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Ecosystem services and disservices of forests and greenspaces: A pan-European representative study of societal perceptions

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ABSTRACT

Understanding public perceptions of ecosystem services and disservices of forests and greenspaces is essential for developing targeted forest policy and management strategies. However, across Europe, geographic differences and the role of demographic patterns and values in shaping perceptions remain largely unexplored.

This study assesses societal perceptions of forests and greenspace services for the first time on a continental scale, encompassing data from 33 countries. Based on a representative sample ($n = 10,782$), perceptions were assessed from two angles: First, by analysing regional differences across Europe. Second, by examining how Schwartz's values (i.e., openness to change, conservation, self-enhancement, and self-transcendence) and demographics (i.e., age, gender) relate to their perceived importance.

Overall, regulating and cultural ecosystem services are perceived as very important, and provisioning services as less important. Disservices are generally perceived as unimportant. Hierarchical clustering identifies four regional clusters across Europe, showing significant regional differences in perceptions.

Structural equation modelling shows that demographics and values significantly predict perceptions, with values having the strongest influence. Self-transcendence, openness to change, and conservation values are positively associated with regulating and cultural services, while self-enhancement values are negatively associated. Provisioning services are positively associated with openness to change, conservation, and self-enhancement values, but negatively with self-transcendence. Gender, age, education, and income also significantly predict perceptions.

Altogether, our analysis of major patterns in perceptions of ecosystem services across Europe – and specifically the assessment of regional, demographic and value differences – provides a critical and so far, largely missing knowledge base to inform forest policy, management and nature planning.

1. Introduction

Recent European Union (EU) policies, such as the EU Biodiversity Strategy for 2030 and the New EU Forest Strategy for 2030, underline the critical role of forests and trees in mitigating climate change and

reversing biodiversity loss, as well as providing raw materials for a bio-based economy. These policies also call for the protection of old-growth forests and afforestation (European Commission, 2020, 2021). In addition, the New EU Forest Strategy promotes resilient and multifunctional forests via sustainable forest management (European Commission,

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2021). Such policy developments show the critical role that forests and trees play in delivering a wide range of benefits to society and highlight the need to sustain social and economic benefits derived from ecosystem services through sustainable management practices (MEA, 2005; Winkel et al., 2022). Forests and trees refer, thereby, not only to forests as a major land use type, but also to greenspaces that contain woodlands and trees often located in urban environments, which is reflected in EU policy frameworks such as the EU Biodiversity Strategy for 2030 (European Commission, 2020; Haase et al., 2014).

In this study, we analyse how citizens perceive different ecosystem services and disservices provided by both forests and greenspaces with trees. In the Common International Classification of Ecosystem Services (CICES), ecosystem services are classified into three categories: provisioning services (e.g., timber, firewood), regulating and maintenance services (e.g., water quality, erosion protection and carbon storage) and cultural services (e.g., recreational opportunities, aesthetic and spiritual values) (Haines-Young, 2023). While ecosystem services are widely researched, less is known about disservices, defined as “the ecosystem generated functions, processes and attributes that result in perceived or actual negative impacts on human wellbeing” (Shackleton et al., 2016). In the context of forests and greenspaces, examples include health risks (e.g. wildlife/insect bites, allergies) or threats to homes and properties (e.g. from forest fires, storms) (Escobedo et al., 2011; Lyytimäki, 2019). To better understand how citizens experience the full spectrum of nature’s impacts on people, it is important to consider both ecosystem services and ecosystem disservices, as these may significantly affect how the public perceives net benefits (Blanco et al., 2019).

Understanding societal perceptions of ecosystem services and disservices is vital for informing both policymakers and (forest) land managers. This can avoid mismatches between societal perceptions, policies and management practices, and reduce the risk of conflicts (De Vreese et al., 2019; Fabra-Crespo et al., 2012). To this end, studying public perceptions can provide valuable insights for designing initiatives that are based on broad societal support. Furthermore, research has shown that societal pressures can play a critical role in shaping forest management (Konczal et al., 2023). Studying societal perceptions as possible origins of these pressures is vital in a time of significant social (e.g., aging population, migration and urbanisation) and biophysical environmental changes (e.g., climate, land use practices) (Cortinovis et al., 2022; IPCC, 2022).

A recent review has shown that previous research has largely focussed on public perceptions of ecosystem services of forests and greenspaces at the scale of specific cities, regions or individual countries (Ordóñez Barona et al., 2022). For example, studies have been conducted in Central European countries like Germany (Almeida et al., 2018; Busch et al., 2024; Meyer et al., 2019), Slovenia (Torkar & Krašovec, 2019), Czechia (Daněk et al., 2023; Purwestri et al., 2023) and Poland (Derek et al., 2025; Grilli et al., 2016), as well as in Southern European countries such as Italy (Bruzzeze et al., 2022; Carrus et al., 2020), Spain (Rodríguez-Morales et al., 2020), Portugal (Barreira et al., 2025) and Türkiye (Baykalı & Şen, 2024). Other research has investigated perceptions of ecosystem services of forests and greenspaces in Western and Eastern European contexts, including Romania (Pacurar & Albu, 2018), Ukraine (Elbakidze et al., 2025) and Ireland (Howley et al., 2011; Upton et al., 2015). While a recent report carried out a review of studies at the European scale (Ranacher et al., 2020), only few studies attempted to gather empirical data across multiple countries within Europe (Kazungu & Hunziker, 2025; Nordlund et al., 2017) or between European countries and non-European countries (Hochmalová et al., 2022; Kathryn Rodgman et al., 2024). This lack of multi-country comparison is unfortunate, because perceptions of ecosystem services of forests and greenspaces may be strongly influenced by country-specific characteristics. These include forest cover, dependence on forest services for income and cultural and historical uses. Understanding such differences can be critical when designing overarching policy approaches at a level such as the EU (Winkel et al., 2022). However, as this

study includes both EU and non-EU European countries, EU policy frameworks are not equally relevant for all countries included. However, together, existing studies have provided a plethora of evidence that regulating and cultural ecosystem services are frequently perceived as most important by citizens, albeit their perceived importance varies across contexts (e.g., regions, forest types and rurality). For example, heat reduction, climate change and aesthetic quality are particularly appreciated in Southern Europe (Barreira et al., 2025; Bruzzeze et al., 2022; Carrus et al., 2020), while traditional production functions (e.g., wild food, timber) are usually more prominent in Eastern Europe (Pacurar & Albu, 2018). Furthermore, socio-demographic characteristics (e.g., gender, age, education, annual income and place of residence) have consistently been shown to play a significant role in shaping people’s perceptions of forests and greenspaces (Ranacher et al., 2020). For instance, Hegetschweiler et al. (2022) showed that older individuals generally prioritise provisioning services more than younger people. Similarly, Barreira et al. (2025) reported that non-affluent individuals perceive regulating ecosystem services (e.g., heat reduction, humidity) as more important than affluent individuals. While these studies offer valuable insights into the perceptions of forests and greenspaces in European societies, much of the research has been limited in geographical scope, and has therefore not systematically captured social, political and geographical variations across Europe. Hence, this study is, to our knowledge, the first to provide a systematic and representative assessment of societal perceptions towards ecosystem (dis-)services of forests and greenspaces in Europe.

Citizens’ perceptions of ecosystem services and disservices are typically also shaped by values. Values capture the symbolic and practical elements through which people express meaning and orientation in life, which includes spoken and unspoken forms of communication, daily habits, social structures and material culture (Manfredo et al., 2017). Schwartz (1994) defines values as “guiding principles in the life of a person or other social entity”. Although values vary across cultures, sociological research has established typologies of universal value structures that can be found across cultural contexts (Manfredo et al., 2017; Schwartz, 1994, 2006). Specifically, Schwartz’s theory has been applied and tested across the world and offers a frequently used and conceptually robust framework for understanding how value orientations shape environmental perceptions (Schultz & Zelezny, 1999). It consists of ten basic value types (underlying motivational goals; see Appendix A) that are summarised into four categories of so-called “higher order values”: self-transcendence, openness to change, self-enhancement and conservation (Schwartz, 2006). Self-transcendence values (universalism and benevolence) capture respondents motivated to act selflessly and to be helpful to others. These values are strongly linked to ideals of equality, justice (both environmental and social), tolerance, and pro-environmental attitudes. Openness to change values (self-direction and stimulation) relate to freedom of thought and action as well as excitement, novelty, and change. Individuals with those values are more likely to welcome new experiences and prefer independent lifestyles (Manfredo et al., 2017; Schwartz, 2012). Hence, openness to change values are likely to be associated with cultural ecosystem services (e.g., hiking, mountain biking) (Manfredo et al., 2017). Self-enhancement values (achievement, power) relate to individuals that focus on success, ambition as well as dominance over resources and others. These values are often tied to seeing forests as assets and for economic gain (e.g., timber production, hunting). The openness to change and self-enhancement values share the underlying value type of hedonism, i.e. respondents that relate to pleasure and sensuous gratification (Schwartz, 2006, 2012; Vecchione et al., 2015). Finally, conservation values (security, conformity, tradition) relate to stability, safety, adherence to established norms and traditions (Vecchione et al., 2015). These are linked to risk avoidance and may be associated with increased concern over ecosystem disservices (Vecchione et al., 2015). The Schwartz’ conservation value category has little to do with nature conservation as such, but more with conservation

of the status quo for e.g. personal security. Existing research recognises the critical role of these values in perceptions research, however, there remains a lack of empirical studies linking value assessments with ecosystem services perceptions.

In this study, we use the term ‘perceptions’ as an umbrella concept that captures how people understand, experience and evaluate forests and greenspaces in relation to the wider socio-ecological context (Shackleton et al., 2019; Ordóñez Barona et al., 2022). Perceptions comprise among others, values of nature (Pascual et al., 2023), diverse knowledges and beliefs about nature and the biodiversity crisis (Ordóñez Barona et al., 2022), human-nature relationships (Beery et al., 2023) and attitudes towards nature policies (Buijs et al., 2025). Furthermore, perceptions are developed and articulated through embodied and socially mediated human-nature relationships (Buijs et al., 2025; Giusti, 2019), including nature connectedness (Beery et al., 2023) and sense of place (Masterson et al., 2019). Taken together, these concepts jointly shape how people perceive the importance of forests and the ecosystems they provide.

To date, particularly insights into how values shape perceptions of ecosystem services of forests and greenspaces have been lacking, and only few studies exist (Ordóñez Barona et al., 2022; Pülzl et al., 2021). Drawing on Schwartz’s theory of basic values, we assume a values-to-perceptions pathway because values provide guiding orientations that shape how people perceive environmental issues (Manfredo et al., 2017; Schultz & Zelezny, 1999). Therefore, values influence how people perceive the importance of ecosystem services.

Summing up, our study pursues the following research questions:

1. What is the perceived importance of ecosystem services and disservices in Europe?
 - a. How does the perceived importance vary geographically in Europe?
 - b. How is the perceived importance influenced by socio-demographics and values?

2. Methodology

2.1. Survey design

A European-wide survey was designed in an iterative process between researchers involved in the European-funded Horizon 2020 CLEARINGHOUSE project with the aim of assessing public perceptions towards ecosystem services and ecosystem disservices. It consisted of seven thematic blocks totalling 37 questions; in this paper, we used only the subset of closed survey questions directly relevant to our research, encompassing questions on ecosystem services and disservices (see Appendix B). The survey aimed at collecting representative data on the public in Europe.

2.2. Sampling area

The sampling area covered 33 countries in Europe, representing the entire geographical diversity of the continent, covering all major cultural, political, topographical and climatic zones. The total population of the countries covered stands at 810 million people, with a high level of urbanisation at approximately 72%, varying strongly between less urbanised countries at 50% or less (e.g., Romania, Serbia, Albania) and highly urbanised countries at 80% or more (e.g., Belgium, Denmark and the United Kingdom) (Clark et al., 2019; United Nations, 2022). Some countries (e.g. Iceland, Luxemburg or Belarus) were not sampled due to the high costs of obtaining a representative sample. Forests cover around 35% of the land surface across the sampling area (excluding Russia), encompassing diverse types from boreal and temperate forests to Mediterranean vegetation, with varying management intensity, type, and extent (FOREST EUROPE, 2020).

2.3. Survey elements

2.3.1. Ecosystem services and disservices

This study included 17 relevant ecosystem services of forests and greenspaces as identified in CICES v5.2 (Haines-Young, 2023) (see Table 1). Additionally, we selected 10 ecosystem disservices from the

Table 1

Overview of categories of ecosystem services, survey statements and short names as used in this study.

Type	Survey statements	Short name
Provisioning services	Forests/parks provide products other than wood (e.g. mushrooms, berries, nuts, medicinal plants)	Wild food supply
	Forests/parks provide wood for timber and furniture	Timber supply
	Forests/parks provide fuelwood	Firewood supply
	Forests/parks provide opportunities to hunt game	Game hunting
Regulating & maintenance services	Forests/parks improve air quality	Air quality regulation
	Forests/parks protect water quality and protect soils from erosion	Water quality & erosion protection
	Forests/parks reduce temperature	Local climate regulation
	Forests/parks provide living space for plants and animal species	Habitat support (plants and animals)
	Forests/parks reduce noise	Noise reduction
	Forests/parks store carbon and reduces climate change	Carbon storage
	Forests/parks lessen the negative impact of natural hazards (e.g. storms, floods)	Natural hazard mitigation
	Forests/parks provide benefits to human health and well-being	Human health benefits
Cultural services	Forests/parks provide opportunities for education (e.g. for forest kindergartens, schools)	Educational opportunities
	Forests/parks provide cultural, emotional and spiritual value	Cultural and spiritual value
	Forests/parks provide jobs and economic activity	Employment opportunities
	Forests/parks provide recreation and sports opportunities	Recreational opportunities
Disservices	Forests/parks are beautiful	Aesthetic value
	Forests/parks are obscuring views	View obstruction
	Forests/parks are a foregone land use opportunity (e.g. less land for industry, housing and businesses)	Land use limitation (foregone land use)
	Forests/parks cause damage to public infrastructure (e.g. trees falling on electricity lines)	Infrastructure damage
	Forests/parks have a negative impact on the local climate	Negative impact on local climate
	Forests/parks are unsafe (e.g. uncontrolled pet dogs, risk of crime, falling branches)	Safety concerns
	Forests/parks contribute to air pollution from blocking wind	Contribution to air pollution
	Forests/parks are a source of health risks (e.g. wildlife/insect bites, allergies)	Health risk concerns
	Forests/parks are a cost to society (e.g. costs for planting, maintaining, removal)	Economic costs
	Forests/parks pose a threat to homes and properties (e.g. forest fires, storms)	Property threats
	Forests/parks cause environmental issues (e.g. spread of invasive species)	Invasive species spread

literature (Escobedo et al., 2011; Lyytimäki, 2019; Roman et al., 2020). Respondents rated the importance of ecosystem services and disservices on a scale from “0 = Is not important” to “100 = Is very much important”.

2.3.2. Portrait Value Questionnaire (PVQ-21)

To assess values with the Schwartz typology, the Portrait Value Questionnaire with 21 statements (PVQ-21) (Schwartz, 2006; Vecchione et al., 2015) was used. In line with Schwartz's theory, the PVQ-21 statements generally describe people's feelings, their beliefs, their goals, their lifestyles and social background (Schwartz & Cieciuch, 2021). The PVQ-21 was specifically developed and tested for cross-national samples, which makes it particularly suitable for our study design covering 33 countries (Manfredo et al., 2017; Schultz & Zelezny, 1999). Respondents rated the PVQ-21 statements by how similar a person is to themselves using a 5-point Likert scale ranging from 0 ('not like me at all') to 5 ('very much like me').

2.4. Data collection

The data collection was led by a third-party polling agency. Prior to data collection, the questionnaire was translated (from British English into 29 national languages) and tested for quality and technical functionality. The minimum time to complete the sections of the questionnaire relevant to this study was estimated to be around 7:30 minutes. The full data set was collected between March and July 2021, targeting the general population aged 18 years and above across all states and regions, urban and rural areas in all covered countries. The target for the number of responses was set at $n = 384$ (+10% oversampling) per country, with an incidence rate of 100% among the general population. This amounted to a total number of 13,319 responses from 33 countries.

The respondents were recruited through a diversified multi-sourcing process. To avoid bias, indirect and direct methods were used in the panel building process (e.g., advertisements and emailing). Panel members were recruited exclusively using permission-based techniques. The multi-sourcing process contributed to representativeness to some extent, because the individual source panels already reflected an approximately representative distribution of all relevant target groups based on demographic characteristics.

Each national sample was considered representative if the proportion of the sample corresponded to the national distributions per characteristic (age, gender, and regions) derived from census data from the statistical offices or from Eurostat. Predefined age distributions categories were of 18-30 years (30%), 31-50 years (40%), 61-65 years (15%) and 66+ years (15%). The target gender distribution per country was 50% male and 50% female. To ensure validity, the analysis considered the margin of error and 95% confidence level.

2.5. Data preparation and overview of the sample

Data preparation included data cleaning to remove nonsensical answers. Specifically, responses with missing and uniform data (i.e., standard deviation = 0) in the PVQ-21 were excluded, as were those with missing and uniform data across ecosystem services and disservices (i.e., mean score = 0, 50, or 100; standard deviation = 0). Additionally, respondents who completed the questionnaire in less than 7:30 minutes were considered 'speeders' and were excluded. As a result, 2,537 cases were removed from the total of 13,319 cases, leaving 10,782 valid responses.

The sample is characterised by respondents of a median age of 42 years, with the largest age group being 31–50-year-old respondents. More than half of the respondents live in the centre of a city (52.5%) and more than half of the respondents are females (51.3%). Furthermore, the most represented highest level of education attained is attending school until the age of 17 to 19, followed by respondents with a bachelor's degree. Few respondents themselves or their family members own or

manage a forest and very few respondents do not go to a forest or park at all. A detailed overview of the sample can be found in Appendix C.

2.6. Data analysis

The collected data was statistically analysed in RStudio version 2024.04.2+764 and in SPSS AMOS. Missing entries were excluded from the analysis.

2.6.1. Descriptive statistics

Descriptive statistics were used, specifically the median ($\bar{x}$) and interquartile range (IQR), to summarise how important respondents perceived ecosystem services and disservices to be (measured on a scale from 0 (not important) to 100 (very much important)). Median values were calculated for each ecosystem services category, and these were then visualised on heat maps to represent the distribution of perceived importance across Europe. To aid interpretability, the following importance categories were defined based on the median ($\bar{x}$): 0-19 = not important, 20-39 = somewhat important, 40-59 = moderately important, 60-79 = important, and 80-100 = very important. The level of agreement was assessed using the IQR, which represents the range that contains 50% of the data between the first and third quartile. The level of agreement was defined as follows: IQR > 20 indicated low agreement, IQR = 10-20 indicated moderate agreement, and IQR < 10 indicated high agreement.

2.6.2. Hierarchical clustering

Hierarchical cluster analysis with the Gower distance matrix (Gower, 1971) was used to cluster the 33 countries into meaningful geographic subgroups with similar perceptions. This approach is suitable for mixed data, including ordinal data. The cluster analysis with 17 ecosystem services and 10 disservices did not yield meaningful clusters, so the 10 disservices were excluded from the clustering. After rerunning the analysis, the optimal number of clusters was set at $k = 4$, which was determined based on a dendrogram as shown in Appendix D (Kaufman & Rousseeuw, 1990; Rousseeuw, 1987). The choice was guided by the need to balance statistical robustness and interpretability, with the aim of capturing meaningful regional differences. To validate the clusters based on the similarities and differences between the 17 ecosystem services, we performed principal component analysis (PCA) and visualised it using a scatterplot as shown in Fig. 1. Dimension 1 represents the majority of the data with 52.73% and dimension 2 represents additional variance with 20.79%.

Cluster 1 consisted of a mix of Southern European countries (Albania, Bosnia and Herzegovina, Slovenia) and Eastern European countries (Poland, Hungary), as well as Türkiye. Cluster 2 was composed of countries from Southern, Eastern, Northern, and Western Europe. Cluster 3 was predominantly characterised by Northern and Western European countries. Cluster 4 consisted mainly of Eastern European countries (Romania, Russia, and Ukraine), along with Serbia (Fig. 1).

2.6.3. Structural Equation Modelling

Subsequently, structural equation modelling (SEM) was used to determine how values and socio-demographic characteristics influenced respondents' perceived importance of ecosystem services and disservices. Predictor variables included the four higher-order values derived from PVQ-21, as well as socio-demographic characteristics (age, gender, income, education, rurality, and region). The latent variables were the perceived importance of provisioning, regulating, and cultural ecosystem services and ecosystem disservices.

Confirmatory factor analysis (CFA) was used to build the measurement model for the three ecosystem service categories. The initial CFA model did not meet acceptable thresholds for Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). Therefore, indicators with low factor loadings were removed. As the categories were predefined and theoretically

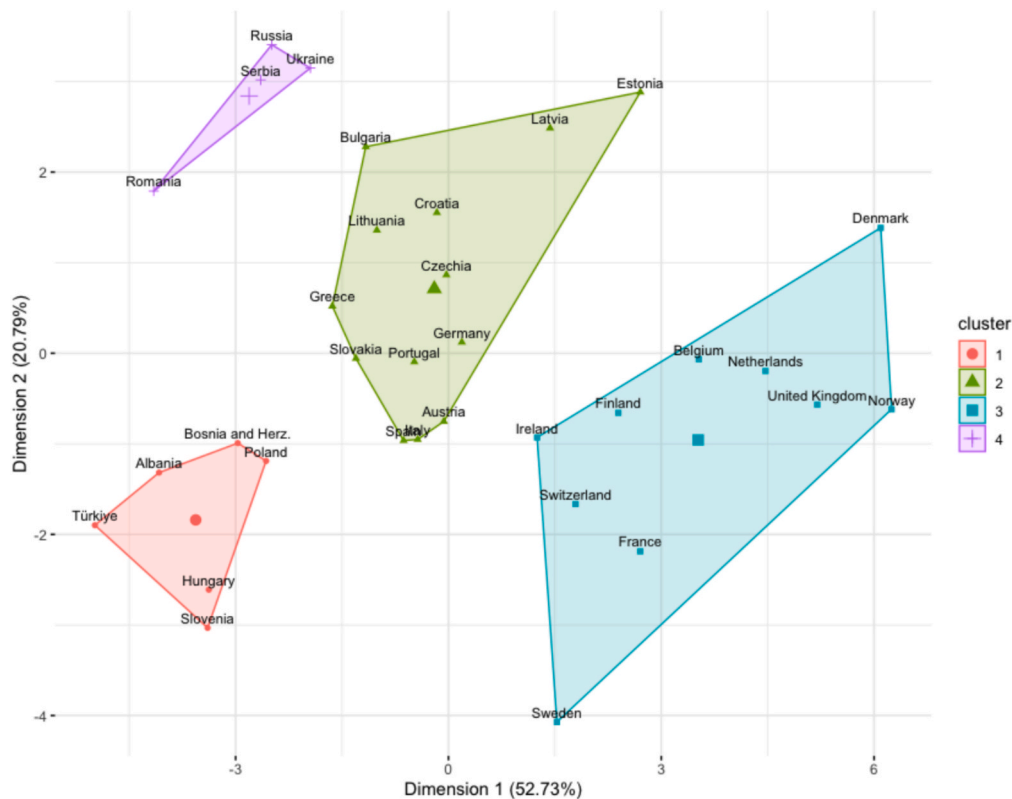


Fig. 1. Scatter plot showing four country clusters.

grounded, only minimal adjustments were made at the indicator level.

The final model showed good internal consistency (Cronbach's alpha and composite reliability > 0.7) and convergent validity (average variance extracted > 0.5 ; see Appendix E). Discriminant validity was confirmed using the Fornell-Larcker (FL) criterion (see Appendix F, Table F2).

The ecosystem disservices construct did not form a valid latent variable (i.e. the items did not group together well enough) and failed to meet acceptable fit indices, so it was ultimately excluded from the final model.

Overall, three models were tested: Model 1 with values only, model 2 with socio-demographic characteristics only, and model 3 with a combined set of predictors. Model 3 achieved the best fit (CFI = 0.918, TLI = 0.984, and RMSEA = 0.038).

3. Results

3.1. Overall perceptions of ecosystem services and disservices in Europe

Across the entire sample, we identified preferences regarding respondents' perceived importance of ecosystem services provided by forests and greenspaces (Fig. 2). Overall, regulating and cultural ecosystem services were perceived as most important. Provisioning services were perceived as considerably less important, while ecosystem disservices were perceived as not important (Fig. 3).

In more detail, the regulating ecosystem service air quality regulation ($\bar{x}$ = 95, IQR = 22) was perceived as most important. Furthermore, habitat support ($\bar{x}$ = 93, IQR = 26) and carbon storage ($\bar{x}$ = 90, IQR = 32) were also perceived as very important. From the analysed cultural ecosystem services aesthetic value ($\bar{x}$ = 94, IQR = 24), human health benefits ($\bar{x}$ = 93, IQR = 24) and recreational opportunities ($\bar{x}$ = 83, IQR = 39) were perceived as the most important ones. The most important provisioning ecosystem service was wild food supply ($\bar{x}$ = 56, IQR = 64), whereas the least important one was game hunting ($\bar{x}$ = 6, IQR = 39).

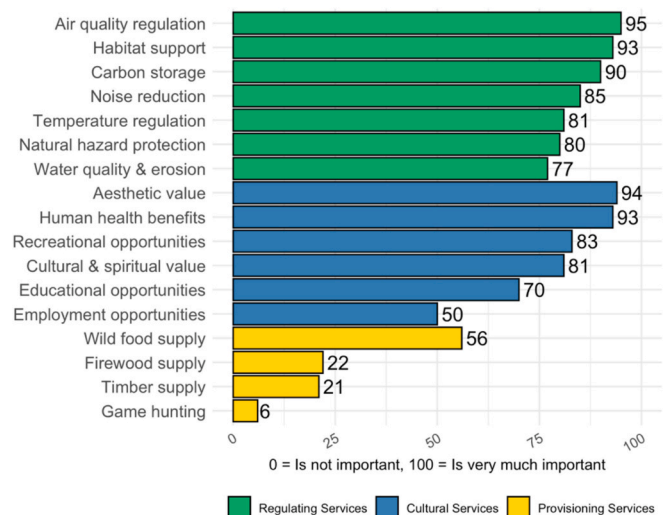


Fig. 2. Perceived importance of ecosystem services from forests and greenspaces in Europe (Median values shown).

Almost all ecosystem disservices were perceived as less important than ecosystem services. The only exception was game hunting ($\bar{x}$ = 6, IQR = 39), which was perceived as less important than most disservices. Safety concerns ($\bar{x}$ = 15, IQR = 46), health risk concerns ($\bar{x}$ = 13, IQR = 42) and invasive species spread ($\bar{x}$ = 10, IQR = 39) were perceived as more important disservices. Further details are included in Appendix G.

3.2. Geographical distribution in the perception of ecosystem services and disservices

Using hierarchical cluster analysis, we determined four geographical

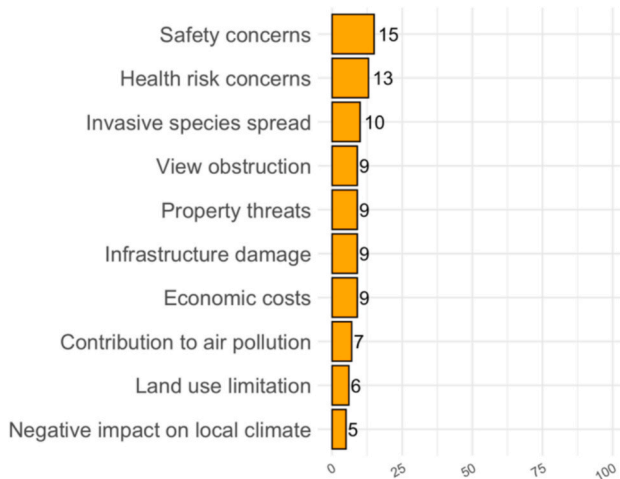


Fig. 3. Perceived importance of ecosystem disservices from forests and greenspaces in Europe (Median values shown).

distribution clusters across Europe. A Kruskal-Wallis test revealed significant differences between all types of ecosystem services ($p < .001$). The different levels of attached importance to ecosystem services categories are shown in Fig. 4.

Overall, a North-West to East gradient emerged in public perceptions of ecosystem services across the four regional clusters. While respondents in cluster 3 (mainly Northern and Western European countries) perceived regulating and cultural ecosystem services as important, those in cluster 4 (mainly Eastern European countries) saw them as very important, with cluster 1 and cluster 2 falling in between. Significant differences were also found in the perceived importance of provisioning services and disservices. The detailed cluster-level and country-level results for ecosystem services categories can be found in Appendix H and I, respectively.

3.2.1. Regulating ecosystem services

Fig. 5 shows the geographical distribution of the perceived importance of regulating ecosystem services across Europe. These services were perceived as very important ($\bar{x} = 80$ –100) in 79% of the countries, predominately in Southern and Eastern Europe. Respondents in cluster 4

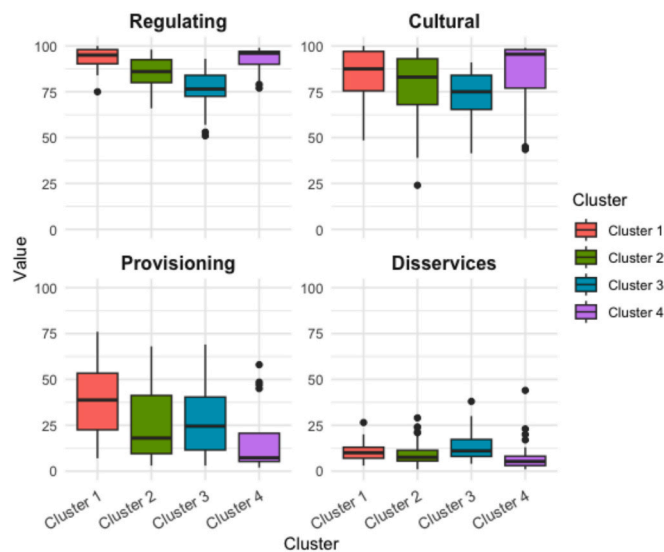


Fig. 4. Boxplot showing perceived importance of ecosystem services categories across four European clusters on a scale from 0 to 100 (0 = Not important, 100 = Very important).

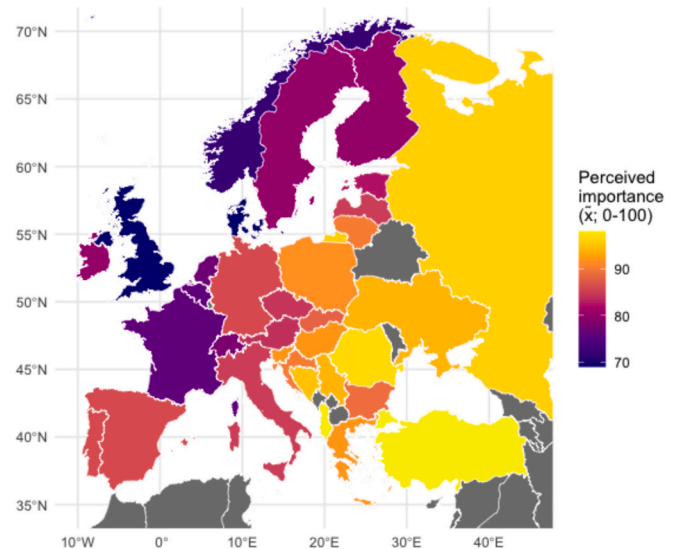


Fig. 5. Perceived importance of regulating ecosystem services in Europe (Grey = no data).

(including Romania ($\bar{x} = 97$, IQR = 1.5) and Ukraine ($\bar{x} = 94$, IQR = 10.25)) perceived the highest importance of regulating ecosystem services overall ($\bar{x} = 96$, IQR = 7) with high agreement, making it the most unified region in terms of the perceived importance of these services. Respondents in cluster 1, consisting of countries like Albania ($\bar{x} = 98$, IQR = 11) and Türkiye ($\bar{x} = 98$, IQR = 2), also perceived regulating ecosystem services as very important ($\bar{x} = 95$, IQR = 7.75) with high agreement, and significantly more important than respondents in cluster 2 ($p < .001$) and cluster 3 ($p < .001$). Respondents in several Western and Eastern European countries such as Germany ($\bar{x} = 86$, IQR = 14.75), Czechia ($\bar{x} = 84.5$, IQR = 10) and Austria ($\bar{x} = 84$, IQR = 14.5) also perceived these services as very important, yet with lower median values and only moderate agreement, as indicated by the IQR. These countries fell within cluster 2, which overall perceived regulating services as very important ($\bar{x} = 86$, IQR = 12.5; moderate agreement) and significantly more important than respondents in cluster 3 ($p < .001$), but significantly less than respondents in cluster 4 ($p = .0017$). In contrast, regulating ecosystem services were perceived as (only) important ($\bar{x} = 60$ –79) in 21% of the studied countries, mostly in Northern Europe. For example, respondents in the United Kingdom ($\bar{x} = 69$, IQR = 13), Denmark ($\bar{x} = 69$, IQR = 14.25), and Norway ($\bar{x} = 72$, IQR = 17) all perceived them as important, although with moderate agreement. This pattern is consistent with the cluster 3 average ($\bar{x} = 76.5$, IQR = 11.5), where respondents perceived regulating services significantly less important than respondents in cluster 4 ($p < .001$).

3.2.2. Cultural ecosystem services

The distribution of the perceived importance of cultural ecosystem services across Europe is shown in Fig. 6. Respondents in 70% of all countries perceived them as very important, particularly respondents in Southern and Eastern Europe, for instance in Albania ($\bar{x} = 97.5$), Serbia ($\bar{x} = 95.5$), and Romania ($\bar{x} = 94$). However, the level of agreement among respondents in Albania (IQR = 30) was very low, while in Serbia (IQR = 11.5) and Romania (IQR = 10.625) there was moderate agreement among respondents. This is also reflected across all of cluster 1, where cultural services were perceived as very important ($\bar{x} = 87.5$, IQR = 21.5), albeit with low agreement, and significantly more important than in cluster 3, which was characterised by Northern and Western European countries ($p = .0017$). In cluster 4, cultural ecosystem services were perceived as even more important ($\bar{x} = 95.5$, IQR = 21), but with moderate agreement. Respondents in Germany ($\bar{x} = 86$, IQR = 14.75), Austria ($\bar{x} = 84$, IQR = 14.5) and Czechia ($\bar{x} = 83$, IQR = 20.625) also

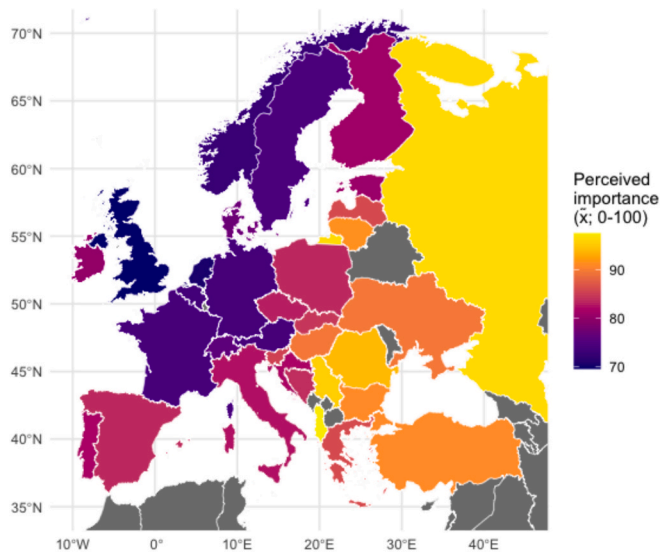


Fig. 6. Perceived importance of cultural ecosystem services in Europe (Grey = no data).

perceived cultural ecosystem services as very important. These countries belonged to cluster 2, which overall rated cultural services similarly ($\bar{x}$ = 83, IQR = 25), although with low agreement within the countries. In contrast, in 30% of the studied countries, cultural ecosystem services were perceived as (only) important. This was particularly true in several Northern and Western European countries, such as Norway ($\bar{x}$ = 72.5, IQR = 18.125), the Netherlands ($\bar{x}$ = 70.25, IQR = 15.125), and the United Kingdom ($\bar{x}$ = 69.5, IQR = 14.75). These countries were part of cluster 3, where cultural ecosystem services were perceived as important ($\bar{x}$ = 75, IQR = 18.625) with moderate agreement, and significantly lower than in cluster 4 (p < .001).

3.2.3. Provisioning ecosystem services

Fig. 7 illustrates the geographical variation in the perceived importance of provisioning ecosystem services across Europe. Overall, provisioning ecosystem services were not perceived as very important ($\bar{x}$ = 80–100) or important ($\bar{x}$ = 60–79) in any of the countries. The highest levels of importance were reported by respondents in Slovenia ($\bar{x}$ = 51.25; IQR = 16.125), Sweden ($\bar{x}$ = 44; IQR = 15), and Hungary ($\bar{x}$ =

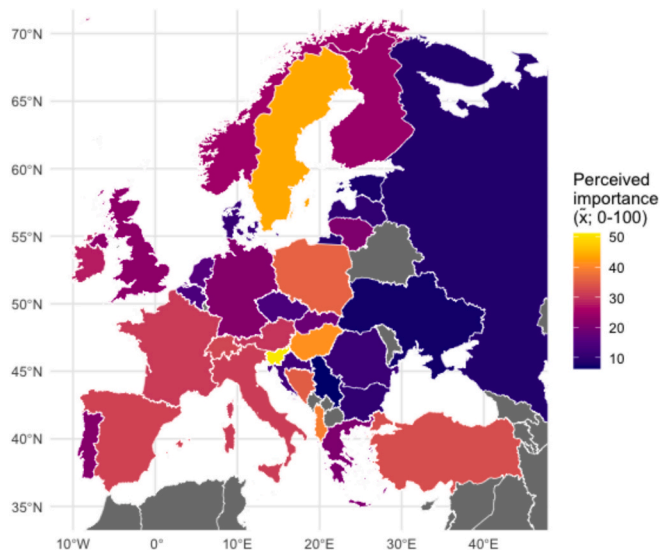


Fig. 7. Perceived importance of provisioning ecosystem services in Europe (Grey = no data).

41.5; IQR = 22.75), where these services were perceived as moderately important (9% of studied countries had a median between 40–59). The level of agreement was moderate in Slovenia and Sweden, while it was low in Hungary. These countries were part of cluster 1 ($\bar{x}$ = 38.75, IQR = 30.875) and cluster 3 ($\bar{x}$ = 24.5, IQR = 28.875), where respondents overall rated provisioning services as somewhat important. Respondents in cluster 1 perceived these services as significantly more important than respondents in cluster 2 (p = .0197) and cluster 4 (p < .001). Provisioning ecosystem services were perceived as somewhat important ($\bar{x}$ = 20–39) in 52% of the studied countries. This included countries such as Italy ($\bar{x}$ = 31; IQR = 12.5), France ($\bar{x}$ = 30.5; IQR = 17) and Germany ($\bar{x}$ = 21.25; IQR = 17.125). All three countries showed moderate levels of agreement. Germany belonged to cluster 2, where respondents rated provisioning services as not important overall ($\bar{x}$ = 18, IQR = 31.75), although strong variation existed across countries. Conversely, provisioning ecosystem services were perceived as not important ($\bar{x}$ = 0–19) in 39% of the studied countries, for instance in Latvia ($\bar{x}$ = 10; IQR = 12.75), Denmark ($\bar{x}$ = 11; IQR = 10.375), and Estonia ($\bar{x}$ = 7.5; IQR = 13), all with moderate levels of agreement. Similar findings were generated for Russia ($\bar{x}$ = 8.5, IQR = 15), Ukraine ($\bar{x}$ = 7, IQR = 13.125), and Serbia ($\bar{x}$ = 6.25, IQR = 11), also with moderate levels of agreement. This is reflected in cluster 4, which reported the lowest overall valuation for provisioning services ($\bar{x}$ = 7.25, IQR = 15.375).

3.2.4. Ecosystem disservices

In all countries except for the United Kingdom, ecosystem disservices were perceived as not important ($\bar{x}$ = 0–19; Fig. 8). In the United Kingdom, respondents perceived them as somewhat important with a high level of agreement ($\bar{x}$ = 25.25, IQR = 4.625). Among countries still falling within the “not important” range, Ireland ($\bar{x}$ = 19, IQR = 4.75), Sweden ($\bar{x}$ = 19, IQR = 3.5), and Lithuania ($\bar{x}$ = 16, IQR = 7), all with high levels of agreement, perceived them as being of higher importance when compared, for instance, with countries such as Romania ($\bar{x}$ = 4.5, IQR = 2.625), Ukraine ($\bar{x}$ = 3, IQR = 1.75) and Bulgaria ($\bar{x}$ = 2, IQR = 1), which had the lowest perceived importance of ecosystem disservices, all with high levels of agreement. These country-level variations align with the regional cluster analysis. Respondents in cluster 3 (mainly Northern and Western European countries) perceived ecosystem disservices as not important overall ($\bar{x}$ = 11, IQR = 9.25), but significantly more important than respondents in cluster 4 (Eastern European countries and Serbia; p < .001). Respondents in cluster 2 also perceived disservices as not important ($\bar{x}$ = 7.5, IQR = 5.875; high agreement), but still significantly

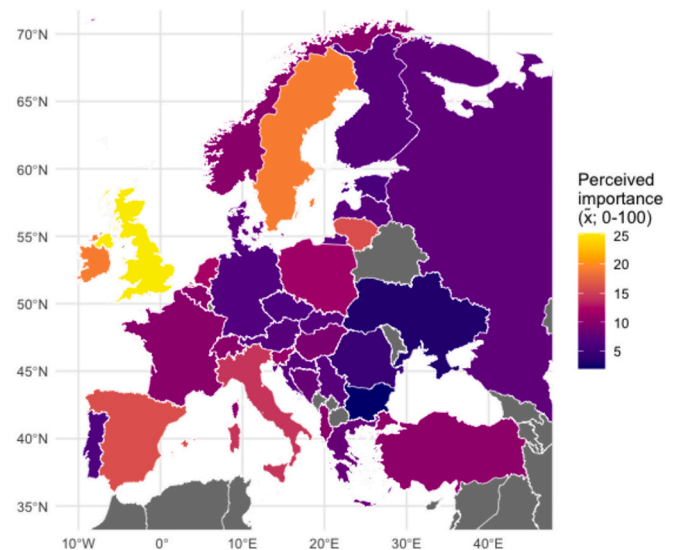


Fig. 8. Perceived importance of ecosystem disservices in Europe (Grey = no data).

more important than respondents in cluster 4 ($p = .0476$), and significantly less important than respondents in cluster 3 ($p < .001$). For respondents in cluster 1, ecosystem disservices were perceived as not important ($\bar{x} = 10$, IQR = 6), with high agreement, although, perceived as significantly more important than by respondents in cluster 4 ($p = .0012$). Respondents in cluster 4 perceived disservices as not important ($\bar{x} = 5.25$, IQR = 5.125), with the lowest attributed importance across all clusters.

3.3. The role of demographics and basic values in the perception of ecosystem services

This section addresses how human dimensions (values and demographics) influenced the perceived importance of ecosystem services. Fig. 9 illustrates all direct and significant effects of demographics and values in relation to ecosystem services categories (regulating, provisioning, and cultural).

Values were stronger predictors of the perceived importance of regulating ecosystem services than demographics, as shown by their beta-coefficients. Regulating ecosystem services were most strongly and positively associated with self-transcendence values ($\beta = 0.327$, $p < .001$), i.e., respondents who are supportive of others and who support (environmental) justice perceived them as most important. Likewise, openness to change values ($\beta = 0.168$, $p < .001$), referring to respondents who seek autonomy and value novelty, and conservation

values ($\beta = 0.142$, $p < .001$), referring to respondents linked to tradition and security, were also significantly and positively associated with the importance attached to regulating services, as indicated by their positive path coefficients. Among demographic predictors, being female ($\beta = 0.137$, $p < .001$) and older in age ($\beta = 0.130$, $p < .001$) were significant positive predictors, indicating that women and older respondents perceived these services as more important than men and younger respondents. While income had no significant effect ($\beta = 0.004$, $p = .171$), higher education was a weak negative predictor ($\beta = -0.037$, $p = .003$), indicating that, on average, respondents with higher education levels perceived the importance of regulating ecosystem services as slightly lower. Additionally, the place of residence played a role. Compared to respondents living in the city centre (reference category), those living in a suburb of a city ($\beta = 0.082$, $p = .002$), nearby a city ($\beta = 0.150$, $p < .001$), and in the rural countryside ($\beta = 0.075$, $p = .048$) attached more importance to regulating services. Among the regulating services in our model, air quality regulation (factor loading = 1.0) and carbon storage (factor loading = 0.934) had the highest factor loadings as shown in Fig. 9, indicating that they were the most important ecosystem services perceived by the respondents.

Provisioning ecosystem services were most strongly predicted by the respondents' place of residence. Respondents in the countryside ($\beta = 0.319$, $p < .001$) and those living nearby a city ($\beta = 0.214$, $p < .001$) showed the strongest positive association with the perceived importance of these services. Respondents in the suburb of a city ($\beta = 0.054$, $p =$

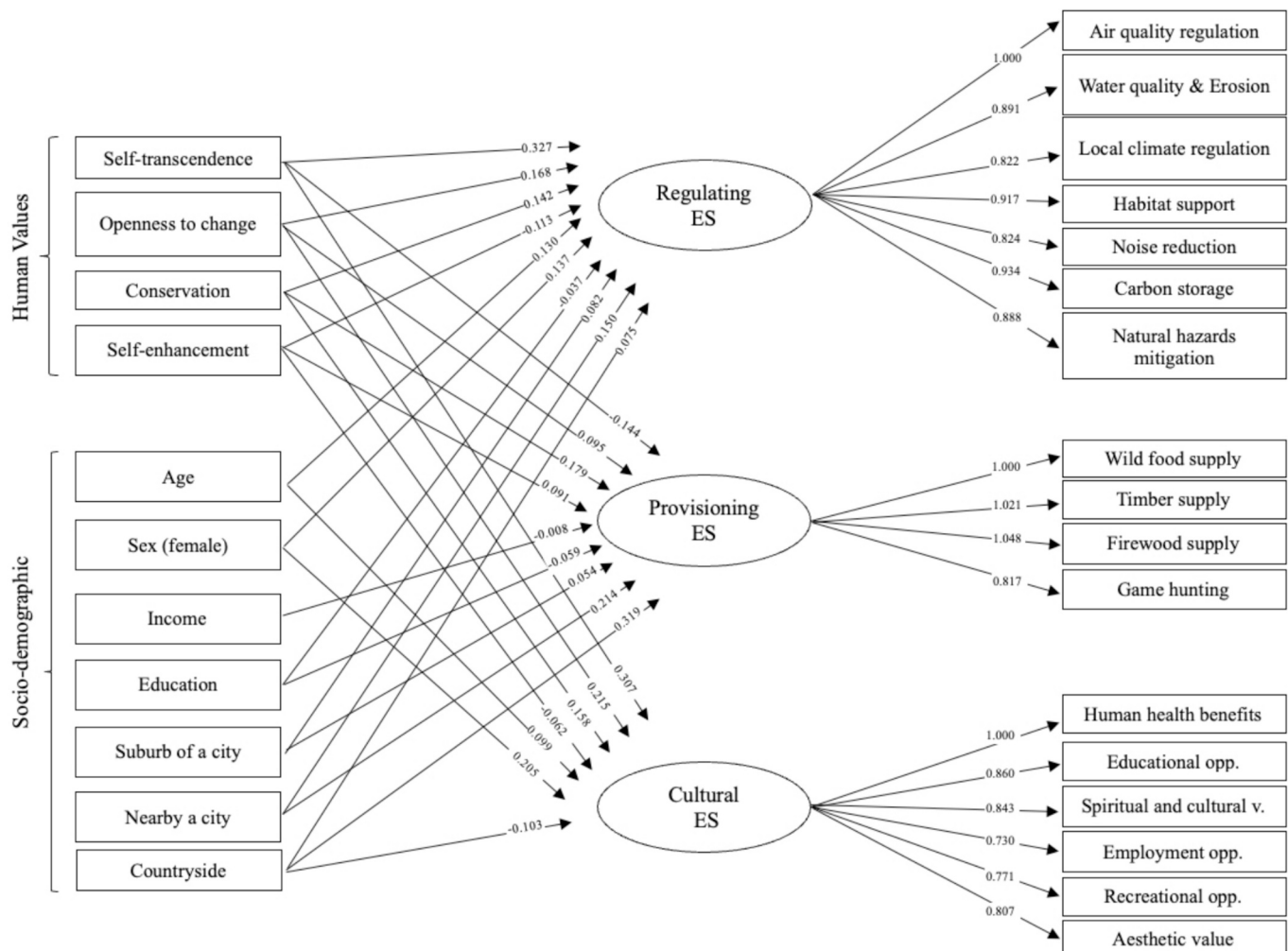


Fig. 9. Structural Equation Model showing path coefficients for sociodemographic and values towards regulating, provisioning and cultural ecosystem services (Note: Only significant predictors are included in the figure).

.037) showed a weaker but still positive association. All these respondents were more likely to perceive these services as important compared to respondents living in the city centre (reference category). Following the place of residence and looking at values, conservation values ($\beta = 0.179, p < .001$), openness to change values ($\beta = 0.095, p < .001$), and self-enhancement values ($\beta = 0.091, p < .001$) were all positively associated with the perceived importance of provisioning services. Self-transcendence values ($\beta = -0.144, p < .001$) showed a strong negative association, suggesting that respondents who cherish equality, justice and tolerance for all as well as helpfulness to others tended to place less importance on provisioning services. Among demographics, higher levels of education ($\beta = -0.059, p < 0.001$) and income ($\beta = -0.008, p = .005$) were weak, but significant negative predictors, suggesting that more educated and affluent respondents were likely to perceive these services as less important. Age ($\beta = 0.006, p = .570$) and gender ($\beta = 0.016, p = .428$) were not significant. Among the indicators for provisioning services in our model, firewood supply (factor loading = 1.048) was the most important service followed by timber supply (factor loading = 1.021), wild food supply (factor loading = 1.0) and game hunting (factor loading = 0.817).

Cultural ecosystem services were most strongly predicted by values. The strongest predictor was self-transcendence values ($\beta = 0.307, p < .001$), which means that respondents who value helping others, safeguarding the environment and standing up for justice assigned the highest importance to cultural ecosystem services compared to groups of respondents with other value orientations. Also, openness to change values ($\beta = 0.215, p < .001$) and conservation values ($\beta = 0.158, p < .001$) were weaker, but significantly and positively associated with the perceived importance of cultural services. In contrast, self-enhancement values ($\beta = -0.062, p < .001$) were negatively associated with cultural services, indicating a lower appreciation among respondents who prioritise achievement and power. Among demographics, being female ($\beta = 0.205, p < .001$) and older age ($\beta = 0.099, p < .001$) were strong positive predictors, meaning that female and older respondents perceived cultural services (recreation, aesthetic and spiritual values) as more important than male and younger respondents. The place of residence played a different role than in other service categories. Respondents living in the countryside ($\beta = -0.103, p = .004$) were negatively associated with the perceived importance of cultural services compared to city dwellers (reference category). This indicated that respondents who live in the city attach more importance to these services than rural residents. Those respondents living in suburbs ($\beta = 0.009, p = .749$) and nearby rural areas ($\beta = -0.041, p = .200$) did not differ significantly from the city dwellers reference group. Also, income ($\beta = -0.001, p = .817$) and education ($\beta = -0.020, p = .096$) were not significant predictors in our model. The most important indicators for cultural ecosystem services in our SEM model were human health benefits (factor loading = 1.0) and educational opportunities (factor loading = 0.860), while employment opportunities (factor loading = 0.730) were least important. For the detailed SEM results for predictors of perceived importance of ecosystem services, please see Appendix J.

4. Discussion

4.1. Non-material ecosystem services are most important to Europeans

This analysis found a consistently high appreciation for regulating and cultural ecosystem services in forests. Across 33 countries in Europe, we showed that air quality regulation, aesthetic value, habitat support, and human health benefits were considered as most important by the respondents. In comparison, the importance attributed to provisioning ecosystem services was considerably lower, while ecosystem disservices were perceived as not important.

These results match findings from many national studies (or studies comparing a few countries) indicating that the environmental and recreational benefits of forests tend to be perceived as more important than

economic and material benefits (Ranacher et al., 2020) (although it is important to note that economic and material benefits can also arise from cultural ecosystem services, e.g. in tourism or education, or in some specific instances from regulating services, e.g. through carbon markets). More specifically, previous studies have repeatedly identified regulating services as those most highly appreciated by respondents. In particular, habitat support (Hegetschweiler et al., 2022; Thiemann et al., 2022) and climate change mitigation relating to carbon storage (Almeida et al., 2018; Nordlund et al., 2017) were consistently perceived as the most important in the respective studies. Similarly, the high appreciation for cultural services such as aesthetic value, human health benefits, and recreational opportunities echoes evidence in peri-urban and urban contexts (Buchel & Frantzeskaki, 2015; Hegetschweiler et al., 2022; Kičić et al., 2025).

Our findings also reflect broader societal trends. In more urbanised European societies, forests and greenspaces are increasingly viewed as places to support well-being, mental health, and spiritual fulfilment. This is reflected in the popularity of activities like mountain biking, hiking, and forest bathing (Rodríguez-Morales et al., 2020; Roux et al., 2022). The comparatively low importance attributed to provisioning ecosystem services in our study was, hence, not surprising, and could be understood signalling a broader shift in how natural areas and forests specifically are perceived (Howley et al., 2011; Rametsteiner & Kraxner, 2003; Ranacher et al., 2020). The historically strong valuation of forests as sources of provisioning ecosystem services such as timber, firewood, wild food, and game has diminished in people's perspective, particularly in relation to urban lifestyles, and is much less visible in people's daily lives today. This relates to what has been described as a growing sense of nature alienation (Beery et al., 2023). In addition, the perception of provisioning services is overshadowed by public rejections of tree harvesting and concerns over industrial forest activity, which are often perceived as ecologically harmful and visually disruptive (Gundersen & Frivold, 2008).

Taken together, our findings point to a substantial divide between the economics of forestry and societal preferences in Europe (Konczal et al., 2023; Winkel et al., 2022). For stakeholders like forest owners and managers, provisioning services remain the most important source of their income, a fact that underscores this key tension (Lovrić et al., 2025). The gap between the low public appreciation of provisioning ecosystem services on the one hand, and the economic reliance of the EU bioeconomy on timber and related products on the other hand, presents a source of conflict. It creates a challenge for EU forest policymakers to reconcile the demands of the public and the forest sector and to navigate discussions over "the right form" of sustainable forest management. This mismatch in interests between stakeholders, particularly between forest managers and industry on the one hand, and citizens and conservationists on the other hand, has been described before (Winkel & Sotirov, 2016; Sotirov et al., 2021). It continues to shape EU forest policy debates, including those surrounding the EU Forest Strategy for 2030 (Gordeeva et al., 2022; Pecurul-Botines et al., 2025; Roux et al., 2025). However, such tensions may also serve as a starting point for dialogue and creativity, offering an opportunity to explore integrative solutions (Sotirov & Arts, 2018; Zachrisson & Beland Lindahl, 2013). In any case, our findings underline the importance of forest policies and management strategies that align societal preferences with current forest management practices, including a forest governance regime that responds to recent changes in societal perceptions, values, and expectations across Europe (Winkel et al., 2022).

Finally, the low importance attributed to ecosystem disservices remains somewhat surprising. As previous literature has indicated, citizens tend to experience not only the benefits but also the nuisances associated with forests and greenspaces (Blanco et al., 2019; Ordóñez Barona et al., 2022). In this study, respondents perceived ecosystem disservices as being of less importance than ecosystem services, with the exception of game hunting. From a psychological perspective, one might expect that negative experiences (e.g., allergies, uncontrolled pet dogs,

risk of crime, falling branches) would influence respondents' perceptions significantly, but this remains unsupported by our study. One possible explanation for this is the episodic, localised, and seasonal nature of some ecosystem disservices, making them less salient to study respondents (if at all) (Shackleton et al., 2016). Another contributing factor could be the normative framing of forests and greenspaces as inherently beneficial, coupled with a lack of awareness of disservices as they are far too often neglected in public debates (Roman et al., 2020).

4.2. European regions diverge in the perception of ecosystem services and disservices

A key finding of this study is the existence of clear geographic differences in the perceived importance of regulating and cultural ecosystem services across Europe, with particularly pronounced differences between certain regional clusters. While regulating and cultural ecosystem services were perceived as more important than provisioning ones by respondents in all countries, their importance increased along a gradient from North-Western to Eastern Europe. Respondents in cluster 3 (e.g., Belgium, Denmark, Finland) perceived regulating and cultural ecosystem services as (only) important (regulating $\bar{x}$ = 76.5, cultural $\bar{x}$ = 75), while they were perceived as more important by respondents in cluster 2 (e.g., Croatia, Germany; regulating $\bar{x}$ = 86, cultural $\bar{x}$ = 83). This increase in perceived importance continued in cluster 1 (e.g., Albania, Slovenia; regulating $\bar{x}$ = 95, cultural $\bar{x}$ = 87.5) and peaked in cluster 4 (e.g., Romania, Ukraine; regulating $\bar{x}$ = 96, cultural $\bar{x}$ = 95.5). In contrast, no clear geographic gradient emerged for provisioning ecosystem services. Although provisioning services were perceived as significantly less important overall, their perceived importance varied rather irregularly across countries, with peaks observed in a small number of cases, notably Slovenia ($\bar{x}$ = 51.25; IQR = 16.125), Sweden ($\bar{x}$ = 44; IQR = 15), and Hungary ($\bar{x}$ = 41.5; IQR = 22.75).

The pattern for regulating and cultural ecosystem services was somewhat unexpected, particularly given prior studies showing strong environmental appreciation in Northern and Western European countries such as Finland, Norway, and Sweden, where regulating services like biodiversity protection and climate mitigation are highly prioritised (Nordlund et al., 2017). Our data can only show this pattern, but not explain it, which renders possible explanations speculative. One such possible explanation could be that the degree of nature connectedness is higher in the less urbanised regions of Southern and Eastern Europe – and reversely the degree of alienation from nature is lower. Another explanation may be that there is a degree of saturation in Northern and Western Europe or higher demand for these services in countries with less advanced greenspace planning systems. Citizens from Norway, Finland and Sweden benefit from high shares of forest cover and well-established public access to forests and greenspaces. At the same time, citizens from Denmark, Belgium and the Netherlands, despite having among the lowest forest covers in Europe and among the highest levels of urbanisation, still possess well-established planning systems that incorporate large shares of urban and peri-urban greenspace (Evers et al., 2024; FOREST EUROPE, 2020). Together, these reported differences are likely influenced by a complex interplay of factors, which extends to the differences in forest cover, the availability of greenspaces in urban areas, access and management on the one hand, while on the other hand, respondents' views were likely shaped by their own local traditions, proximity to forests and dependence on ecosystem services for income, just to name a few (FOREST EUROPE, 2020; Winkel et al., 2022). Factors such as cultural and historical uses, and socio-economic factors, vary from region to region, and may have played an important role as well.

4.3. Values and demographics significantly influenced societal perceptions

The second sub-question in this research investigated how socio-demographics and values shape the perceived importance of

ecosystem services. Overall, this study found that values, as conceptualised by Schwartz's typology, had stronger predictive power than socio-demographic characteristics for the perceived importance of regulating and cultural services. Prior studies have already noted the importance of values as a concept for analysing and interpreting environmental perceptions (Manfredo et al., 2017; Schultz & Zelezny, 1999) as well as the predictive power of values over demographics such as gender, age, education, and income (Pülzl et al., 2021; Vecchione et al., 2015).

Specifically, the PVQ-21 part of the questionnaire revealed that respondents with self-transcendence values, such as concern for others and environmental justice, were most supportive of regulating and cultural services. This result is in line with previous studies reporting a positive relationship between self-transcendence values and pro-environmental attitudes (Schultz & Zelezny, 1999). Our results are further supported by Pülzl et al. (2021), who found that self-transcendence values were most significantly associated with services like climate change mitigation, clean air and water, and recreation opportunities in five European countries (Austria, Spain, Germany, Russia and Sweden). Openness to change values were strongly associated with regulating and cultural services, which indicated that individuals with freedom of thought and with independent lifestyles tend to perceive non-material benefits as important in our study. Here, our findings diverge slightly from Pülzl et al. (2021), who reported a weaker association between respondents with openness to change values and forest ecosystem services. Interestingly, conservation values (in Schwartz's terminology associated with tradition, security, and order) also positively influenced the perceived importance of cultural and regulating services across studies. Similarly, both studies show that respondents with self-enhancement values tend to care least about regulating and cultural services, which reflects the findings of Pülzl et al. (2021). This is in line with earlier research indicating that respondents with self-enhancement values are less likely to attach importance to non-material benefits of forests and greenspaces (Schwartz & Cieciuch, 2021).

The perceptions of provisioning services followed a different pattern than those observed for regulating and cultural services. First, interestingly, this study found that their perceived importance was most strongly associated with one specific socio-demographic characteristic, the place of residence. Secondly, referring to values, respondents with conservation values, openness to change values, and self-enhancement values were all positively associated with provisioning services. Notably, self-transcendence values were negatively associated with these services, suggesting that respondents concerned with altruism and environmental protection may view extractive forest uses with scepticism. These findings align with Pülzl et al. (2021), who reported that citizens with self-transcendence values tend to perceive a lower importance of provisioning services.

Furthermore, demographics also significantly shaped perceptions. Women and older respondents perceived regulating and cultural ecosystem services as more important than men and younger respondents. These results reflect those of Ode Sang et al. (2016), who reported that in urban Swedish contexts, women valued the aesthetic value of greenspaces more than men, and that older citizens were more active in nature compared to younger citizens. In a similar way, Purwestri et al. (2023) reported that older citizens and women in Czechia placed significantly more importance on all ecosystem services categories. Overall, these results suggest that women and older people are generally more positive towards the multifunctional role of forests and greenspaces. Possibly, this can be explained by a greater concern about the sustainable use and well-being of forests and greenspaces due to stronger emotional and recreational attachments.

Regarding provisioning services, as already noted, this study found that they were first and foremost associated with the respondents' place of residence. Respondents living in the countryside, nearby a city, and in the suburb of a city placed greater importance on these services compared to city dwellers. This urban-rural divide is consistent with

earlier research, e.g. from Türkiye and Spain (Baykalı & Şen, 2024; Rodríguez-Morales et al., 2020). For example, Baykalı & Şen (2024) showed that particularly wild foods and firewood were perceived as more important by rural residents than by city dwellers. Rural citizens in Spain reported much higher awareness of provisioning services, with none selecting the “no response/don’t know” option, in contrast to 29% of urban residents (Rodríguez-Morales et al., 2020).

In turn, urban dwellers placed greater importance on cultural ecosystem services and activities like recreation and sports (Rodríguez-Morales et al., 2020). This was further confirmed by our findings, where the place of residence was a negative predictor for cultural ecosystem services among respondents in the countryside, meaning they were significantly less likely to value cultural ecosystem services compared to city dwellers. For regulating ecosystem services, respondents living in city centres perceived them as less important than those living in suburbs, nearby a city, or in the countryside. This is interesting given the attention on trees for cooling in municipal planning strategies across Europe. One possible explanation is that city dwellers may be less aware or less directly exposed in their daily lives to these regulating services (e.g., air quality regulation) compared to cultural services (e.g., recreation and sports) (Buchel & Frantzeskaki, 2015). Overall, these contrasting perspectives highlight how personal everyday experiences with the local environment strongly influence how citizens perceive forest ecosystem services.

Lastly, education and income were also significant predictors. Respondents with high education levels and greater affluence were less likely to perceive provisioning services as important. These results may be explained by the fact that these respondents are less reliant on direct forest products and that they possess greater environmental awareness about the impacts of extractive forest activities. Also, these perceptions likely align with their lifestyles and views on personal well-being.

4.4. Limitations and future research

This study relied on a large and diverse sample of the European public to assess ecosystem services based on a modified version of the CICES framework, while the disservices framework was adopted from the literature. While the study team invested much effort in ensuring comparability of translated questions by involving forest and environmental social scientists/academics for translating and checking the survey into all languages (29 languages to collect responses in 33 European countries), differences in language use and terms may inevitably lead to nuances and differences in interpretation by respondents that are difficult to navigate. The share of invalid responses was 19%, which could be attributed to the length of the questionnaire and the relatively low incentive for participation.

Although respondents were asked how important each ecosystem service and disservice is to them personally, some may have answered with a broader societal view in mind. For example, respondents may have responded to provisioning services such as wild food or game hunting, despite not foraging or hunting themselves. Such mixed interpretations are common in environmental perception research, as respondents often blur personal and societal meanings of ecosystem services influenced by diverse underlying values (Chan et al., 2012). This nuance should therefore be considered when interpreting the relatively low values for provisioning services.

The ecosystem services evaluated by respondents may also differ considerably depending on the specific forests or greenspace they had in mind. Future research may benefit from scaled-down, site-specific data to account for these local contexts. Moreover, this study presented broad regional clusters based on statistical similarities in the perception data, but these clusters should not be understood as formal geopolitical groupings. Yet, future work could benefit from more detailed geographic analysis (e.g., at the NUTS II level), which would provide deeper insights and potentially link perceptions to specific forest types. In addition, future research may also benefit from incorporating information about

landscape types that respondents visit (e.g., rural forests, peri-urban forests, urban parks) and explore geographical value orientations across Europe. These factors may also shape how respondents assess the importance of different ecosystem services and disservices.

Although our study included one socially derived disservice (safety concerns), most of the disservices included were ecological or management related. Baumeister et al. (2022) found that many negative perceptions relate to social issues such as noise, littering, overcrowding and conflicts with other users. Such socially derived disservices were not captured by our study but could be included in future research.

Additionally, the questionnaire design relied exclusively on closed questions to maintain analytical efficiency. Including open questions or interviews for future research could provide more nuanced responses and insights into public perceptions.

5. Conclusions

This study assesses, for the first time, societal perceptions of ecosystem services of forests and greenspaces on a continental European scale, encompassing data from 33 countries. Across Europe, ecosystem services are perceived as important by the majority of respondents, with regulating and cultural ecosystem services considered significantly more important compared to provisioning services. Meanwhile, ecosystem disservices were perceived to be of little significance to the respondents in this study. The study further reveals a cross-continental gradient: the perceived importance of regulating and cultural ecosystem services gradually increased from North-Western to Eastern Europe. Furthermore, within and across all countries, considerable differences exist at the individual level that can be related to both socio-demographic variables and the values respondents hold. Here, values were stronger predictors of perceived importance than socio-demographic variables.

European forest policies promote sustainable and multifunctional forest management to balance forest protection, restoration, economic use, and societal demands. We argue that monitoring and understanding public perceptions of forests and the ecosystem services they provide is critical for informing policies and decision-making that governs forest and greenspace management. Importantly, this study suggests that not only sociodemographic differences should be accounted for, but also the underlying values, which shape how the public perceives ecosystem services.

CRedit authorship contribution statement

Dennis Roitsch: Writing – original draft, Formal analysis. **Kiki Ekiawan Lamatungga:** Formal analysis. **Jakob Derks:** Writing – review & editing, Conceptualization. **Rik De Vreese:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Arjen Buijs:** Writing – review & editing, Validation, Supervision, Methodology. **Ivana Zivojinovic:** Writing – review & editing, Conceptualization. **Helga Pülzl:** Writing – review & editing, Conceptualization. **Georg Winkel:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Disclaimer

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ecoser.2026.101832>.

Data availability

Data will be made available on request.

References

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