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Psychological and physical components in forming preferences on urban greenery management – the case of trees.

Abstract:

Public opinion is increasingly important in managing urban greenery. In this regard, this study demonstrates the importance of sociological (environmental worldviews), psychological (place attachment, perceived benefits of trees), and physical factors (type of building people live in, and urban greenery) in forming residents' opinions on whether the municipality or landowners should decide about tree removal on private land. Logistic regression models were applied to analyze data collected through a survey (N=199) and satellite image-derived Normalized Difference Vegetation Index carried out in two Polish cities to predict the likelihood of a respondent indicating whether landowners or the municipality should decide about tree removal on private land. The results revealed that, of two worldviews, Anthropocentrism and Environmentalism, the former is connected with the opinion that the landowner should decide about tree removal. Moreover, a stronger sense of place attachment strengthens this opinion. At the same time, greater recognition of cultural ecosystem services provided by trees and living in multi-family houses is related to the opinion that the municipality should decide about tree removal. The results also demonstrated that, when managing urban greenery, it is vital to consider not only the quality of greenery but also less obvious metrics that can affect tree management. Based on these findings we conclude that the participation of residents in tree management decisions requires careful consideration of social factors affecting their preferences.

Keywords:

Place attachment; tree removal; urban greenery quality (NDVI); type of building; New Ecological Paradigm (NEP)

1. Introduction: urban tree management challenges

1.1. Study background

Trees are a vital part of urban greenery. Greenery type, quality, and location play an important role in the functioning of cities (Collins et al., 2019). While cities get hotter, more polluted and stressful, trees can reduce temperatures, remove air pollution and reduce stress (Abass, Appiah & Afriyie, 2019; Biernacka & Kronenberg, 2019; Lin, 2020). The protective properties of trees are particularly relevant in Europe, where urbanized areas are almost entirely located within the forest biome, resulting in trees

covering 30% of the area (Nowak & Greenfield, 2020). Thus, trees are a key criterion for determining the quality of urban greenery (Taylor & Hochuli, 2017).

In the last 40 years, public attitudes toward trees have changed from a commodity-oriented perspective to an orientation in which their cultural (non-commodity) services play more pronounced roles (Tarrant & Cordell, 2002). This is shown by public appreciation for urban trees (Collins et al., 2019) and their support for more tree planting in parkland and for 'natural' methods of tree management (Fuller et al., 2016; Harper et al., 2016; Jennings et al., 2016).

Despite general changes in public sentiment, there is significant tree canopy loss in some parts of the world (Morgenroth et al., 2017; Nowak & Greenfield, 2020). Globally, Urban Tree Cover (UTC) decreased slightly (0.2%) between 2012 and 2017 (Nowak & Greenfield, 2020), both in public and private green spaces (Croeser et al., 2020). Urban greenery has been reduced by tree removal caused by increasing urbanization, such as erecting buildings, building roads, and providing other urban services. Therefore, tree management is an important issue affected by the balance between urban development and protection of greenery.

However, planting and removing trees involve societal choices connected with contradictory values and interests. Tree professionals and private arborists differ in their approaches to tree management regarding tree type, size, and abundance (Kirkpatrick et al., 2013). There are also conflicting views among residents, with noteworthy differences between "tree lovers" and "tree haters" or “arboriophobes” (Kirkpatrick et al., 2013, Suchocka, Jankowski & Błaszczyk, 2019) displaying a diversity of values regarding trees. Diversity in the perception of the value of trees often leads to conflicts at different scales that cause decision-making stalemates, generating costs associated with resolving these conflicts and implementing sustainable tree management (Czaja, Kołton & Muras, 2020).

Furthermore, tree management in urban areas involves trade-offs to solve dilemmas in public-private interests (Bagavathiannan et al., 2019). Urban trees on private land are generally not included in urban forest management plans (Klobucar et al., 2021a), which are dominated by the public sector in visioning, planning, and management of green infrastructure (Young & McPherson, 2013). However, private trees provide services not only for the owner but also for the public. As a result, incorporating trees on private land into public tree management plans and implementing various types of private-public partnerships is important (Moskell & Alfred, 2013; Collins et al., 2019). Regulations have been emerging to deal with this issue. For example, in England, local planning authorities have the power to protect trees of special amenity value on private land, where the benefits they provide serve public interests (Write & Slater, 2017; Clark et al., 2020).

Regulations concerning tree removal should not be limited to public urban greenery but should also cover trees on private land (Ordonez-Barona et al., 2021). However, public support for tree protection regulations is vital to their successful implementation (Clark et al., 2020). Therefore, understanding

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factors influencing views related to tree removal regulations on private land is crucial to sustainable urban greenery management. Relations between people and urban greenery are influenced by several physical and psychological factors. Many studies have focused on either physical factors or socio-psychological drivers, but few categorize and simultaneously examine their impact on people-environment relations (Wan, Shen, & Choi, 2020). In the complex issue of tree management, psychological factors coexist with other drivers, but are often overlooked or treated independently from physical factors (Douglas, Lennon & Scott, 2017; Wan, Shen, & Choi, 2020).

In our study, we address this gap by connecting psychological factors, i.e., place attachment (PA) and perceived benefits of trees and environmental worldviews, with physical factors, i.e., type of building people live in and urban greenery cover, to examine how these preferences affect the attribution of the right to manage trees. In particular, we focus on views of who should decide on tree removal on private land – the landowner or the municipality. The assignment of responsibility for tree management to private owners or public bodies is an important component of designing sustainable tree management strategies.

We conducted our research in Poland, where residents must obtain a permit to remove trees on their land. However, in 2017 this regulation was temporarily lifted. Removal of this regulation proved controversial, as there were cases of removals of large numbers of trees, reported by the media (Kronenberg et al., 2021, Przewoźna et al., 2021a), leading to the restoration of mandatory tree removal permits. These legal changes demonstrate a dilemma of legal, social, and environmental dimensions, where solving the conflict required balancing freedom related to decisions about private property with the public good and interest flowing from private property (Bartel & Graham, 2016).

1.2. Conceptual framework and literature review regarding attitudes towards trees

We focus on how multidimensionality (physical, social, and psychological factors) influence opinions on whether to cut down trees. So far, no attempts to use such a multidimensional approach to tree-cutting decisions have been made.

Previous research has shown that differences in perception of the benefits trees provide are an important socio-psychological driver of attitudes towards trees (Hami & Maruthaveeran, 2018; Himes & Muraca, 2018; Maniatakou et al., 2020), including cultural ecosystem services (ES) (Ostoic et al., 2020) in its contextuality (Dickinson & Hobbs, 2017; Pascual et al., 2017). Such differences may arise based on residents' physical surroundings, including greenery quality (Davies & Jones, 2014; Watkins et al., 2017) and the type of buildings in which they live (Koyata et al., 2021). The presence of trees influences the attitudes of residents living nearby (Davies & Jones, 2014) and is related to certain socio-demographic variables, such as income or race (Watkins et al., 2017). Urban tree cover can also

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influence perception, e.g., it can affect perceived safety (Mouratidis, 2019). Moreover, "place-based" drivers and the perceived benefits of trees and views on tree management are related to environmental worldviews that reflect basic beliefs about the environment. Thus, consideration of environmental views can provide insight into how a predominant worldview indicates people's opinions on tree management (van Riper et al., 2019; Ambrose-Oji et al., 2020).

Furthermore, the perception of the benefits of urban greenery and involvement in urban greenery management can be influenced by PA through an emotional connection with the place where greenery is located. For example, people who are more attached to a place may attribute more positive characteristics to the place and be more willing to engage in activities that will benefit the place. In addition, people more attached to a place tend to support its status quo (since changing a place threatens their identification with it) and tend to ensure that a place is not changed (Bartel & Graham, 2016). Place attachment appears to be a significant factor regarding tree management (Bartel & Graham, 2016) and trees can also strengthen place attachment (Colinas et al., 2019; Ostoic et al., 2020). The main predictors explaining greater PA are social ties, length of residence, type of housing, family roots, age, and education level. However, the nature of the locality, e.g., rural or urban, is also important in determining the level of attachment - emotional attachment to a place tends to be greater for rural than for urban areas (Paniotova-Maczka et al., 2021; Verbrugge & van den Born, 2018; Wartmann et al., 2021).

The influence of socio-psychological factors considered in this paper (place attachment, environmental worldviews, and perceived benefits of trees), as well as physical factors (urban greenery cover and type of building people live in), have been analyzed together. Moreover, these factors are used both as independent and dependent variables. In this paper, we evaluate whether they have an impact simultaneously, as independent variables, and with place attachment as a moderating variable.

We evaluate the impacts of psychological, sociological, and physical variables on urban residents' views on who should be responsible for deciding on tree removal on private land. We follow the World Health Organization's (WHO, 2016) recommendation that two crucial sources of information should be considered in analyzing the significance of the environment: surveys enabling studies on perception-based indicators and satellite image-derived Normalized Difference Vegetation Index (NDVI), used as a proxy of greenness. Greenness estimated with NDVI describes general greenery availability (i.e., Giannico et al. 2021) but may also indicate the high vegetation share and its vitality (Klobucar et al. 2021b) and the benefits provided by trees constituting greenery (Marando et al., 2019).

We briefly review the literature on the conceptualization of the constructs of place attachment and empirical evidence supporting our hypothesized associations of several factors with PA, followed by a description of our proposed model. We review variables concerning psychological impact: PA, environmental worldviews (New Ecological Paradigm - NEP) and perception of the environment (perception of ES provided by trees), as well as physical factors indicated by NDVI and type of building.

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1.2.1. Place attachment - an emotional connection with the place greenery is located

Place attachment has gained attention in environmental management studies (including tree management) since the late 1980s (Bricker & Kerstetter, 2000; Kyle et al., 2004; Moore & Graefe, 1994; Vaske & Kobrin, 2001; Williams & Roggenbuck, 1989). PA can be considered in several conceptual dimensions related to the meaning of place, place characteristics, and the emotional, cognitive, and behavioral components of attachment (Brown & Raymond, 2007; Lewicka, 2008; Scannell & Gifford, 2010, 2017). Other concepts related to PA include the sense of place (Jorgensen & Stedman, 2006) and dependence on place (Trentelman, 2009).

In the present study, we focus on the emotional connection with a place. People who have a strong emotional connection with a place treat the place as an integral part of their identity and are particularly sensitive to changes occurring to it (Bonaiuto, Carrus, Martorella & Bonnes, 2002). Previous research showed that this component of the psychological dimension of PA is the strongest indicator of attachment. Moreover, emotional PA can explain behaviors and intentions to become involved in matters about the place to which they are attached (Buta, Holland & Kaplanidou, 2014; Chappell, Parkins & Sherren, 2020; Paniotova-Maczka et al., 2021; Payton, Fulton & Anderson, 2005).

Studies show that PA is related to the level of activism, perception of benefits from the environment, and preferences for management. Furthermore, people with a greater attachment to their place of residence are more often involved in improving the condition of the place and more interested in changes happening to it (Verbrugge & van den Born, 2018). Previous research has also shown that growing PA is connected with increased trust in individuals, which in turn increases citizen activism. However, a similar relationship is not observed in the case of trust in institutions (Payton, Fulton & Anderson, 2005). Previous research has shown that people with higher PA perceive more provisioning benefits from trees, regardless of whether they are in an urban or rural setting (Paniotova-Maczka et al., 2021), and PA influences stakeholder valorization of ES (Cuni-Sanchez, 2019; Lakerveld et al., 2015; Cundill et al., 2017). According to Adams and Adger (2013), non-economic ES are important in creating PA, and ecological PA exists independently of provisioning ES. Trees with their various features (i.e., accessibility or maintenance), regardless of the type of urban greenery (including among others forests, public gardens, parks, and grassland), are important for PA and aesthetics (Krajter Ostoić et al., 2020). According to Kim et al. (2017), individual identity and PA help explain unexpected findings that cannot be interpreted using economic theory alone. Furthermore, PA is also related to perceptions of greenery management. Colley and Craig (2019) observed a positive association of PA with support for leaving greenery in a semi-wild state and for explicit landscaping. The authors argue that the two models should not be treated antagonistically, although they did not consider the quality of greenery and its benefits. Our study considers these factors in the context of tree management on private lands.

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Although prior research has shown a positive and direct relationship between local and easy access to greenery and PA (Arnberger & Eder, 2012), the effect on PA of availability and amount of greenery around a residence is inconsistent. For example, Kimpton, Wickes, and Corcoran (2014) found no relationship between the availability and amount of greenery and higher levels of PA. In contrast, other studies showed that available greenery around a residence increases emotional PA (Hosseini et al., 2021; Colinas et al., 2019; Ostoic et al., 2020).

1.2.2. Environmental worldviews

Environmental worldviews can be defined as a person's beliefs about humanity's relationship with nature (Schultz et al., 2005). Attitudes toward environmental regulation are rooted in environmental worldviews and political orientation (Guo et al., 2021).

There are various measures of environmental worldviews (Bruni et al., 2012). One of the most commonly used is the NEP scale (Dunlap et al., 2000; Xiao et al., 2019). Previous research shows that NEP is one of the strongest predictors of environmental worldviews among a wide range of beliefs. NEP also mediates the effects of external variables (e.g., socio-demographic characteristics, personal values, personality traits) on environmental beliefs (Xiao et al., 2019). Environmental worldviews measured by NEP range from Anthropocentrism (i.e., human-based) to Environmentalism (i.e., nature-based) (van Riper and Kyle 2014). Regarding trees, environmental worldviews are related to people's preferences regarding tree management, e.g., concerning tree removal (van Riper et al., 2019). A study by Tarrant & Cordell (2002) showed a relationship between environmental worldviews and various values attributed to forests (wood production, cleaning air, aesthetics) consistent with ES. Moreover, the strength of the relationship between worldview and forest value depends on the type of forest, i.e., public or private. This demonstrates the importance of ownership in tree management.

1.2.3. Perceptions of the benefits of trees

Urban greenery, including trees, provides people with several important ES that the natural environment directly delivers to people with positive effects on human well-being (Millennium Ecosystem Assessment – MEA, 2005; Haines-Young & Potschin, 2013; TEEB, 2010). The Economics of Ecosystems and Biodiversity (TEEB) (TEEB, 2010) identifies four main types of ES: (1) provisioning (e.g., supply of fruits and nuts, wood, and leaves); (2) regulating (e.g., protection against wind, and a positive effect on health by producing phytoncides – antibacterial substances released into the air by leaves, flowers or bark); (3) habitat (e.g., habitat and food for animals); (4) cultural and amenity (e.g., places of recreation, strengthening interpersonal bonds) (Hesslerová et al., 2022; Wong, Tan, Kolokotsa & Takebayashi, 2021; Xing, Brimblecombe, Wang & Zhang, 2019; Gunnarsson, Knez, Hedblom & Sang, 2017).

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The flow of ES from trees to people is not straightforward (Mace et al., 2012; Bagstad et al., 2014), as the significance of benefits depends on the multi-dimensional ways in which people value nature (Daily et al., 2000; Schröter et al., 2014). These perceptions and values influence policy decisions (e.g., Haines-Young & Potschin, 2013; Díaz et al., 2015). For tree management, previous research shows that positively perceived benefits from trees by property owners do not necessarily result in greater tree and shrub abundance on individual properties (Klobucar et al., 2021a). Moreover, despite all the benefits of urban trees, conflicts between people who receive such benefits can arise over tree management (Maczka et al., 2021). These conflicts can have various causes, including access to information, competitive values or interests, relationships between actors, and issues of ownership and responsibility (Moore, 2014; Maczka et al., 2021).

Besides conflicts related to their benefits, trees also can bring "disservices," which negatively affect the quality of life, e.g., fallen leaves, rotten fruits, and danger from falling branches (Cariñanos et al., 2016; Lyytimäki, 2017; Roman et al., 2021; Kronenberg et al., 2021). Differences in tree properties further complicate perceptions of both ES and disservices, as the same tree product can be a desirable ES in some circumstances and an unwanted disservice in others, e.g., a shadow cast by a tree in a paved car park and shade that obstructs light from reaching someone's house. Therefore, the perception of tree benefits is a multifaceted and context-related issue.

1.2.4. Greenness of residents' surroundings

Adequate quality and quantity of urban greenery are crucial for physical and mental health (WHO, 2016). However, including urban greenery quality in planning, management, and research can be challenging due to problems with datasets based on inconsistent definitions and a lack of data (Feltynowski et al., 2018). The presence of urban greenery improves quality of life (Giannico et al., 2021; Czepkiewicz, 2017), especially in less wealthy communities (Han et al., 2021), as well as promoting socio-cultural connections (Holtan et al., 2015; Hosseini et al., 2021). Access to trees and shrubs in a neighborhood increases resident satisfaction with their community (Ellis et al., 2006), which may impact their trust in decisions by municipal representatives. Similar relationships have been identified in other domains for which local authorities are responsible. For example, Gendel-Guterman and Billig (2021) showed that satisfaction with public services is related to quality of life, which is strongly linked to the quality and accessibility of urban greenery. Thus, the presence of greenery near a person’s residence and its quality may significantly influence, positively or negatively, attitudes toward local authorities and, consequently, trust in decision-making by authorities. Spatial analysis of physical factors describing the greenness of residents’ surroundings (relating to both greenery presence and its quality) could be a significant indicator of this trust, which may be expressed in opinions on local government responsibility for environmental management. In terms of greenery, this responsibility is

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mostly related to tree management and the question of who has the authority to decide about tree removal on private land.

However, the presence of greenery expressed by objective data does not always correspond with the way residents perceive their surroundings (Tabatabaie et al., 2019). For example, when a high density of urban greenery is associated with poor lighting at night, greenery can be perceived as creating an unsafe space (Rahm et al., 2021), and in fact, may be related to higher crime rates (Wolfe & Mennis, 2012). Dense tree cover in a neighborhood is desirable when noise reduction or shade is needed, while medium tree cover is preferred for recreation purposes (Palliwoda et al., 2020). Moreover, semi-public greenery may play a more crucial role in the daily lives of people than large parks or urban forests full of trees (Säumel et al., 2021). Thus, greenery should not be analyzed in isolation from perceptions of trees in neighborhoods. Greenery should be also considered in relation to the type of buildings in the surrounding area since built environment strongly affects plantable space available for trees and shrubs (Klobucar et al., 2021a)

1.2.5. Residence type

Buildings are places of rest and work, closely connected with human activity. Previous research has shown that the type of building people live in, i.e., a single-family or multi-family house, is an important factor related to PA (Lewicka, 2011), as well as to the preferences and behaviors of its residents, e.g., for decision-making regarding energy retrofits (Ebrahimigharehbaghi et al., 2022), food expenditures (Oostenbach, 2021), and energy consumption (Namazkhan et al., 2020). However, there is relatively little research concerning the role of building type on attitudes towards urban greenery. A study in North Adams, Massachusetts, USA, exploring motivations to participate in an urban forestry program and willingness to have a tree planted in one's yard demonstrated differences between people living in multi-family buildings and single-family houses, reflecting concern about maintaining a newly planted tree (Gonçalves, 2019). People living in multi-family buildings were more concerned than those living in single-family houses. Moreover, renters had greater concerns than homeowners. Therefore, it can be surmised that people living in a single-family house (in particular, when the occupant owns the house) were less supportive of external intervention and more supportive of retaining decision-making regarding their property, e.g., deciding about tree removal on private land compared to people living in multi-family buildings. Moreover, people living in multi-family buildings do not own the land or trees, limiting their role in tree governance, e.g., they cannot participate in green infrastructure initiatives (including those concerning trees) without property owner permission (Conway et al., 2022). Therefore, we can deduce that they are likely to support municipality decision-making about trees.

1.3 The conceptual model of the study

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This study aimed to test the influence of PA as a factor moderating the relation between four explanatory covariates (NEP, type of building people live in, perception of ES, and NDVI) and opinions about "Who should decide about removing trees?" (dependent variable) (Figure1).

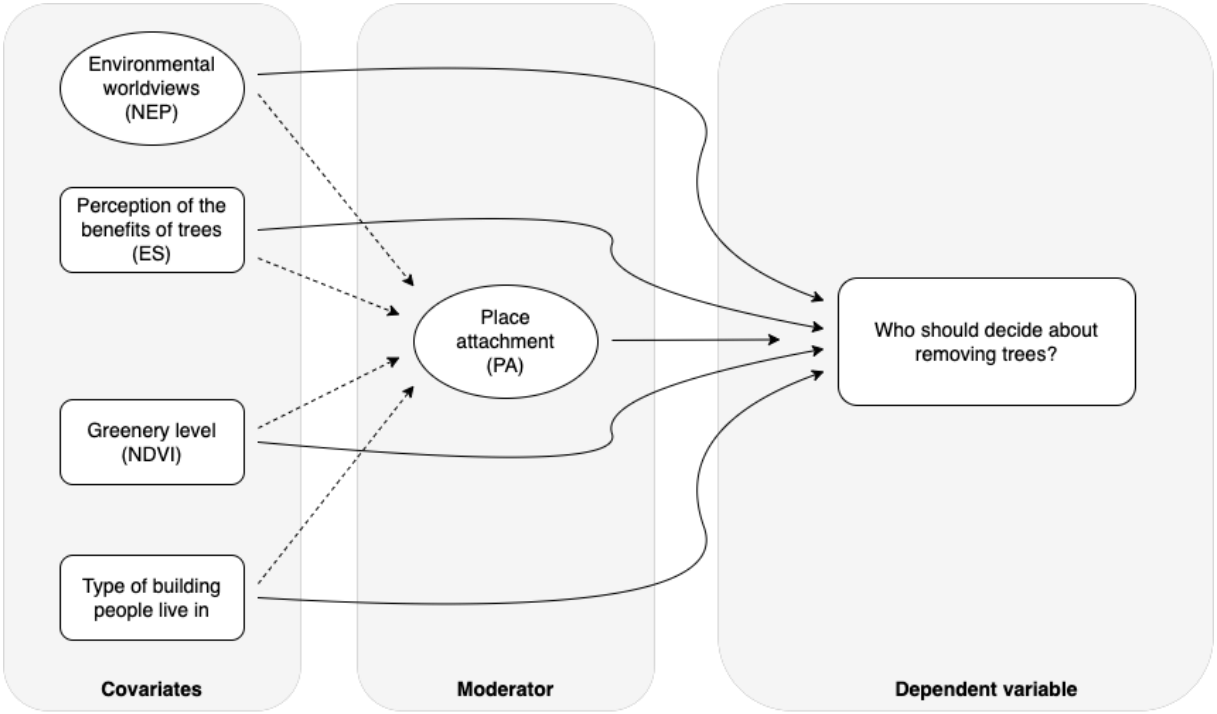

Figure 1. Conceptual model of components in forming preferences on urban greenery management

Note: Two latent constructs included in our analysis are represented by ellipses in Figure 1, while rectangles indicate manifest variables. Solid lines represent direct effects, while dashed lines denote indirect impact through the moderating variable. NEP – New Ecological Paradigm, ES – Ecosystem Services, NDVI – Normalized Difference Vegetation Index, PA – Place Attachment.

The analysis has two components. We formulated five hypotheses, and in the first step tested relationships between covariates and the dependent variable (H1.1-H1.4, below). Next, we tested the moderating significance of PA (H.2, below), which is the main focus of the analysis.

H1.1. Individuals with pro-environmental worldviews (Environmentalism) are less likely to indicate that landowners should be responsible for deciding about tree removal on their private land.

H1.2. Respondents who recognize the benefits of trees are less likely to indicate that landowners can decide to remove trees on private land.

H1.3. The higher the quality of greenery near a respondent's home the less likely they are to indicate that the landowner should decide about removing trees on private land.

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H1.4. The likelihood of indicating that the landowner should decide on tree removal on private land is higher for respondents living in a single-family house than those living in multi-family buildings.

H2. PA moderates the effect of: a) environmental worldviews; b) perceived benefits of trees; c) the quality of the greenery in the area surrounding a respondent's home; and d) the type of building people live in, on the likelihood of indicating that the landowner should decide about removing trees on private land.

2. Data and methods

2.1. Data collection

Data for this study were obtained via an online survey conducted in June and August 2020, on an adult population of citizens of two Polish cities: Gdańsk and Poznań. Two cities were selected because the research takes into account the vegetation cover in urban areas, which varies between these cities due to landform differences. Therefore, the selected cities are similar in size (Gdańsk 468k and Poznań 536k residents in 2019[1]) and greenness (mean NDVI in our study was 0.5), but Poznan is a concentric city, while Gdańsk is a more linear, seaside city (Figure 2). In Gdansk, forest area accounts for 18% of the city's area, while in Poznan, forests account for 14% of the city's area (according to Corine Land Cover 2018). By using two case studies we aimed to diminish the impact of potential idiosyncratic condition that might occur had only one case study city been used.

1 Local Data Bank https://bdl.stat.gov.pl/BDL (accessed on 7 April 2022).

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Figure 2. Case study locations.

Respondents were recruited using Facebook and the local news media. A map-aided questionnaire was used. Respondents were asked to answer questions related to the perceived benefits of trees (which they indicated on an interactive map), their attitudes towards removing trees, their attachment to the place they live, and their environmental worldviews. Trees identified by a respondent were marked on maps, as was the location of the respondent's home. Using such geolocated data enabled a comparison of the results with the surrounding greenness and its impact on the responses received.

The list of perceived benefits was based on the TEEB classification of ES (TEEB 2010) and its adaptation for trees in Poland by Kronenberg (2012). We modified the classification before application in our research to avoid scientific jargon. For this purpose, we conducted a pilot study based on 10 semi-structured in-depth interviews (IDI) of city residents. Finally, after adjustment, we had a list of 17 perceived benefits of trees, including both non-cultural (e.g., delivery of fruit and nuts, protection from high winds, etc.) and cultural (e.g., impact on the aesthetics of space, places of recreation, etc.). The full list is presented in online supplementary material (SM) section A3.

Sample representativeness was accounted for through the following steps. First, we deleted records with missing data for any variable, resulting in N=199. Sample representativeness is a problem noted for online data collection methods (Brown, 2017; Czepkiewicz et al., 2017). We controlled representativeness by comparing the characteristics of our sample with census information; as expected,

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our sample was biased towards younger segments of the population (Figure 3). Detailed information about the survey can be found in Przewoźna et al. (2021b) and statistics characterizing the sample are presented in SM in Table 1.1.

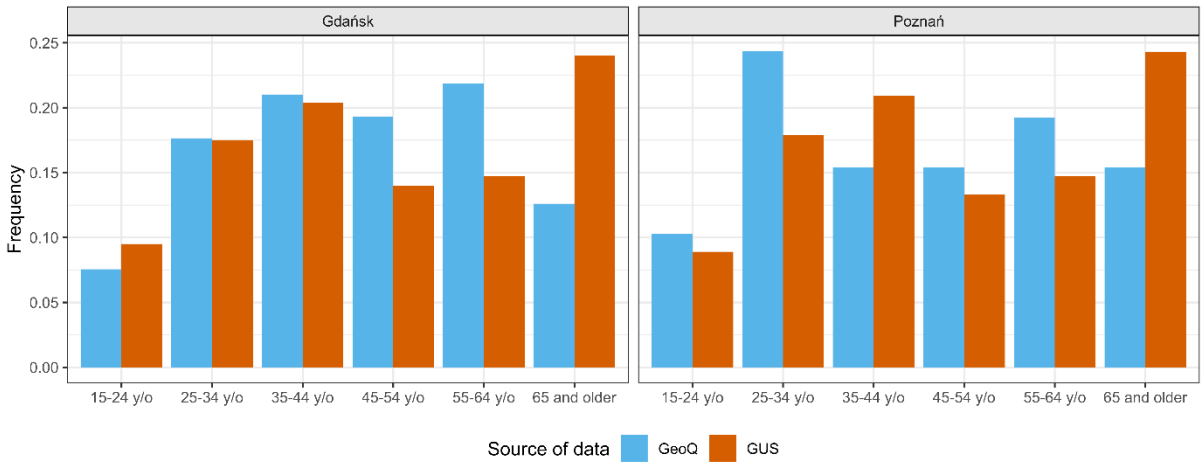

Figure 3. Sample characteristics vs. census data (GeoQ - survey sample; GUS - data from the Local Data Bank (census data) accessed on 1 November 2019)

The dependent variable in our analysis was **public attitudes toward tree management,** which we measured by asking respondents, "Who, in your opinion, should decide about tree removal on private land?" Respondents could choose from three options: (1) Municipality or another office, considering the reason for tree removal; (2) Landowner, regardless of the circumstances; and (3) Landowner, except in special cases. We dichotomized the 3-option response in such a way that $E(TREE_i = 1) = \pi_{1i}$ is the probability that respondent chooses options (2) or (3), while $E(TREE_i = 0) = 1 - \pi_{1i}$ is the probability that option (1) was preferred.

Four explanatory variables were hypothesized as impacting respondent opinion on who should decide about tree removal:

(1) **an environmental worldview**, measured by implementing the 15-item NEP (Dunlap et al., 2000) using questions with a 4-point rating scale from "Strongly disagree" to "Strongly agree"; (2) the **perception of benefits provided by trees** indicated on an interactive map, expressed with indexes of ES. Due to the nature of ES and for analytical reasons, four types of ES (see section 1.2.3) were dichotomized into two types: non-cultural - ES (types 1-3 in TEEB), and cultural services - ES (type 4 in TEEB). The ES index is equivalent to the rating assigned for non-cultural or cultural ES; (3) the greenness of the **area surrounding a respondent's home**, expressed by mean NDVI calculated within 800m of their home (following Czepkiewicz, 2017), which reflected the availability of many ES, including those that did not require direct access to the site where they were provided; and

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(4) the **type of building** where the respondent lives, operationalized by a dichotomous variable indicating whether the respondent resides in a multi-family housing (marked as 1) or a single-family house (the reference category, marked as 0).

In addition, we identified a moderating variable, **PA**, calculated based on the 9-item version of the PA scale (Lewicka, 2011), measured on a five-point agree-disagree format of the Likert scale. We present the operationalization of all explanatory variables and the moderating variable in SM section 2.1., while descriptive statistics for all variables are provided in SM section 2.2.

2.2. Analytical approach

We estimated a set of logistic regression models predicting the likelihood of a respondent indicating that landowners should have the right to decide about tree removal on private land (i.e., π_{1i}), as opposed to the likelihood of indicating municipalities have the authority over this decision (i.e., $1 - \pi_{1i}$). We transformed the abovementioned probabilities by the logit link function, where the logit coefficient $\eta_i = log(\pi_{1i}/(1 - \pi_{1i}))$ is the log of the odds of the event $TREE_i = 1$, as opposed to $TREE_i = 0$. We built eight different regression models step-by-step, with all explanatory variables added in a stepwise manner as detailed in Table 1). We opted not to include all explanatory variables and their interactions with the PA scale in a single model, as we wanted to estimate an Events Per Variable criterion determining the number of variables that can be included in the regression to achieve a minimally acceptable level of statistical power (Agresti et al., 2007). Moreover, as we hypothesized that PA moderates the effect of explanatory variables on attitudes toward tree management, we implemented a standard procedure of verifying the existence of a moderating effect, which entails the addition of an interaction term in a regression model and checking whether the interaction is statistically significant (Aguinis, 2004; Jose, 2013). Our regression models are generally expressed as follows:

$$\eta_i = \beta_0 + \beta_Z \Delta_{Zi} + \beta_{PA} PA_i + \beta_Y (PA_i \times \Delta_{Zi}),$$

where β_0 is an intercept, β_Z denotes regression coefficients for all explanatory variables denoted by Δ_{Zi}, β_{PA} is the regression coefficient for the moderating variable PA, and β_Y denotes the regression coefficient for the interaction term between PA and a set of explanatory variables Δ_{Zi}. The analysis was performed in R (R Core Team, 2018). We used the following R packages: corpcor (Schafer et al., 2021), cluster (Maechler et al., 2021), dplyr (Wickham et al., 2022), flextable (Gohel, 2021), ggplot2 (Wickham, 2016), GPArotation (Bernaards & Jennrich, 2005), haven (Wickham & Miller, 2021), kableExtra (Zhu, 2021), psych (Revelle, 2022), psychTools (Revelle, 2021), sjPlot (Lüdecke, 2021), texreg (Leifeld, 2013), and tidyverFwse (Wickham, 2017).

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3. Results

Table 1 presents the results of the logistic regression models, with public attitudes toward tree management as the dependent variable. The regression coefficient and its standard errors are not transformed, i.e., they present the estimation of the natural logarithm of the likelihood that landowners should have the right to decide about tree removal. Results can be transformed into actual likelihoods by implementing an exponential function with the regression estimations as its argument. Each model incorporates NDVI-800 and building type as explanatory variables and includes environmental worldviews, which are the perception of the benefits of trees, PA, and the interaction of PA with other variables to evaluate whether PA moderates the effect of each explanatory variable on the dependent factor.

Table 1. Results of logistic regressions: log-odds coefficients with standard errors in parentheses

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Intercept	1.00	0.91	1.22	1.26	1.07	1.00	1.22	1.77
	(1.02)	(1.03)	(0.97)	(0.98)	(0.99)	(1.02)	(1.04)	(1.17)
NEP-Anthropocentrism	0.42*		0.39*	0.39*	0.03	0.40*	0.39*	0.41*
	(0.19)		(0.19)	(0.20)	(0.24)	(0.20)	(0.20)	(0.20)
NEP-Environmentalism	-0.45							
	(0.33)							
ES-Non-cultural		-0.01						
		(1.07)						
ES-Cultural		-2.19**	-2.01**	-2.00**	-2.13**	-1.35	-2.00**	-2.03**
		(0.82)	(0.66)	(0.66)	(0.68)	(0.92)	(0.66)	(0.67)
PA				-0.04	0.22	0.31	0.01	-0.68
				(0.20)	(0.23)	(0.41)	(0.42)	(0.83)

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NDVI-800	0.89	1.00	0.74	0.73	1.30	0.80	0.73	-0.37
	(1.64)	(1.68)	(1.70)	(1.70)	(1.75)	(1.71)	(1.70)	(2.18)
Type of building people live in	-1.26***	-1.23**	-1.27***	-1.29***	-1.44***	-1.33***	-1.23*	-1.27**
	(0.37)	(0.38)	(0.38)	(0.39)	(0.41)	(0.39)	(0.60)	(0.39)
PA * NEP-Anthropocentrism					0.55*			
					(0.22)			
PA * ES-Cultural						-0.81		
						(0.83)		
PA * Type of building people live in							-0.06	
							(0.47)	
PA * NDVI-800								1.41
								(1.78)
AIC	246.91	243.33	239.03	241.00	236.51	242.04	242.99	242.38
BIC	263.38	259.79	255.50	260.76	259.56	265.09	266.04	265.42
log Likelihood	-118.45	-116.66	-114.52	-114.50	-111.25	-114.02	-114.49	-114.19
Variance residual	236.91	233.33	229.03	229.00	222.51	228.04	228.99	228.38
Num. obs.	199	199	199	199	199	199	199	199

Notes: * *p < .05;* ** *p < .01;* *** *p < .001.*

Model 1, in which Anthropocentrism and Environmentalism are explanatory variables, indicates that, on average, anthropocentric-oriented respondents are more likely to indicate that the owner should decide about tree removal (the log-odds coefficient is 0.42, which translates into an odds ratio (OR)

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equal to exp(0.42) = 1.52; p-value (p) equal to 0.028). At the same time, respondents more environmentally oriented are inclined to believe that the municipality should decide about tree removal (OR = 0.64; p = 0.172). This supports hypothesis H1.1. However, the association between NEP and the dependent variable is only significant for Anthropocentrism, not for Environmentalism. Thus, we excluded Environmentalism from further analysis.

Similarly, Model 2 incorporates into regression analysis perceived non-cultural and cultural benefits of trees. No evidence was found of a significant effect on the dependent variable for non-cultural benefits (OR = 0.99; p = 0.990), whereas the effect of cultural benefits was significant (OR = 0.11; p = 0.007). Those recognizing cultural ES from trees support the opinion that the municipality should decide on tree removal. Consequently, subsequent models (3-8) include only cultural benefits as explanatory variable. Model 2 supports hypothesis H1.2, i.e., the more highly respondents perceive the cultural benefits of trees, the less they support the opinion that the owner should decide about tree removal.

Model 3 summarizes the results of the two previous regressions, showing that both Anthropocentrism and recognition of cultural benefits of trees significantly impact attitudes toward the management of tree removal (OR equal to 1.48 (p=0.041) and 0.13 (p=0.002), respectively for Anthropocentrism and cultural benefits).

In order to evaluate H1.3 and H1.4, we included NDVI-800 and building type as explanatory variables in all the models. Surprisingly, hypothesis H1.3 was not confirmed, which rejects the thesis that the higher the quality of greenery in the area surrounding a respondent's home, the less likely they are to believe that the landowner should decide about removing trees (OR = 2.09; p = 0.665). However, we confirmed hypothesis H1.4, i.e., our analysis supports the proposition that respondents who inhabit multi-family housing have a higher probability of agreeing with the statement that the municipality should have the right to decide about tree removal on private land (OR = 0.28; p = 0.01).

Finally, model 4 includes PA as the dependent variable, and models 5-8 add the interaction between PA and all other variables to test hypothesis H2. The results are mixed. Firstly, PA did not affect opinions about who should decide on tree removals (OR = 0.96; p = 0.665). Secondly, we only observed a moderating effect of PA (OR = 1.73; p = 0.014) for the NEP Anthropocentrism scale (Model 5); interactions of PA with other variables were not significant.

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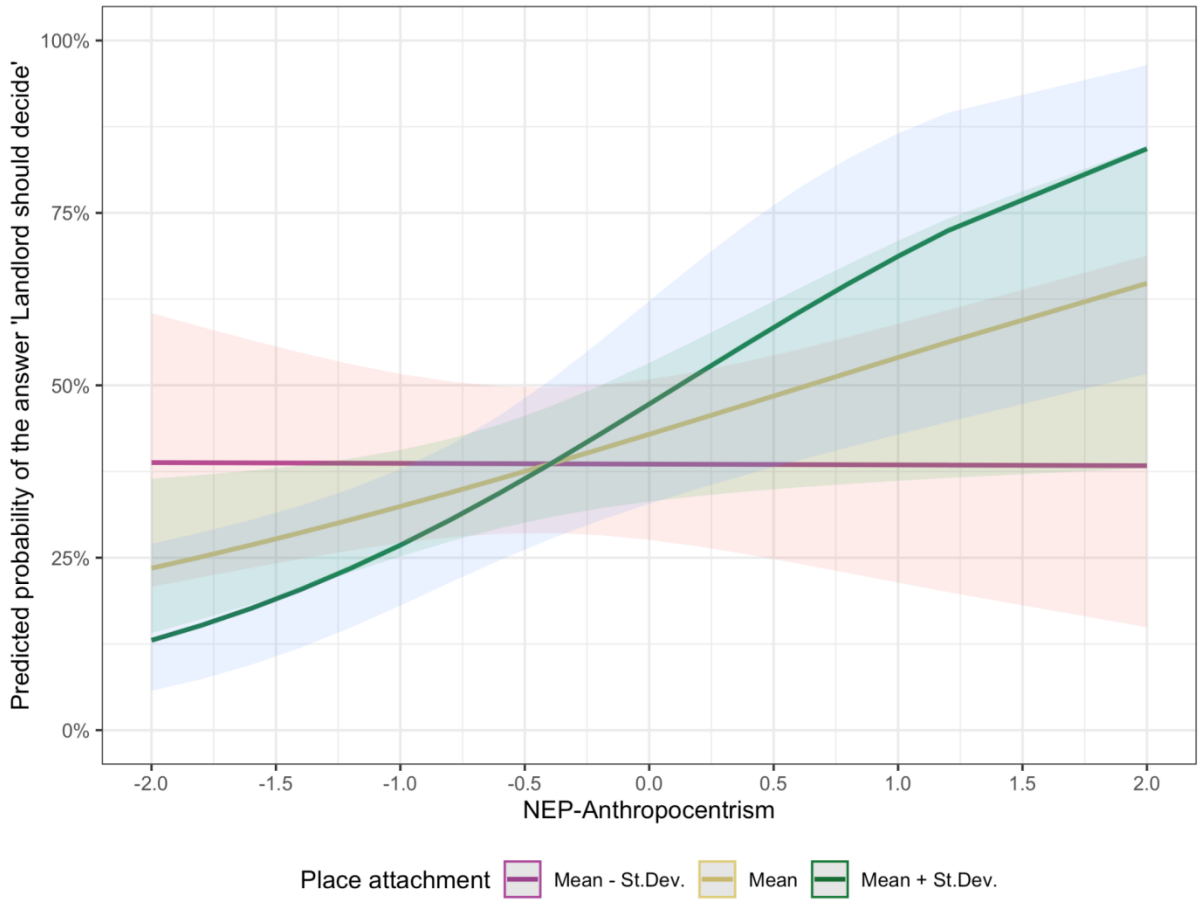

Figure 4. Effect of place attachment on the relationship between NEP-Anthropocentrism and attitudes toward tree management (Model 5)

To facilitate interpretation of the moderating effect, Figure 4 shows the association between Anthropocentrism and the predicted probability of the answer that the landowner should be responsible for tree removal decisions, along with a 95% confidence interval, for three groups of respondents, i.e., (i) those with the highest level of attachment to their residence (respondents whose PA scores are one standard deviation or more above the mean value), (ii) those with a mean level of PA, and (iii) those with the lowest PA (respondents having PA scores at least one standard deviation below the mean). The analysis demonstrates that the association between Anthropocentrism and the dependent variable is not significant for respondents with the lowest PA, but it was significant at higher PA values. This shows that Anthropocentrism increases the likelihood that a respondent will indicate that the landowner should decide about tree removal when the respondent feels a greater sense of attachment to their place of residence.

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4. Discussion

This study examines attitudes towards urban greenery management, specifically the preference for public or private responsibility for tree removal on private land. For this purpose, the impact of sociological, physical (environmental), and psychological variables are evaluated.

The effect of sociological factors, i.e., environmental worldviews, was significant. Respondents with an Anthropocentric orientation are more likely to support the idea that the landowner should decide on tree removal on their private land. Furthermore, the recognition of cultural ES provided by trees also had a significant effect, indicating a preference for public greenery management, i.e., the belief that the municipality should decide about removing trees from private land. Interestingly, the greenery (expressed by an NDVI index) of the area surrounding a respondent's home does not influence the opinion of who should decide about removing trees on private land. However, the type of building respondents live in had a significant effect, with those living in multi-family structures preferring that the municipality decides about removing trees from private land.

Finally, the psychological concept of PA linking the physical environment and its perception by individuals was significant. PA moderates opinions about the relationship between Anthropocentrism and the preference for public or private management of greenery. Stronger PA implies a more Anthropocentric worldview and the preference for landowner rather than municipal management of tree removal.

The causal factors underlying opinions on tree removal are not straightforward. The influence of Anthropocentrism on the preference for urban greenery management, as well as the moderating effect of PA on this preference, could be explained by the respondents' sense of agency, understood as independence, the belief that "I am the one who is causing or generating an action" (Lewicka, 2013; Gallagher, 2000). Furthermore, a higher level of PA makes respondents care more about their place and prefer to make decisions about it (Davenport & Anderson, 2005; Walker & Ryan, 2008; Buta et al., 2014; Van Veelen & Haggett, 2016). In previous studies, the association between PA and a pro-environmental orientation (Environmentalism) was examined at the level of specific natural areas (e.g., park, forest), where the place itself provided environmental functions. Comparing our results with prior studies (Budruk et al., 2009; Wynveen et al., 2021), we show that PA contributes to a greater assertion of one's views of nature, regardless of whether those views are Environmentalism or Anthropocentrism.

The significance of cultural ES compared to other ES lies in their relational nature and contextuality (Dickinson & Hobbs, 2017; Pascual et al., 2017). Cultural ES always stems from interpretations that vary among social groups. Individuals or groups may value the same element of the environment in many, sometimes contradictory, ways (Himes & Muraca, 2018; Maniatakou et al., 2020). Thus, cultural ES has the potential to generate conflicts, especially relationship conflicts, more than other ES types (Maczka et al., 2019, 2021). Our research shows that residents that appreciate cultural ES support

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municipality-led tree management. Respondents want to protect opportunities for recreation and other cultural ES, which can be scarce, especially in densely populated urban areas. This agrees with the support we found for public greenery management from people living in multi-family buildings. This can be explained by the fact people living in multi-family buildings do not own trees and land that they could make decisions on. Hence, their preference for having responsibility for tree management lies with the municipality can stem from their lack of ownership. Their role in greenery decision-making processes is limited (Conway et al., 2022). Furthermore, the lack of impact of greenery on opinions about tree management is confirmed by previous research indicating that the presence of greenery does not by itself guarantee its appreciation by local residents (Tabatabaie et al., 2019; Rahm et al., 2021; Palliwoda et al., 2020). In recent literature, it is argued that small, semi-public greenery often plays an important role in everyday life (Säumel et al., 2021), although such areas may not directly translate into physical measures of greenery, such as NDVI. This can be particularly important in densely populated cities where many people live in multi-family housing, and urban overdevelopment leaves little plantable space for trees and shrubs (Klobucar et al., 2021a). Therefore, it is not surprising that a relationship with responsibility for tree removal decisions was observed for both the type of building in which respondents lived and the cultural ES valued by them. The importance of cultural ES in such decisions is particularly relevant, as it indicates the role of greenery on public attitudes, even if the greenery is not of high quality, so long as it is present in appropriately landscaped areas with adequate infrastructure. Our results emphasize that in urban greenery management, perception-based indicators may play a more critical role than objective/physical indicators that are often used, for example, in studies on access to urban greenery (Giannico et al., 2021).

To summarize, the opinion that the landowner should decide on tree removal on their private land is connected with an anthropocentric worldview, and anthropocentrism is strengthened by PA. The preference that the municipality should decide on tree removal is, in comparison, related to the appreciation of cultural ES provided by trees and to people living in multifamily housing. Thus, we identify two distinct positions regarding tree management. Our results show that the establishment of a unified greenery management policy could be challenging even within the boundaries of a single municipality, as it can face different public perceptions in neighborhoods with a range of residential building types.

5. Conclusion

Our research demonstrates the importance of environmental worldviews, perception of benefits of trees, greenery quality, type of residential building, and emotional attachment to place, in influencing preferences about urban greenery management (i.e., who should decide on tree removal on private

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property – the landowner or the municipality). The results reveal that in managing urban greenery, it is important to consider not only the quality of greenery but additional less obvious metrics that can affect tree management.

Municipal greenery management (including on private land) faces the challenge that residents may perceive greenery differently than objective indicators would suggest. This can influence social legitimacy, i.e., how residents accept strategic visions of municipal development. Setting up a common approach for urban greenery management requires a decision-making process with greater social support, given the conflictual nature of cultural ES and the lack of objective indicators for their measurement. Investing in deliberative public participation methods that allow the expression of different points of resident views is a method to manage conflict. Previous studies on ES in public consultation (Maczka et al., 2019, 2021) show that stakeholders framed cultural ES – compared to other ES – in a negative context connected with negative patterns of behavior, such as noncompliance with rules and regulations. This suggests there is an important role of public participation in urban greenery management.

In our study, we investigated the level of emotional PA related to residence, in the location where trees are located. Investigating the feeling of attachment to natural objects in a place of residence could lead to different results – this may provide direction for future research. In this study, we did not evaluate the moderating role of identification with a place or the importance of place in preference for public/private urban greenery management. This could be further investigated. Future research could also measure emotional attachment to certain environmental features and test how this could affect opinions about public/private management of urban greenery. Moreover, the influence of location attachment on trust in local authorities and overall quality of life requires investigation. Future research on greenery management could also consider respondents' sense of and/or need for an agency.

Two limitations of this study need to be acknowledged. First, the data has biases typical of Internet-based data collection. Our online survey (computer-assisted self-interviewing - CASI) was available on the Internet for self-completion in questionnaire format. This limits the scope of the sample, narrowing it to people who use a computer/mobile device with Internet access and may have discouraged those with weaker computer skills from participating. Moreover, the survey proved to be tiresome, resulting in some respondents dropping out before it was completed. This situation was especially evident in the final section of the survey – NEP. Direct, face-to-face, and randomized sampling would be needed to further corroborate our findings. Secondly, our study took place in two large cities in Poland. Thus, the results are interpretable in the local geographical context. Further research should focus on other spatially related factors (such as vegetation or characteristics of the urban fabric) that could influence the outcome.

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