forests. In connection to the perceived functions of natural deadwood among young generations, De Meo et al. (2024) revealed that among young generations in Italy, Iran, and Türkiye, the most significant function of natural deadwood identified by respondents was its role as a biodiversity hotspot. Paletto et al. (2023) further reported that more Turkish students perceived lying and standing deadwood positively in terms of aesthetic value (50 and 29.5%, respectively) compared to the Italian students (37.5 and 7%, respectively). Moreover, although the Turkish respondents positively accepted the presence of deadwood and were aware of their ecological importance, they still favored forests without it from an aesthetic perspective (Bayraktar et al., 2024; De Meo et al., 2024). The preference for the naturalness of the forests among those Italian students may be shaped by the ongoing discussions surrounding silviculture management practices and perception toward clean forests free from shrubs and deadwood (Paletto et al., 2023). In our survey, the young Czech respondents may have been influenced by environmental-friendly discussions toward natural landscapes, which likely shaped their preference for closer-to-nature forests. The research was carried out during the bark beetle outbreak when the forests and forestry sector faced negative perceptions from the Czech public. This led to initiatives, such as a nationwide project funded by the Ministry of Agriculture of the Czech Republic, which launched the website[2] ("Don't Feed the Bug") to provide accurate information on combating bark beetle infestations. Meanwhile, research and publications into preventing and mitigating the impacts of bark beetle outbreaks continue to be a priority (Hlásny et al., 2021b,c).

From our survey, respondents residing in areas with larger population size ($\geq$ 20,000) together with frequent forest attendance had about 1.3 times higher chances of showing a strong preference toward mixed stands (Table 6). The predictor analysis results also presented a medium occurrence of deadwood preference, significantly associated with the respondents' residential place in Prague-Central Bohemia (odd ratio = 1.35), together with frequent forest visits. In contrast, these respondents were more inclined to dislike the minimum presence of natural deadwood. Prague-Central Bohemia has a larger proportion of high population sizes (over 20,000 people) compared to Bohemia and Moravia ($p < 0.001$) and a considerable proportion (71.3%) of their landscapes were under the moderately high and high vegetation index category, which was comparable to other groups of study (Table 2)

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regions. In the Czech Republic, municipal forests play a vital role, particularly near major urban agglomerations, offering residents a refuge from the pressures of daily city life (Jůza et al., 2020). This proximity drives the demand for nature-based recreation, especially outside Prague, which has limited forest cover inside the city (Riedl et al., 2020). Our findings were supported by a study in Latvia, where urban dwellers were willing to travel a longer distance to visit forests than those from rural regions (Jankovska et al., 2013). Urban inhabitants in Italy indicated preferences for visiting peri-urban forests because of their fresh air and naturalness level (Paletto et al., 2017). Additionally, another study among urban residents in Germany provided insight that a forested landscape's attributes, such as stand type diversity and naturalness, were more important than the distance and facilities (Boll et al., 2014). Nature is regarded as a source of positive emotions, providing restorative experiences that improve wellbeing and reduce stress. On the other hand, urban environments tend to evoke mixed responses, including positive attributes like energy and social engagement, alongside negatives, such as noise, crowding, and stress (Beute and De Kort, 2019). In this context, urbanization, a complex process involving the growth and expansion of city infrastructure, can lead to varying preferences among urban inhabitants, but the development of forest recreation in the city should be prioritized.

Studies on societal preferences for forest environments are essential for understanding visitor behavior, linking it with a preferred forest management type. Experiences with other entities, such as wildlife or fellow visitors, have been shown to significantly shape their preferences. Moreover, the visitors may influence these interactions, further impacting their overall perception of the forest environment (Skov-Petersen et al., 2021). Our study did not explore the connection between respondents' selections and their interactions with other entities, including reasons for forest type preferences under study. Therefore, we recommend future research to address these gaps and explore the dynamics of these interactions. Additionally, associations between preferences and respondents' attributes emphasize the need for a forestry communication strategy incorporating the importance of recreational value and sustainable tourism practices in forests (Riedl et al., 2019).

5 Conclusion

Our findings revealed that respondents preferred mixed stands, medium-level ground layers, and a moderate amount of natural deadwood, reflecting a desire for the natural appeal of forests and the enjoyment of walking within them. Recreational forests are expected to provide essential facilities for educational purposes, as well as ensure accessibility for all visitors. Using Czechs as a case study, these results can serve as proxy measures for developing recreational services in other countries with similar socio-demographic and forest characteristics. Our results emphasize the need for a balance between forest accessibility and conservation, as well as providing recreational facilities that align with society's preference for outdoor activities and natural environments.

Frequent forest visits, combined with being in the active age group (18–45 years old), were the main predictors of how forest appearances were valued. Other significant factors influencing high scores for forest visuals included living in urban-suburban areas, higher education levels, and gender. Understanding these preferences can help forest owners and managers tailor the development and promotion of recreational services to specific target groups based on their characteristics and location, making them more cost-effective and at the same time, accepted by the community. When considering visitors' desires, forest management strategies must ensure the continued biodiversity of flora and fauna and the resilience and health of forests. Furthermore, the links between preferences and respondents' attributes highlight the need for a forestry communication strategy that integrates the significance of recreational value and sustainable tourism practices in forest management.

Our results indicated the importance of continuous monitoring to address emerging challenges faced by forests and shifts in public preferences, as well as the critical role of policymakers in balancing forest conservation with recreational use through the promotion of sustainable, closer-to-nature forest management and regulations of infrastructure development in nature-based tourism.

Since we did not examine the underlying reasons for societal preferences regarding forest views, naturalness, and facilities, particularly their benefits for human wellbeing, further research should address these aspects. Additionally, further exploration of preferences and the potential benefits of outdoor activities in urban and rural forests could be done to enhance recreational opportunities that promote public health and wellbeing through natural environments.

Data availability statement

The CORINE land cover dataset analyzed during the current study is available in the Copernicus Land Monitoring Service repository, https://land.copernicus.eu/pan-european/corine-land-cover. The raw data from the survey supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Participants were first provided with an explanation of the survey's purpose and objectives. Only those who gave informed consent proceeded to complete the online questionnaire. No personally identifiable information was collected, ensuring the anonymity and confidentiality of all participants. The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments or equivalent ethical standards. The study protocol was approved by the Ethics Committee of the Faculty of Forestry and Wood Sciences, Czech Univ of Life Sciences, Prague to: Česká Zemědělská Univerzita v Praze (CZU). The survey was done in collaboration with STEAM/MARK, Inc., a marketing research agency, a member of SIMAR (Society of Market and Opinion Research Agencies) and

ESOMAR (The World Organization for Opinion and Marketing Research). All STEM/MARK activities, including informed consent provision and processing of personal data, are carried out following the ICC/ESOMAR industry code and company guidelines (https://esomar.org/uploads/attachments/ckqtawvjq00uukdtrhst5sk9u-iccesomar-international-code-english.pdf).

Author contributions

RP: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – review & editing. MH: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. PP: Investigation, Methodology, Writing – original draft, Writing – review & editing. MT: Investigation, Software, Writing – original draft, Writing – review & editing. DH-B: Data curation, Formal Analysis, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing. SA: Investigation, Writing – original draft, Writing – review & editing. SL: Data curation, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing. FR: Data curation, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing. MH: Investigation, Methodology, Writing – original draft, Writing – review & editing. VJ: Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. MR: Investigation, Methodology, Writing – original draft, Writing – review & editing. RD: Funding acquisition, Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research work was supported by the project "Payments for ecosystem services of forest and forestry", financed by the Ministry of Agriculture of the Czech Republic with NAZV (Grant No. QK23020008).

Acknowledgments

We appreciate the support of the "Advanced research supporting the forestry and wood-processing sector's adaptation to global change and the 4th industrial revolution (EVA 4.0)" project. We also appreciate the support of Harald Vacik in developing the earlier draft of the questionnaire. We thank Jitka Šišáková and Richard Lee Manore for proofreading the article and wish to acknowledge the helpful input of the reviewers.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The authors declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/ffgc.2025.1486532/full#supplementary-material

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